THE CROFT WOODLANDS PROJECT

HIGHLANDS & ISLANDS WOODLANDS HANDBOOK

for crofters, communities and small woodland owners

Bernard Planterose

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(their names are in their case studies).

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There are thirteen sections to this handbook with coloured headings that are also used in the cross referencing boxes throughout the text. Sections 2 to 4 utilise the same blue colour as they all focus largely on silvicultural advice. Sections 5 to 9 utilise the same green colour as they all look at integration of woodland with other land uses. Climate change implications are given in coloured boxes at the start of 7 of the 13 sections and are a thread that runs throughout. There are also 19 case studies that are distributed throughout the handbook, several of which could have been placed within a number of sections on account of the diversity of activities they describe.

Feedback

Please provide feedback on any aspect of this handbook to the Woodland Trust Scotland at scotland@woodlandtrust.org.uk or Bernard Planterose at northwoodsdesign@btconnect.com

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LIST OF CASE STUDIES (BY SECTION)

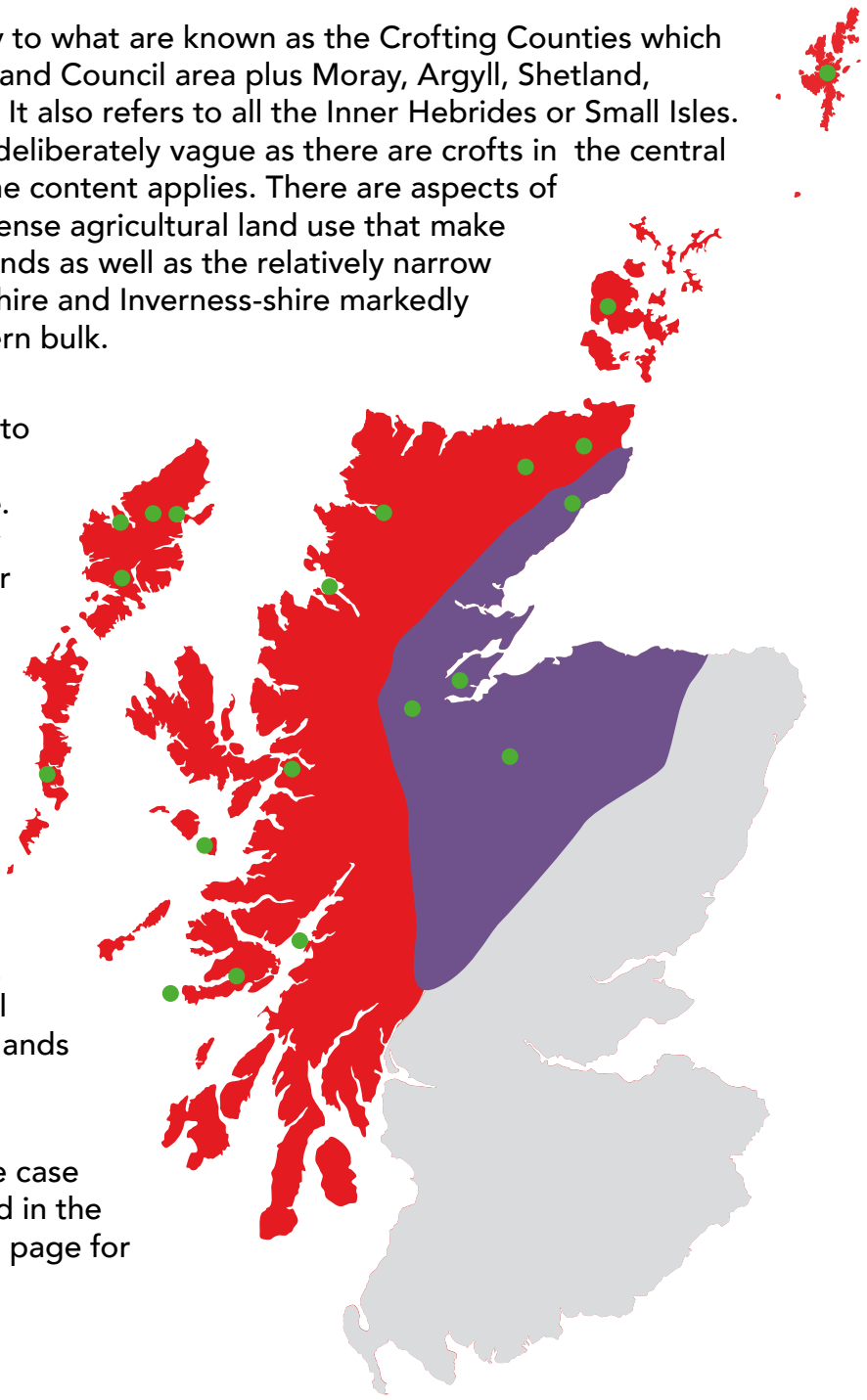
GEOGRAPHICAL COVERAGE OF THIS HANDBOOK

This handbook refers primarily to what are known as the Crofting Counties which include the whole of the Highland Council area plus Moray, Argyll, Shetland, Orkney and the Western Isles. It also refers to all the Inner Hebrides or Small Isles. Its south eastern boundary is deliberately vague as there are crofts in the central Highlands to which much of the content applies. There are aspects of climate, soils and relatively intense agricultural land use that make the central and eastern Highlands as well as the relatively narrow eastern coastal strip of Ross-shire and Inverness-shire markedly different from the more western bulk.

The red area is often referred to as oceanic and the purple as continental in terms of climate. Oceanic areas are significantly wetter and on average warmer in the winter and cooler in the summer. These differences can make profound differences to what can be grown both in the way of crops and trees.

The red area can be argued to constitute a distinct 'bioregion' which we could call the 'Atlantic north west and islands bioregion'.

The green dots indicate where case studies, which are interspersed in the text, are located (see previous page for names).



INTRODUCTION
by Bill Ritchie

There has been a fundamental change in attitudes to native woodland and woodland creation in the Highlands and Islands over the past 30-40 years. I remember not so many decades ago the UK Forestry Commission under-planting birch and rowan woods with Sitka spruce and lodgepole pine! Thanks to a small group of highly motivated people, including 'guerrilla planters' (of which Bernard was one!), the importance of protecting the remaining fragments of native woodlands and expanding native woodland cover to provide both ecological and economic benefits is now widely accepted. Since the 1980s there has been significant regeneration and creation of native woodland and with it a significant number of people benefiting economically from the woods. Each section of this book is illustrated by case studies of just some of these people. These case studies highlight the economic benefits of even small woodlands in this region and will surely inspire anyone contemplating the establishment of woodland whether for shelter belts, productive woodlands, amenity woodlands, woodlands for ecological enhancement, or a mixture of all of these.

Crucially, whilst the handbook is a practical guide to woodland establishment and management, it also challenges the current paradigm of land management in much of the Highlands and Islands. It's a paradigm which sees large scale monoculture forestry, large scale sheep ranching and large tracts of so called deer forest as somehow normal. There is no evidence that this is environmentally or economically sound. Land reform provides us with new and exciting opportunities to shift to a new paradigm. With the reform of ownership patterns, including community ownership, and the ability to create new crofts, we can now envisage a much more diverse pattern of land ownership and management practices that will lead to a mosaic of robust and resilient environmental and economic activity. The handbook aims to help achieve this vision by suggesting a selection of options that will create a better balance of grazing and woodlands, linking this to employment and economic opportunities, whilst increasing the fertility and productivity of the land.

The guidance in this book is based on a deep understanding of woodland ecology and places our largely deforested landscape, the 'wet desert' as Fraser Darling called it, in its historical context. Noting the consequent decline in productivity, including the impact of deforestation on our native salmon and sea trout, it argues for significant reforestation to tackle the decline in soil and riverine fertility. Significantly it claims, rightly in my opinion, that browsing by domestic and wild animals is essential to the successful management of established woodlands. There is no conflict between livestock rearing and woodlands. Indeed they can be mutually beneficial provided the balance between grazing pressure and regeneration is carefully managed as emphasized in the handbook.

The focus is on growing trees in the crofting counties. This is really important. The topography, climate, soils, and land use practices single out the crofting counties from the rest of the UK creating, with a few notable exceptions, a distinct bioregion characterised by a cool wet climate and acid soils. This sets limits on what trees can be grown where. All the advice and guidance given is based on

decades of hands-on experience in the crofting counties. Bernard's own experience ranges from creating a tree nursery in the far north west of Sutherland, through establishing a flourishing woodland on Isle Martin (a wind and salt sprayed west coast island) to managing a productive conifer woodland and creating a business building timber houses and cabins in Wester Ross.

The focus on the crofting counties is also timely. The Scottish Government has just announced its new forestry strategy, which sets out to increase woodland cover significantly over the next few decades. As crofters occupy around 20% of the Highlands and Islands they are well placed to play an important role in this new strategy.

I am sure that this handbook will not only be of considerable practical use to crofters and others in the establishment of woodlands but will feed into strategic level discussions about land ownership, land management, and funding options to support land management, by a new generation of woodland stewards.

Finally, if like me you don't know your 'shifting baseline syndrome' from your 'trophic cascade' you will be pleased to know that there is a very good and comprehensive glossary at the back of the book!

FOREWORD
by Iain Thomson

A worldwide challenge faces food production and wildlife. Can we in Scotland adapt to systems that are ecologically sound, sustainable, and provide a living for a rural population? Deer stalking and grouse shooting occupies land much of which might be suitable for growing trees. Taxation talks, incentives persuade: would it be possible for livestock and woodlands to become an integrated agro-forestry industry? Could conservation cattle and managed woodlands become one form of land usage with an overall aim of protecting, indeed enhancing the very bio-diversity on which we depend? What's needed is diversification away from single forms of land usage, be it deer stalking or sheep, a revival of rural communities, a holistic caring for the environment rather than greater exploitation. Much land usage is in the traditional hands of OAPs. Young blood is needed, informed and enthusiastic, with access to land, to learn and develop the ecological principles spelt out in this handbook which will govern our survival. And if that comes about, we could look forward with confidence.

Bernard Planterose, a man with many years practical experience of that which he writes, has produced this handbook which is a comprehensive guide offering many common sense solutions to some of the apparent land use conflicts we face in the Highlands and Islands. It's an enlightened contribution of ideas and information for a situation which calls for decisive action. It should be read and considered by politicians, policy makers, farmers, foresters and public alike in a united effort to advance sustainable land use in our part of the country and, in so doing, address the impending disaster of climate change.

SECTION 1
WOODLANDS FOR THE FUTURE
Reforestation for rural development : from community woods to woodland crofts

"…the environmental rehabilitation of the Scottish Highlands can be achieved by means which simultaneously bring about the restoration of people to some at least of the many localities where both human communities and the Gaelic culture associated with these communities were long ago destroyed. The Highlands, if such a course were to be embarked upon would be very different from the Highlands of today. Much of the area would be more thickly populated than has been the case in recent times. It would be more thickly wooded also – with timber and timber products being of greater economic importance, in all probability, than either sheep or deer. We have the opportunity today in the Scottish Highlands to turn around the processes which have done so much damage both to this area's people and to its natural environment. All of us with an interest in the Highlands – established residents, incomers, environmentalists and others – could readily resolve to work together for the region's general benefit. We could jointly bring about the repopulation as well as the ecological restoration of all the many places where, as Hugh Maclennan commented, 'You feel that everyone who ever mattered is dead and gone'".

~ James Hunter, On the Other Side of Sorrow, 1995, 2014.

INTRODUCTION

In 1993 the first edition of this handbook placed on the table a bold notion that *"Crofting forestry at its most ambitious could be about making efforts, however small at first, to help start putting back… [a forest]… resource for the benefit of local people all over the Highlands and Islands. It can be argued that we stand at a point in time (with only 1% of the original forest left over Scotland as a whole) where we can literally start designing a forestry resource very nearly from scratch to our own specifications. The type of forest that we choose must be to the mutual benefit of ourselves and the long term health of the land – for the two are surely interlinked… "* It envisaged… *"a network of woodland, forests and shelterbelts integrated with existing and novel agricultural and horticultural activities offering… an opportunity to dramatically diversify the crofting economy and to develop enterprises which concentrate more on the 'home' and local economy. To achieve this will, of course, involve a large scale effort by a lot of individuals and a great deal of co-operation from estates to build a sufficiently big resource to sustain local industry and employment".*

Twenty five years on from those provocative sentiments and from James Hunter's similar call to arms of the time, it is fair to say that a good start has been made to this predictably long and challenging process. A great many individuals throughout the Highlands and Islands have indeed initiated woodland-based projects on a great variety of scales: collaborations of a type and scale that were only vaguely imagined at the end of the last century have become reality and community groups, representing wide perspectives on the land and its possible uses, have acquired land and, in a great many cases, have placed woodland and land restoration at the heart of their renewal efforts. The woodland and land restoration model has taken root in all sectors of land use and in all ownership types with

private estates, NGO owned estates, community-owned land, individual crofters, farmers and grazings committees all making significant contributions.

Scottish Forestry Strategy planting targets: increase the annual woodland creation target of 10,000 hectares (ha) per year to 15,000 ha by 2024/25. By 2032 Scotland's woodland cover will increase from around 18% to 21% of the Scottish land area.

However many hectares of woodland have been planted or regenerated since 1993 and however many hectares are planned for the coming decades, in order to secure the long-term viability, regeneration and use of our land and its natural resources, we need to pursue two overlapping and fundamental objectives:

1. BALANCE between grazing pressure and the regeneration of all vegetation (trees, heath and grasslands) along with the soils that support it
2. INTEGRATION of woodlands with hill farming, crofting, horticulture, landscape and wildlife conservation and other land uses.

Taking these key objectives on board, this handbook describes innovative and integrated combinations of productive land use that deliver a wider range of products and services than are supported today and which in turn can support greater diversity and employment.

The handbook prescribes a landscape of variety and beauty increasingly characterized in land use discussion and policy as a WOODLAND MOSAIC with heath, bog, and grasslands. Woodland mosaic, an evocative descriptor, is starting to offer a consensus view of what we might be aiming at throughout the uplands of Scotland – something that might accommodate many viewpoints.

In the sections that follow, we attempt to put some flesh on the bones of this useful but still somewhat vague concept. Specifically we advance the key concept of AGROFORESTRY; again a term gaining currency in policy documents and discussion. The handbook offers some tangible descriptions and options that fall within its scope. Few of these are mutually exclusive on sufficiently large land units but some are, and therefore require zonation or a change in attitudes and directions.

Landscape in transition : planted native trees forming a matrix of bog, woodland, scrub and heath (Coigach).

Agroforestry embraces a spectrum or suite of management systems in which tree and woodland management form a binding element of a mixed economy that includes animal husbandry, horticulture, fruit growing or non-tree forest products (NTFPs). As this handbook will illustrate, there is a wealth of possibilities when woodland provides the matrix within which other land uses can thrive. A range of symbioses develops. These are nearly always richer, more productive, more resilient, and often more economic; they also employ more people than the single use systems we largely have today.

Refer to section 6, 'Grazing Animals and Woodland' for more on Agroforestry.

A key diagram that illustrates the relationship between today's monocultural or grossly simplified management systems (be they deer, sheep or conifer forest) and low employment can be found in the ecology section towards the end of this handbook. It expresses in slightly more technical language the unfortunate route that leads from 'simplified and depleted ecosystems' to 'limited employment and a narrowly based economy' – a route easy to follow and hard to reverse. It is suggested that we seek a deeper understanding of the underlying processes that have led us to today's relatively limited upland resource base and accompanying low rural employment, depopulation and shrinking youth engagement with the land.

Refer to Section 12, 'Woodland Ecology' for some detail on underlying processes at work in our upland environments.

Responding to this need for deeper understanding, an increasing emphasis is being placed today on a more scientific basis to upland land-use management in Scotland. Some will argue it is high time we went beyond superficial and poorly informed analysis of the state of the land that perhaps reflects our failure to agree on land-use objectives. Indeed we are failing to agree on reasonable grazing densities, culling targets, the effects of muirburn, and predator control. In essence, we are failing to agree on what is healthy and what is not; what is sustainable and what is not. A new generation of land managers and policy makers needs to aspire to a much higher level of ecological literacy. In the coming decades they will certainly be required to deal with changing climate, new diseases, species extinctions, and increasing pressure on land resources from many quarters, ranging from food production and renewable energy to tourism. This handbook is intended to contribute to that aspiration.

The land can and should provide new employment but this requires innovation and rehabilitation of its biological potential. We can't just wave a wand and get acidic heath and bog, eroded peat and acidified burns and lochs, to miraculously produce more. Instead it requires concerted, educated and integrated approaches. These will include far more people working the land, all armed with greater knowledge.

So you might skip the WOODLAND ECOLOGY section of this handbook if you like but, on the other hand, you might even choose to read it first! For therein lie introductions to a good many of the underlying principles and processes that should come to underpin all our approaches to future land and freshwater management. We ignore nutrient cycles, acidification and loss of species at our peril.

KEY THEMES OF THIS HANDBOOK

There are several key themes that occur over and over in the following sections of this handbook. Some are at least as old as the first edition but others are new and reflect advancing developments in land-use thinking and practice. The following paragraph highlights these key themes in purple.

Balance of grazing with woodland regeneration, woodland mosaics and agroforestry have already been introduced. PRODUCTIVE OR BIOLOGICAL POTENTIAL is frequently linked to NUTRIENT CYCLING and nutrient management and expands the age old understanding of FERTILITY and FECUNDITY. BIODIVERSITY is new

lingo for species diversity, perhaps better at embracing every form of life, from fungal webs to top predators, and embodying the need to preserve gene pools. ECOSYSTEM HEALTH and ECOSYSTEM FUNCTIONALITY refer to the holistic state of the whole soil, vegetation, water and biotic web or complex. These are hard to quantify, but easier to recognise once we have developed a better grasp of nutrient pathways, food webs and species interdependencies. REFORESTATION scoops up all these terms, taking in LAND REFORM on its way to delivering RURAL DEVELOPMENT which in turn embraces RE-INHABITATION or RE-POPULATION, integrated with new EMPLOYMENT. RURAL DEVELOPMENT FORESTRY (RDF) is the international terminology for the delivery of rural regeneration based around woodland and forest resources.

Planted and naturally regenerated native Scots pine and birch diversifying conifer and heath landscape.

Refer to section 12 'Woodland Ecology' for more on deer and woodlands.

The number of times that the DEER PROBLEM (termed that for fully one hundred years), which sums up the difficulty of deer or grazing pressure in relation to other land uses, is referred to throughout the handbook can hardly be ignored. Sadly we still seem a long way from solving it. Indeed, until very recently, numbers have increased decade on decade over that long period. They now represent a major obstacle to the whole agenda of land renewal that the majority would like to see. The barrier to the regeneration of soils, diversity of vegetation and woodlands that high deer populations cause (in some but not all areas) is recognised by policy makers, foresters and farmers alike. But the opportunity cost in terms of the alternative economic activity which people have had to forego, is hardly discussed, let alone quantified. This handbook demonstrates the rich array of economic alternatives to managing deer for sport shooting and should help to explain how its simple regimes undermine a far more diverse and biologically productive landscape capable of delivering wider employment opportunities and better carbon management: objectives that increase in priority with every passing year.

Perhaps this would be a good summary of the handbook's key theme: A greater diversity of land management models and agroforestry provide the key tools for rural regeneration in the Highlands and Islands where agroforestry embraces a suite of land-use types based around a 'mosaic' or woodland, grassland, heathland and bog matrix, which underpins ecological and economic sustainability.

A SCOTTISH WOODLAND CULTURE

Before looking to the future and focusing on the specific opportunities and challenges of our area, it is encouraging to see where the undoubted advances we have made in the Highlands and Islands over the last 25 years fit into the broader Scottish picture.

Taking the country as a whole, it has been said that (since the last Ice Age) the greatest extent of forest cover of all types over Scotland came before 6000 BP and its lowest cover around 1920. This is also true in broad terms for most of the Highlands and Islands. However in terms of its specifically *native* woodland cover the nadir came later around 1975-80. This was brought about by a period of intensive (mostly exotic) conifer expansion, which included the underplanting of significant areas of native woodlands (Scots pine and broadleaved). The other very significant factor was the incremental loss of unenclosed woodland remnants to grazing sheep, deer and goats, often in combination with uncontrolled muirburn. Significantly from our perspective, 90% of the remaining Scottish native woods at the end of the 20th century were nevertheless in the Highlands and Islands.

Refer to section 12 'Woodland Ecology' for more on peak forest and woodland history.

While the commercial conifer expansion of the mid to end 20th century caused considerable grief to hill farmers in some upland areas of Scotland, the parlous state of native woodlands was brought sharply into relief by survey work commissioned by Friends of the Earth and Forestry Commission Scotland. This both reflected and fostered a rising tide of pressure from NGOs, woodland scientists and the public calling for urgent conservation of the remaining fragments. The introduction of the broadleaved woodland supplement in 1985, and the native pinewoods grant in 1988, were the decisive fiscal actions that finally reversed the long and gradual decline of the native or semi-natural woodland cover of Scotland.

This tide of persuasive public pressure had been ignited and informed by a plethora of grass roots groups from the early 1980s who inspired a generation of tree planters and woodland managers. In neither order of size, significance nor precise chronology, the groups included the Native Woodland Discussion Group, Loch Garry Tree Group, Scottish Community Woods Campaign, Woodschool, Reforesting Scotland, Trees for Life, Borders Forest Trust, and Scottish Native Woods. At the turn of the century a major boost was given by the Millennium Forest for Scotland Trust, which spawned a considerable number of new projects. The Community Woodland Association formed in 2003 has come to represent nearly 200 community owned or managed woodlands throughout the country of which about 45% are in the areas covered by this handbook. Off-shoots of Reforesting Scotland have included Woods for All, The Scottish Wild Harvests Association and the One Thousand Huts Campaign.

The Reforesting Scotland Journal acts as the main forum for the many strands of social forestry and woodland culture in Scotland today. https://www.reforestingscotland.org/publications/journal/

The combined influence of these groups and the advance in knowledge they have brought constitutes nothing short of a new 'Scottish Woodland Culture'. It embraces practical woodland establishment and management, a renewed and broadened timber manufacturing and construction industry, a broad range of inspirational and educational woodland related projects and forums, a blossoming of home-grown timber building and crafting, an impetus and focus to rural community land acquisition and a political campaigning force of real influence to promote all aspects of woodland policy.

In an international context, the Scottish woodland restoration movement can be seen as an exemplar of Rural Development Forestry. Its symbiosis with the Land Reform movement adds further strength to its already persuasive political, social and environmental agenda. Excitingly for us, the Highlands and Islands have been at the forefront of woodland restoration of all types, by virtue of having large areas

of available land and a great potential for environmental improvements to the benefit of crofters, farmers and future land users. Community ownership, also advancing most rapidly in our region, has placed a high priority on reforestation as part of overall land restoration and the creation of new livelihoods.

NEW MODELS FOR RURAL DEVELOPMENT

It may seem a long way from the relatively simple act of planting trees and regenerating woodland to rural development and repopulation and it undeniably does take a leap of imagination. However, community ownership and greater diversity in land management are now seen by many as the prime vehicles for the economic and social rehabilitation of a significant proportion of the Highlands and Islands. Providing that land-use is environmentally sound, we could have repopulation as well as the ecological restoration that James Hunter (amongst others) speaks of in The Other Side of Sorrow. That would indeed be truly sustainable development.

Coigach & Assynt Living Landscape (CALL) is one of the largest landscape-scale restoration projects in Europe, covering 635 square kilometres, included within a 40-year vision and comprising 14 partner organisations. These include community land-owners, community interest groups, charitable landowners, private land-owners and charitable membership organisations – refer to CASE STUDY

As already noted, communities acquiring land are giving a high priority to woodland and land restoration, reflecting a wider focus throughout Scotland. Although the community ownership model is particularly well placed to develop integrated and innovative approaches to land use, starting out as it does with a fresh approach and inclusive mandate, a workable vision for the Highlands and Islands as a whole must embrace all types and scales of landownership. Single ownership units, be they private or NGO, are part of the vision and their ability to undertake landscape scale restoration projects is particularly valuable. A trend towards partnerships of land owners of different types sharing common goals should prove a very exciting model for rural development in the future, as already exemplified for instance by the Coigach and Assynt Living Landscape (CALL) project, which does not include any government landowners.

'Centre for Sustainable Forests and landscapes' based in Edinburgh University, established in 2018. Mission is to work with a wide range of partners to provide the critical interdisciplinary knowledge to deliver sustainable landscape management and policy development, with an emphasis on forested landscape mosaics

Significant landscape scale reforestation projects and the involvement of our major institutions of research and learning are also now rapidly becoming an integral and critical part of the burgeoning belief in reforestation as a model or paradigm for rural development across the uplands of Scotland.

For example, the newly announced Cairngorms Connect Partnership promises to deliver *"the biggest habitat restoration project in Britain"* encompassing 600 km^2. It contends that as the *"landscape becomes wilder, more visitors will be attracted to it: walkers, adventurers, photographers, wildlife watchers and hunters will all help support local businesses and provide new opportunities"*.

© John MacPherson / WTML

Naturally sheltered and drained pasture with diversity of productive and multiple use woodland.

The new 'Centre for Sustainable Forests and Landscapes' aims to help deliver sustainable landscape management and policies *"with an emphasis on forested landscape mosaics"*: a strong echo of the fundamental concept running through this handbook.

With these sizeable and influential players, the arguments for reappraisal of upland land use are becoming irresistible. It seems finally possible to break out of the deadlock of monocultural approaches and re-invent ourselves with many innovations in a new working rural environment. We can draw great strength and encouragement from what has been achieved so far in our efforts to get trees in the ground: new native species woodlands are already changing landscapes from the Small Isles to the Northern Isles. In the future, the efforts of the few will be backed up by increasing institutional and policy support as we make the transition from relatively simple monocultural regimes of deer and sheep to more diverse, complex and ultimately more economic agroforestry systems. Grazing will be in harmony once more with vegetation and soils.

CROFT WOODLANDS AND WOODLAND CROFTING – beginnings

For all the importance of the big schemes and partnerships that attract the headlines and the big grants, the crofting model affords special opportunities. Its highly distributed nature and its socially integrated and central place in the culture of the Highlands and Islands constitute an immense force for change. Supported by its progressive representative body, the Scottish Crofting Federation and an increasingly responsive grant system, not to mention legislation, its determination to grow and embrace innovative land uses and partnerships has the potential to put a new generation back into close relationship with the land.

Ever since the Crofter Forestry (Scotland) Act 1991 and subsequent crofter forestry legislation finally gave crofters ownership over trees and woodland on their crofts and Common Grazings, the ambition to bring together agricultural and woodland interests in the crofting context has been growing.

The Crofting Forestry Handbook was published by the then Scottish Crofters Union in 1993 to help build on this development.

For the time being at least – a distinction remains between 'croft woodlands' (woods *on* crofts) and 'woodland crofts' (crofts *in* woods) in terms of their development and support. The expectation is that a croft woodland will be making some contribution to the croft economy, while on a woodland croft, the trees will be the significant player. In reality, the relationship between the two is a continuum, and it is to be anticipated that the distinction will become less relevant over time.

© Andy Robinson

© Duncan Halley

(Left) Starting from clearfell : Andy Robinson's 2.5ha Langamull woodland croft. 80% of the ground will be planted with trees including a large forest garden. He has already formed a garden and small tree nursery and will start on a house in a couple of years using croft house grant. (Right) A vision of the future from SW Norway.

Croft Woodlands

After the Crofter Forestry act in 1991 there was an upsurge in planting of new croft woodlands. By 2007 approximately 11,000ha had been planted, but in the following 7 years only 600ha was planted. This decline coincided with the closure of the Scottish Forestry Grant Scheme and the introduction of the Scottish Rural Development Programme.

A 2014 study commissioned by FCS examined the barriers to crofter forestry and proposed a range of solutions.

Three key barriers were identified:
Cultural – woodland creation and management is still an alien concept to many crofters – traditionally forestry is the landlord's asset.
Capability & Confidence – a general lack of understanding about the benefits of trees, and a lack of knowledge and skills in woodland establishment and management.

Finance – as noted in the report "this is potentially a show stopper". Crofter and common grazings typically do not have significant financial resources, and are generally risk averse.

These barriers were partially overcome – or rather circumnavigated – during the first flush of plantings after the 1991 Act by the involvement of forest management companies who took the financial and technical burden off crofters and delivered mostly large-scale schemes.

When the new SRDP grants came in, forest management companies moved away from crofter schemes. Grants could no longer be assigned directly to agents, and changes in support for marginal sites meant that many of the larger common grazings schemes were no longer financially attractive.

In response to the decline in planting, the Croft Woodlands Project was set up in 2015 by a partnership led by the Woodland Trust and involving FCS, the Scottish Crofting Federation, Point & Sandwick Trust and Coigach and Assynt Living Landscape. The partnership subsequently grew to include the Orkney Woodland Project, Shetland Amenity Trust, Argyll Small Woods Coop and the Highland Small Communities Housing Trust. This handbook is one of the outputs of the Project.

© Jenny Taylor

A man of vision and determination! Nick Morrison, planting trees on his croft in Orphir that will surely benefit from a little shelter.

The Project aims to address the barriers to croft woodlands by engaging crofters directly in planning and delivering their own woodland projects, and offering them the tools to make that possible. As of the time of writing, the project has assisted approximately 250 crofters and smallholders in the Highlands and Islands to plan, fund and plant woodlands. The majority of schemes have been small and on in-bye or hill-edge land, reflecting not only the challenges of establishing woodland in some very difficult, exposed sites, but also the integrated land management

objectives of the crofters – shelter, biodiversity, woodfuel – indeed the whole range of outputs and benefits articulated in this handbook.

Croft woodlands have received funding support over the years on the same basis as any other woodland creation project, large or small. Recent, welcome developments have incorporated a number of croft-woodland friendly measures into the current grant scheme, and there is an apparent political willingness to reduce the barriers to access to woodland creation support for smaller schemes.

Woodland Crofts

In parallel to the development of croft woodlands, the idea of applying the crofting model to the management of existing woodlands captured the imagination in both crofting & woodland circles. However, it was not legally possible to create new crofts to enable the delivery of this new vision and it took further legislation to secure this option (see box below).

Whilst new legislation allows woodland creation and management as a legitimate crofting activity, it is worth emphasizing that a woodland croft is legally just a croft – there is no distinction in law and the term is primarily a descriptive one. It is useful though to differentiate between such crofts and more traditional crofts and, importantly, more conventional models of forestry.

The definition adopted by The Woodland Crofts Partnership is: *"A woodland croft is a croft with sufficient tree cover overall to be considered a woodland under UK forestry policy"*.

It thus has to exhibit a minimum of 20% tree canopy cover. The definition embraces not just crofts newly created from existing woodland, but crofts that have been planted up under the 1990s crofter forestry legislation, and crofts which throughout their existence have been wooded. Thus, although the development of 'new' woodland crofts has been slow to gather momentum (for a number of understandable reasons), there is an existing pool of woodland crofts distributed across the crofting counties. Current inventory work suggests this pool may total as many as 300-400 crofts.

A small piece of land surrounded by even more legislation than before …

The Crofting Reform Act 2007 introduced the ability for landowners in the crofting counties – or other areas designated by Scottish ministers – to apply to create new crofts from their land, and importantly to withhold certain rights from the tenancy, including the right to buy.

Although the crofter forestry legislation of the 1990s had extended the definition of 'cultivation' of the croft (a condition of a tenancy) to include 'the planting of trees and use of the land as woodland', the 2007 Act introduced the concept of 'purposeful use' as an alternative to cultivation, offering landowners further flexibility to explicitly create a croft for the purpose of being a *woodland* croft.

The wider concept of woodland crofting was thus finally legitimized by this landmark legislation. In 2008 Forestry Commission Scotland (FCS) and Highlands & Islands Enterprise (HIE) jointly funded a Woodland Crofts Officer to support the concept, a role that was subsequently taken on by the third sector partnership we have today – the Woodland Crofts Partnership.

Some new woodland crofts have been created by private landowners, but it is community owners that have been at the forefront of their development. The Case Study "Community Owned Woodland Crofts" in this section gives details of these.

At this time the crofting grant support system remains skewed to conventional agricultural support for crofters and it is still difficult for them to acquire sufficient funding for specifically woodland-management related activity. This is proving frustrating. One of the features of managing woodland on crofts is the expectation

that this should be fully integrated with other croft activity, including livestock production and other cropping or horticulture. Alas, the grant system is struggling to cope with such a holistic approach!

Refer to Section 11 'Woodland design, planning and grant applications'

The current difficulties are at the small scale of individual crofts but assurances have been received from the Scottish Government that this should be resolved in the context of new priorities and support schemes outside the EU.

WOODLAND CROFTING – a vision of the future

To a variable extent, and in some areas more than in others, crofting has been in decline for a combination of reasons that vary in importance from township to township. They include ageing population, drift of young from rural areas and away from traditional livelihoods, along with decreasing incomes from traditional crofting enterprises, especially sheep. On the other hand many crofters have embraced change vigorously through tourism provision and horticulture, for instance. A variety of small crafts, traditional and novel, are proving viable, and remote home working and web-based ventures are more possible than ever.

The ambition of woodland crofting embraces the creation of new individual and clusters of woodland crofts, the transition of traditional crofting to incorporate elements of forestry and, at its most ambitious level, crofts that are predominantly, even exclusively, woodland based. These enterprises would seek to maximise economic potential through a wide range of management types described in this handbook broadly under a definition of agroforestry. They can be isolated, they can be co-operative, they can be small or large. The combined effect, however, will be the creation of the mosaic of woodland and grazings, grasslands, heaths, machair and montane zones that is introduced above and is increasingly promoted by strategy and land use institutions.

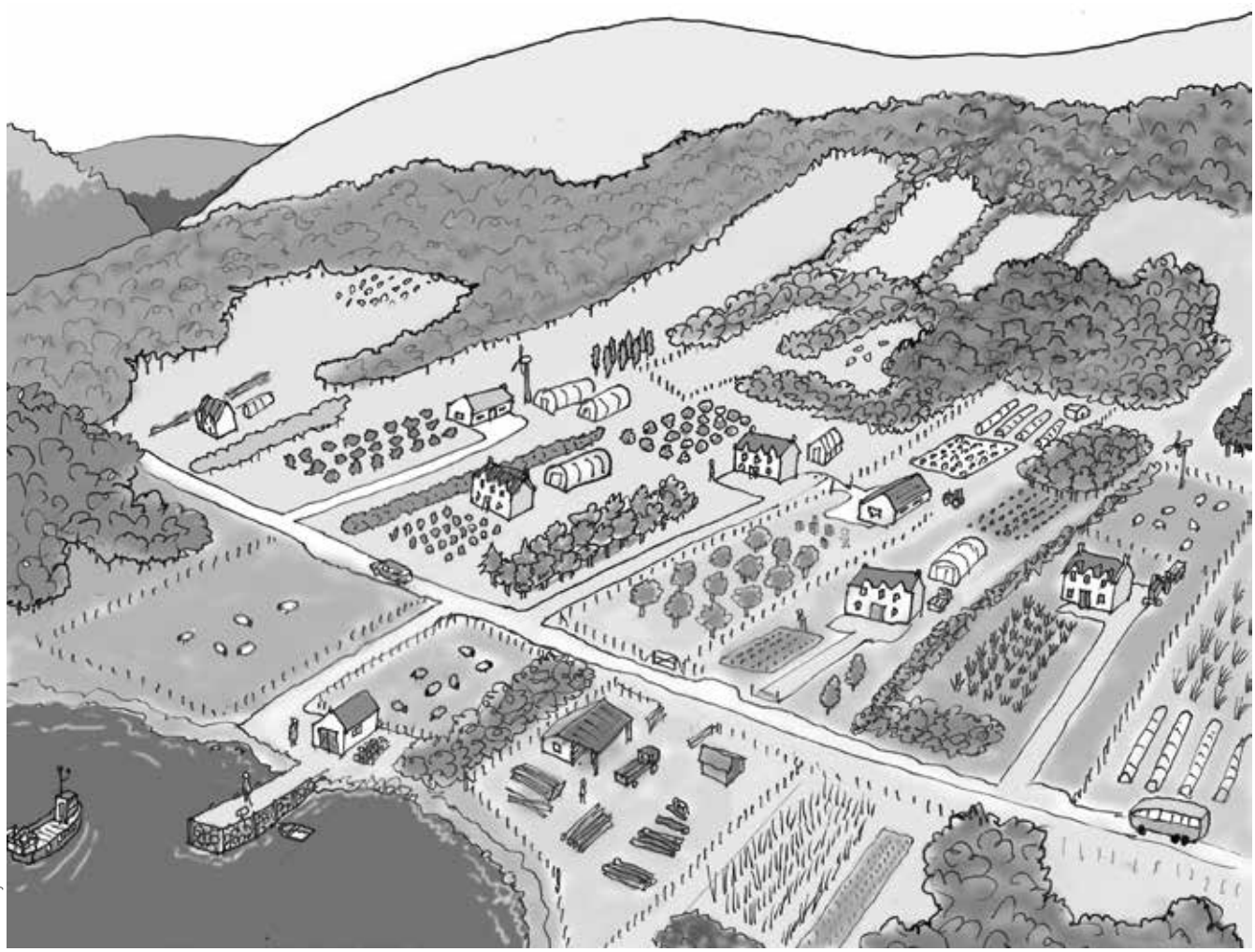
© Duncan Halley

Crofting landscape of the future? Domestic stock and woodland combined with some timber trees and some open woodland for firewood and shelter in SW Norway.

See section 13 'Norway and Scotland: a comparison' to gain insight on landscape scale reforestation of poor and peaty land.

It is clear that markedly different versions of woodland crofting will be appropriate to different parts of the Highlands and Islands with the ideal of more or less trees and woodland in relation to grazing according to local traditions, soils and exposure. In the islands and on the seaboard, the approach to re-establishing a proportion of trees and woodlands tends to focus greatly on shelter provision to crops, stock and buildings. It is clear already however (and the Case Studies in this

handbook serve to illustrate) that even extreme environments, such as coast and montane, which are currently almost treeless, do not preclude tree growth. Trees are almost a prerequisite to horticultural enterprise, besides offering opportunities in commercial fuelwood provision and enhancing tourist facilities.



Idealized woodland crofting township with a balance of grazing and woodlands and a diversity of small scale enterprises, all benefitting from the shelter and natural drainage of shelterbelts and hedges.

Individual crofts will also naturally develop their own versions of woodland crofting depending on scale, resources and local markets. Many existing crofts will be too small to be able to create more than a few shelterbelts. Others, and especially where crofts have been amalgamated or where apportionments have been granted, have much greater potential. Crofts that require most of their in-bye for animal production or hay for winter feed will find it harder to justify loss of grassland, but improvements to the quality of grazing that well-positioned shelterbelts, hedges and woods can provide should be persuasive in many situations, and indeed tree fodder may offer a partial substitute for grass (see Lynbreck Croft Case study).

See Section 9 'Shelterbelts and hedges'.

Such crofts may not see themselves as woodland crofts but nonetheless can become part of a growing township scheme that in its totality exhibits a mosaic of woodland and open ground with grazing and other activities that have arisen by virtue of the cumulative establishment of trees and woods scattered throughout a number of crofts.

The creation from scratch of a complex woodland croft would clearly take decades but some woodland crofts can be created out of existing woodlands and forestry. Even conventional conifer plantations – the most likely type of immediately

See Section 8 'Agroforestry and non-timber forest products'.

available woodland – can provide a useful starting point for the long-term transition to mixed species woodlands and agroforestry that this handbook envisions.

See Section 10 'Home grown timber – markets and uses'.

In time industry will develop around a suitable and appropriately scaled natural resource. Small-scale sawmilling, woodworking, joinery, turnery and coppice crafts can all develop where the woodland resource is of a suitable size and quality. They can form a cluster of co-dependent enterprises sharing some resources and benefiting from joint marketing and premises. Diversity of timber species is necessary, but sufficient scale of production is all-important. Woodland management must be tied to product and market development in a vertically integrated pattern in order to maximise economic opportunities.

The Highlands Small Communities Housing Trust is a registered charity, which helps rural communities secure long term solutions to their local housing needs. It represents a wide range of interests including communities, local government, landowners, crofters and housing associations. By helping rural communities meet their needs for additional affordable housing, it plays an important role in actively supporting their long-term viability. It is a member of the Woodland Crofts Partnership and is central to the development of housing as part of the woodland croft vision.

One of three houses at Kincraig, on land purchased via the Highland Small Communities Housing Trust and their role on the Croft Woodland Partnership. House Design and photography by David Somerville Architects

The woodland croft model sees appropriate rural housing provision as absolutely integral to its full development. A cluster approach to creation of new woodland crofts clearly makes sense. This would not be simply for provision of services and to comply with the usual planning considerations, but could also facilitate the development of appropriate scale joint management and marketing ventures of many sorts. This has ever been the ideal of crofting organisation and way of life. It points the route to its renewal and sustainable development.

© David Blair

Kilfinan Community Forest Company hub built out of timber harvested and milled from their forest.

Where whole crofting communities or grazings committees buy into the concept of a co-ordinated agroforestry enterprise, then larger scale economic possibilities open up. Sawmilling, secondary timber processing, workshops, fabrication, cabin and hut building all become symbiotic and thereby more economically viable. At this larger scale, thresholds are crossed and non-timber forest products such as forest fruits and fungi become more viable, along with wildlife tourism and education, woodland trails and mountain biking.

The way that jointly managed woodlands can bring communities of people together is now well understood and appreciated. Dozens of community woods in the Highlands and Islands testify to this. The very latest development includes Forest Schools, a long standing Scandinavian model of outdoor education, that is resonating with Highland educators and looks set to grow rapidly in the coming years. Woodland crofting is well placed to drive this movement forward, providing

the physically sheltered and welcoming woodland environment it needs to thrive. Apart from its obvious role in keeping our youth connected with the land and local environment, it can help to support timber building and making enterprises.

The Shieling Project in Strathfarrar points the way forward for outdoor educational facilities in our region bringing together history, archaeology and ecology to build new relationships with the land.

WOODLAND CROFTING FOR RURAL DEVELOPMENT

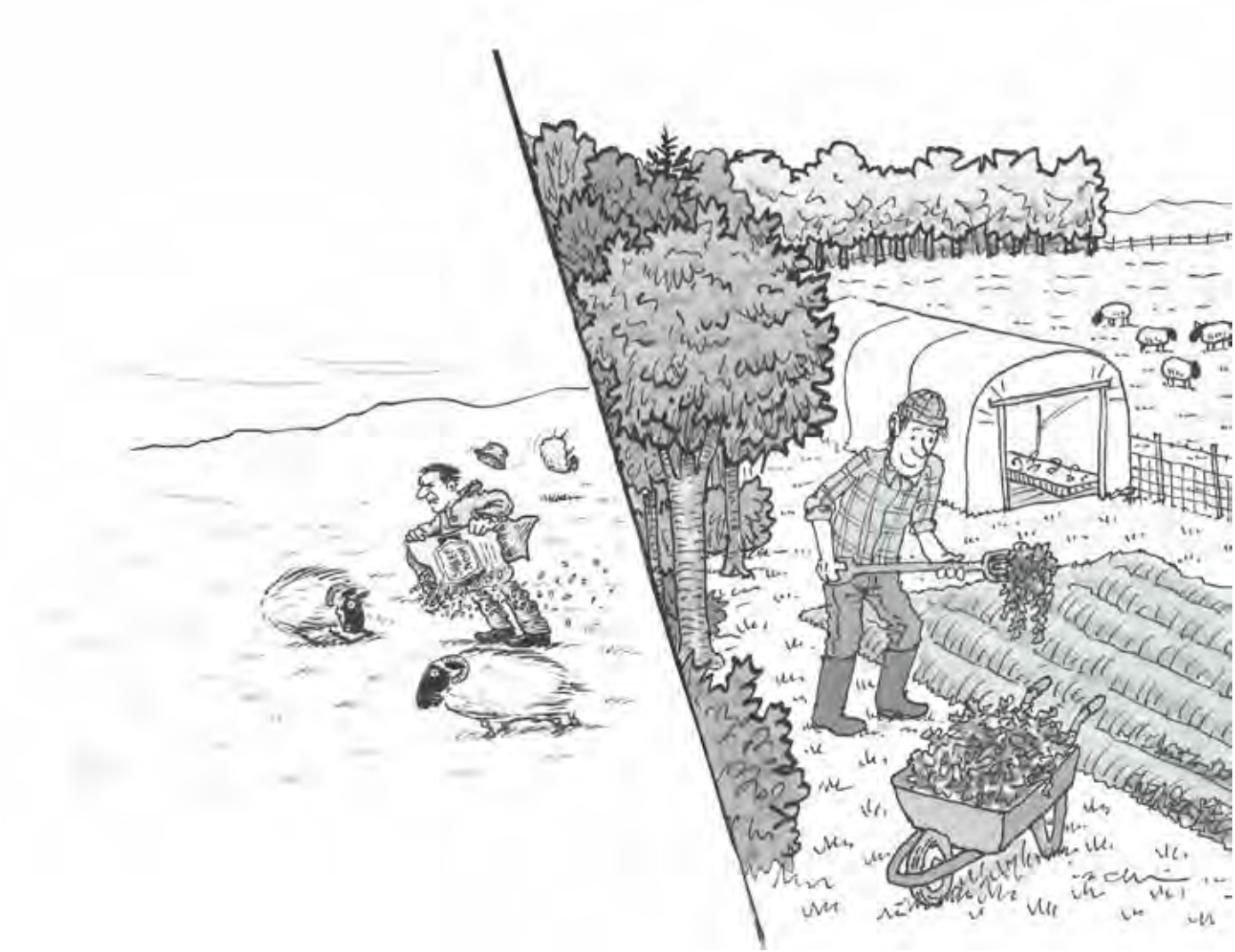
Agreeing the need for a vision is one thing but agreeing the nature of the vision is quite another. Over many parts of our region, you would think the hill was wide enough to accommodate the needs of a great diversity of life and a great many people. And once it was so. By accident and design over the centuries we have depleted the resources of water and land, narrowing our options. We can frame woodland crofting as part of an effort to widen those options once more, acknowledging some repair work is needed to the land and the soil. At the same time we need to acknowledge our wider responsibilities to the agenda of global atmospheric balance. Our culture shifts emphasis with greater global awareness and connectedness. With that comes a need and desire combined to take pressure off other cultures and distant lands. In the future we may need to feed more folk than the land has ever fed or employed.

This handbook places innovative land-use models that utilise trees and woodlands at the heart of an overall vision for rural development. It presents practical routes and models based on principles that land managers of all types are likely to recognize and find sympathetic. The broad principles of sustainability boil down to the maintenance of fertility, a balance between the wild and the domestic, and to the realities of making a living. They are not presented in the abstract but described in relation to products, to employment opportunities and to tangible outputs like natural drainage and pasture improvement. In short they relate to growing healthy food, building houses and creating good work for the next generation.

Although there is no doubt that we have drifted from the land as measured by a number of criteria (eg 57% of Highland children leave the region after school age), successful new husbandries and innovative land use surely offer the best mechanism to attract new blood back. Natural resource based livelihoods need to be more exciting, better paid and to offer genuine and realistic opportunities for house building and the development of rewarding and secure rural lifestyles. Woodland crofting in its widest sense offers that opportunity. It both deserves and requires a package of integrated strategic and policy decisions, backed by appropriate financial support that would facilitate innovative land use practices, promote access to small parcels of land and help develop skills for small-scale horticulture and agroforestry.

In 2017 a new class of recreational accommodation under 30 sqm was exempted from some of the more onerous domestic Building Standards. This could form a basis for the development of appropriate standards for rural worker accommodation and specifically to help develop woodland crofting and woodland management more generally.
http:// www.thousandhuts.org/ wpcontent/ uploads/ 2011/05/180327 -GOODPRACTICE- GUIDE- firstversion- for-website.pdf

Both planning policy and Building Standards could provide a more sympathetic environment than currently exists for development of woodland crofts within plantations and closely associated with woodlands. Building design and access for 'deep woodland' settings is profoundly different from urban design. Some building standards do not encourage the kind of small scale, flexible combinations of accommodation with workshop space most appropriate to woodland crofting. Recent changes to Building Standards to facilitate hutting could provide a starting point for an examination of standards for small and even micro accommodation that would be more appropriate and sympathetic to the lifestyles, finances and skills of aspiring woodland crofters.



Paradise regained on the woodland croft.

CASE STUDY

COMMUNITY-OWNED WOODLAND CROFTS

by Jamie McIntyre

Crofting as a tenure system is widely recognised for the public benefits it can bring: helping retain population in rural areas, contributing to sensitive management of the land, and providing economic opportunities. It is no surprise therefore, that community landowners have embraced the opportunity to create new woodland crofts, in the expectation that these too would help deliver similar local benefits to those provided by more traditional crofts.

The first such community landowner to do so was the North West Mull Community Woodland Company (NWMCWC), which had purchased two former Forestry Commission (FCS) plantations close to the village of Dervaig on Mull through the National Forest Land Scheme in 2006. In response to local demand, NWMCWC created 9 new woodland crofts, totalling 32ha in area, within the 251ha Langamull forest in 2012, all of which were subsequently let.

Interest in following in NWMCWC's footsteps was widespread amongst community woodland owners, but it was Kilfinan Community Forest Company (KCFC) which was the next to develop woodland crofts, creating 3 during 2017 in their forest near Tighnabruaich, also purchased from FCS. Indeed Argyll & its islands appear to be something of a hotbed for woodland crofts, as the next most advanced community proposals for woodland crofts are at Tiroran Forest on Mull.

As pioneers, NWMCWC were first to encounter and address a number of issues which are especially relevant to community owners, largely relating to protecting the community interest. Traditionally, crofting law has been concerned primarily with the rights of crofters, but this now required to be balanced with the interests of the wider community, as landowner and crofting landlord.

Kilfinan Community Forest : the three woodland crofts are in the middle distance clear felled area.

In particular, the right to buy the croft has been withheld from tenancies (a provision permitted by the Crofting Reform Act of 2007). Further conditions have been applied to restrict the right to assign, to ensure that the crofts are maintained as

woodland crofts, and to ensure that their management integrates with the requirements of the Long Term Forest Plan, which governs the wider forest.

KCFC were able to build on this approach. They also developed their own conditions, for example requiring any croft house to be built on croft land without decrofting the site, and thus considering it to be an improvement to the croft.

COMMUNITY OBJECTIVES

Another important issue for community landowners is that of allocations. Here NWMCWC and KCFC took differing approaches. The allocations process has to be open and transparent but nonetheless can, and should, reflect the community's own priorities and objectives. On Mull, the focus was on providing crofts for island residents. KCFC had a specific objective of attracting new people to the community, not least to help maintain the primary school roll. In both cases, the community landlord fulfilled its objectives through the letting of the crofts.

One issue that both NWMCWC and KCFC faced related to the nature of the woodland they had inherited. It comprised primarily unthinned stands of non-native conifer, so ongoing management options were limited and in both cases the croft areas were ultimately clearfelled before the new crofts were created. Though this has meant that crofters have not had existing woodland to manage from day one, it has provided them with a 'blank canvas' to reshape the future croft woodland according to their own priorities. The situation does come with its own challenges for the crofter, however, as restocking and associated costs are not well supported through grants.

A SOCIAL EXERCISE?

It is sometimes felt that creation of woodland crofts by community landowners is purely a social exercise for them, and indeed can result in them foregoing potential income. However, the picture is not black and white: the devolving of management responsibilities can result in cost savings, whilst croft rents represent a guaranteed annual income with few overheads once the crofts are set up. Future harvesting income will of course be foregone, and might potentially have been greater overall. However, a timber crop requires ongoing input and is at risk from weather events, pests & disease, all of which are expected to become more significant due to climate change.

As in all things, of course, it is not either/or – all community woodland owners who have developed, or are developing, woodland crofts do so alongside a range of other activities including mainstream timber production. Indeed, this largely explains why croft creation has to date been relatively slow – community owners have many other competing priorities several of which need to be addressed before thoughts can turn to woodland crofts.

Nevertheless, in comparison with the creation of new 'traditional' crofts by community landowners, it is clear that woodland crofts progress is as good or better, and their place on the 'to do' list of community woodland owners in the crofting counties is now firmly established.

http://woodlandcrofts.org.cp-27.webhostbox.net

CASE STUDY

COIGACH & ASSYNT LIVING LANDSCAPE (CALL) PROJECT

by Elaine MacAskill

Woodland restoration plans are flourishing in a huge area of largely roadless land in the northwest Highlands, thanks to an exciting collaborative project between local communities, private landowners and charities, of which the Scottish Wildlife Trust is the lead partner. The Coigach & Assynt Living Landscape Partnership (CALLP) Scheme covers 635 km^2, making it one of the largest Heritage Lottery (HLF) funded landscape schemes of all time. It started in 2016 and should run until 2021, although the partnership is looking beyond that, at least forty years into the future.

THE WOODLAND PROJECT

The Woodland Project is one of 28 within the scheme and, with a £1m budget, the largest. Its aims are threefold: to aid with the expansion of native woodland in the project area, to better protect and enhance existing woodland, and to seek to connect these patches through a combination of fencing and enrichment planting.

Looking west towards Ben More Coigach – Scots pine coming through on poor but machine mounded ground. The bog in middle distance is left unplanted but there is a broad band of hillside planted above it.

HISTORY OF PLANTING IN COIGACH & ASSYNT

Although 1600 ha of new native woodland had been established in the area in the years before the scheme, the level of establishment had been very variable and so the amount of planting had slowly waned. The period 2005-2015 saw a significant reduction in the amount of new crofter woodland schemes. The main barriers to this were:

- In smaller area schemes, the costs of establishment exceeded the grant income.
- On larger areas of common grazing, where scale was not an issue, cash flow was a major problem as the common grazings typically had no means of funding the establishment costs until such time as the grants could be received, which could take several months.

- Securing a bank loan against grant payments was very difficult without being able to offer some form of security. Very few common grazings have any assets such as a building that can be used to secure a loan and few, if any, individual shareholders were willing to offer up their own houses as security.

WOODLAND TRUST TAKES THE STRAIN

During the project's conception, Woodland Trust was invited to become a project partner. The Trust took on the financial and logistical management. This is a great boon as the Woodland Manager they have appointed is able not only to offer advice but also to take administration away from individuals and community groups. Paperwork is thus made simpler for the tenant or landowner as the Woodland Manager can prepare and submit all of the applications and oversee the implementation and on-going management of the woodland works. The Woodland Trust manages the cash flow and then any woodland work is supported until 2031, thus minimising the risks to individuals and community organisations. Another great advantage is that funding through the scheme can top up government grants where the grant income is less than the costs.

REASONS FOR PLANTING

One motivation for local people to establish woodlands in the CALLP area is it allows them to bring ungrazed land into production, thereby creating shelter. In turn, this can bring about an increase in biodiversity as new, large-scale, habitats are created. There is also financial benefit as planting grants can provide some initial income for townships, with the possible future benefit of available fuel wood.

FENCING

Many of the original crofter native woodlands established in the area through the 1990s and 2000s consist predominantly of pioneer species: native pine, birch, willow and rowan. The 'richer' species have been browsed out, or been unable to survive for lack of enough mutual shelter. The original fences are now porous to deer and other browsing animals. The CALL project with the HLF input, backed up by Landfill Tax money, is able to pay for repairs and maintenance to the deer fences. It also encourages, and at times pays for, deer control so that additional and enrichment planting can now take place to restore the species such as oak and elm that we would have hoped would have naturally been there. We are also looking at introducing understorey and flower species, as some of the woodlands were planted away from existing native woodlands with suitable species, which are thus unlikely to migrate over distances in the foreseeable future.

LOCAL PROVENANCE

Getting access to local provenance seedlings is a major challenge, so CALLP established a Tree Nursery in 2012. Seed is collected within the area and grown on for planting out. The project only takes half of the tree stock at present, so that the nursery still trades elsewhere. As the seed is local, the plants produced are very strong and resilient. The Western Isles Planting Model is followed in some places. It allows sycamore and western hemlock in the mix, both of which are resilient, grow fast and, grown at a high density, offer the possibility of firewood from thinnings within 15 years.

Where possible local contractors are being used for the works, but it is a strenuous job and although the opportunity has been given for training locals for woodland works, the uptake to date has been slow.

Lochbroom Woodfuels, a local social enterprise, undertook low-impact felling of a partly wind-thrown conifer block. They used small-scale machinery to generate firewood for local use. This area will be replanted at a higher density than standard to allow for fuelwood harvest in the future.

COMMUNITY OWNED AREAS

The Assynt Foundation manages a large area of land but, like most community organisations, was short of money. CALLP has helped them establish 100ha of new native woodland within a 150ha enclosure, linking up three areas of existing woodland. Another 160ha are currently being established elsewhere on their land, in a way that is attracting Carbon Payments. It will create an income which can be put into other Community Estate activities, as the Foundation aims to become economically sustainable.

Pre-school planting at Glencanisp Lodge, Assynt foundation. Martin and Ellie Callus (father and daughter) planting native trees.

An area managed by Culag Community Woodland is one that has benefited from new deer fencing through CALLP. Once they have the deer population under control, enrichment planting and woodland habitat works, neither of which would be paid for by a government scheme, will go ahead.

CROFTS AND SMALL LAND OWNERSHIPS

A number of crofting and small land-ownerships have been planted throughout the project area and a lot more are in progress. Much of the land isn't registered. That process is time consuming and the forms off-putting, so people really appreciate help and we're getting quicker at doing it!

RESOURCE SHARING BETWEEN LOCAL PROJECTS

The Woodland Project has a number of match funding options for new planting: Forestry Grant Scheme, Morewoods (Woodland Trust scheme) and the Crofting Woodland Project (also a WT scheme). Over all the 28 projects, HLF funds 60% of costs and the remainder is sought from other sources. In general, the Woodland Project has been able to secure more than the 40% match funding needed and the surplus HLF funding has gone to other projects which have struggled to get match funding. Amongst these are an Artist in Residence, Culag Paths, a community grant scheme, and the crofting project – all of which are very valuable to the CALL area and have a significant impact in the community. There is much cross over with other CALL projects such as the Outdoor and Woodland Learning project, Hazelwood Survey, Woodland Artisan etc. This is where the added community and ecological value come from: the spirit of the partnership demonstrates that the whole is greater than the sum of its parts.

THE FUTURE

There is a legacy period to the project from 2021-2031, where schemes established up to 2021 will be maintained until established. During that period we hope that we will all be able to work together towards CALL's 40 year vision and work out what the next steps should be for the community and environment.

To find out more about the CALL Project and its 40 year vision please see: http://coigach-assynt.org

CALL area from the air.

SECTION 2
WOODLAND ESTABLISHMENT

CLIMATE CHANGE AND WOODLANDS

Scottish CO_2 emissions and woodland targets.

All woodlands and plantations play an important part in the Scottish Government's Climate Change Plan for meeting its greenhouse gas (GHG) emission reduction targets for 2018-2032. Forestry is the only sector that delivers a net carbon emissions sink. In other words the only major form of industry that actively removes carbon dioxide from the atmosphere.

Of the 15,000 ha annual establishment target, the native woodland component target is 3000-5000 ha. All figures from the Scottish Government's Forestry Strategy 2019-2029.

Increasing the area of new woodlands of all types will contribute further to the sequestration of carbon and this is a key driver for the latest Scottish woodland creation targets of 12,000 hectares (of new woodland) per year in 2020/21, 14,000 ha in 2022/23 and 15,000 ha in 2024/25. A major barrier to planting in the Highlands and Islands is the need for applicants to finance the works ahead of the grant payment.

Growing woodlands are particularly effective at recovering CO_2 from the atmosphere. For instance, the carbon stock held in a spruce plantation on a 50 year rotation averages 70 tC/ha compared with grassland at about 8 and heather moorland at about 11 tC/ha. But, particularly relevantly to this handbook, the carbon stock is higher on average for broadleaves and increases for all plantation types as rotation length increases. It is also the case that the less the soil disturbance on establishment and harvesting, the lower the emissions and the higher the carbon stocks will build in both soils and woodland vegetation. These factors argue strongly for the types of establishment and management methods and regimes advanced in this book, especially for continuous cover forestry and for more broadleaved planting of timber species on long rotations.

Woodland and peat.

A good deal of debate in the last few years has centred on the carbon balance of establishing new woodlands on peat. There is little dispute that drainage and any form of cultivation of peats will lead to drying with accelerated microbial breakdown. This causes emissions of carbon dioxide and other greenhouse gases, particularly methane. It has been less clear whether or how quickly the carbon sequestered from the growing woodland compensates for that initial loss. Taking a precautionary approach, Scottish Forestry has advised that new planting should not take place on soils with a peat depth of more than 50 cm. Natural regeneration of native trees and manual establishment techniques on peat up to 30 cm deep is almost certain to lead to net carbon sequestration in acceptable time frames – except where such ground should be conserved for other reasons.

Section 13 describes landscape scale natural regeneration of native woodland on peat in SW Norway and argues that, with lower grazing pressure, this would happen in the Highlands and Islands.

Conserving carbon stocks.

Growing woodlands do have a period of peak carbon sequestration (referred to as the mature phase) after which the rate levels off but the stock of carbon continues to grow (along with the biodiversity in nearly all cases) especially in the root systems and soil. Careful harvesting and management operations using continuous cover silvicultural systems (CCF) will maintain a part of any commercial woodland at 'full-vigour phase' (peak carbon sequestration) while other parts are in the establishment phase.

For more on CCF (or LISS) refer to section 3 'Woodland Management'.

INTRODUCTION

Refer to Scottish Forestry mapping tool https://forestry.gov.scot/support-regulations/scottish-forestry-map-viewer

The act of planting a tree, or even a few hundred, around a croft or smallholding is not difficult and the rewards can be huge. The nuts and bolts of this act come down to choosing a site, choosing species appropriate to that site and implementing strategies to prevent grazing animals from eating your young trees. This section and the next (Woodland Management) will give you all the appropriate basic information. But creating a woodland with a life of its own, designed perhaps to yield a range of crops or provide a variety of services, is something else. Establishing, managing and harvesting woodlands is a huge subject and this handbook can do little more than introduce or summarize the main considerations and operations. Following up some of the key references given at the end of the handbook will lead you into a whole world of silvicultural science. When you return to the simple act of tree planting you will be better equipped to choose sites and species and to ask the right questions of those who can help – woodland project officers, forestry consultants and local SF staff.

The emphasis of this handbook is on smaller woods and plantings. It also examines the regeneration of existing woods and the diversification and integration of woodland with other land uses typical of the Highlands and Islands. It is not intended for land managers wishing to establish what might be called commercial softwood plantations, as they will undoubtedly be employing consultant foresters to advise and manage grants and contractors. A later section does however address the larger mixed and native woodland schemes that grazings committees, community groups, and estates may be interested in. These can offer multiple benefits including shelter, recreation, and firewood.

Section 11 looks at planning larger schemes and grant aid.

Conventional approaches to woodland establishment, steered by grant incentives over the last 30 years, have tended to draw strong distinctions between native woodland and conifer plantations, between so-called productive woodland and, by inference, non-productive woodland. There has even been a distinction between 'productive broadleaves' and non-productive ones. Whilst this has been administratively convenient, our increasing understanding of woodlands is that breaking down these distinctions helps us to move towards delivery of a more complex set of integrated benefits or ecosystem services.

This advancing knowledge of woodlands is also leading us to more sophisticated categories and definitions of woodland types, which can help us make better species choices for planting. In the hands of very experienced users, the National Vegetation Classification (NVC), when used in combination with the Ecological Site Classification Decision Support System (ESC-DSS) is a major tool for establishment of woodlands. It should improve success rates for establishment at the same time as assisting in what has been termed 'native authenticity'. The sophisticated approach to species choice that these tools facilitate will help woodland designers to think more in terms of habitat mosaics. These integrate wooded and open habitats in a more natural way and better accommodate multiple land uses. They certainly deliver enhanced biodiversity.

More on NVC in this section below under 'Site and species selection'.

The Scottish Government's Land Use Strategy with its 'Upland Vision' initiative, also develops and promotes these themes. They can be seen as an attempt to adjust the prevalent land use model to one that is simultaneously more environmentally and economically diverse. In a more equitably utilized land use mosaic, the vast natural resources of the Highlands and Islands are undoubtedly capable of supporting far more employment than they do at present.

SITE AND SPECIES SELECTION

Assessing what type of woodland a site is capable of supporting requires a range of site conditions, such as soil type and exposure to be taken into account. Factors such as site access or existing natural or cultural features may further constrain what can be planted where. These broader aspects of design are considered in section 11 Woodland Design and Planning. Deciding precisely which parts of a site to plant and with which species clearly requires detailed knowledge of the varying site conditions and a working knowledge of species requirements.

Consult the Scottish Forestry Map Viewer at an early stage of all woodland planning: https://forestry.gov.scot/support-regulations/scottish-forestry-map-viewer

Sites for natural regeneration will tend to suggest themselves as being immediately adjacent to existing woodland. But the selection of new woodland sites to be established by planting will often be heavily influenced as much by other land use demands as by the requirements of the tree species to be planted. Very often sub-optimal ground is chosen. This tendency to push trees onto the poorer ground not required by grazing animals or other crops has reduced the vigour and stature of upland woodlands and has indeed lead to false perceptions of potential, particularly with regard to timber production.

Whilst choice of sites may be very limited on individual crofts and small land units (by site conditions and other demands), site and species selection can be a daunting prospect on the extensive tracts of Common Grazings and estates. It will often be necessary therefore to seek specialist help. Nevertheless, for those who want to get into the subject themselves and collaborate with consultants and grant aiding bodies, a working knowledge of land types and the species they can support will be essential.

Mechanically mounded brown earth site to shelter grazings.

With about 40 native species to choose from (depending on definition and qualifications of native) and a further 20 commonly planted exotic species, there is a species or group of species suitable for nearly all sites. However, we need to recognize that some sites are just too exposed, too waterlogged, or the soils too shallow or poor in available nutrients, to support trees. Such bog, heath, machair and higher montane sites may be considered naturally treeless and are valuable for the range of plants and animals found within them. As discussed elsewhere, the long term aim of woodland restoration is to establish a mosaic of habitat types – open and wooded – which accommodates a diversity of land uses including well managed grazing of both wild and domestic herbivores.

Refer to Appendix 1 for tree and shrub species. It gives an indication of 'nativeness' and of the current range of 'exotics'.

The National Vegetation Classification (NVC) describes 18 main native woodland types plus seven scrubs or underscrubs, most of which are divided further to give a total of 73 sub-communities. This system is described in greater detail under 'Planting Native Woodlands' below.

FCS Bulletin 112 Creating New Native Woodlands offers information on the soil types, geology, terrain, and vegetation that might be expected on sites suitable for the establishment of each of the woodland NVCs. For each NVC type, it categorises the constituent tree species into 'major' or 'minor', according to their likely dominance.

The SF map viewer website offers a broad-brush categorization of land suitability for the different woodland NVC types, and a range of 'productive' woodland types in its 'Climatic Suitability' map layer. This is useful as a starting point to see what type of woodland might suit an individual site https://forestry.gov.scot/support-regulations/scottish-forestry-map-viewer

ESC DSS can be accessed online http://www.forestdss.org.uk/geoforestdss/esc4.jsp

Skill and experience is needed, however, to ground truth this information to the habitat types that your chosen planting site comprises. A rigorous method of defining those habitat types is offered by the Ecological Site Classification (ESC) system which FCS Bulletin 124 describes in full. In summary it uses a three dimensional matrix of soil moisture, soil fertility and climatic zones to enable any bit of ground to be characterized and matched to an NVC type.

However, even for experienced foresters and ecologists this is quite a process and does not quite get you to the crunch point of quantifying tree species and numbers for your planting site. As one authority points out …

Worrell, Mackenzie, Clifford: FCS, 2014.

"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 number".

Use of local knowledge and careful observation can work.

The reality for most folk is to seek professional help but, for smaller and simpler schemes, an ability simply to recognize your local tree and shrub species, combined with common sense observation of ground and micro-climatic conditions, can lead to adequate planting prescriptions.

Securing suitable provenance of minor species can be difficult and needs careful advance specification and ordering of planting stock.

Whether relying on this simple and instinctive method or on the sophisticated NVC and ESC-DSS methodology, the most common shortcoming in planting specifications is either over-representation of the commonly known species: alder, pine and rowan, or under-representation of less common species: for example goat willow, bird cherry, hazel, aspen, holly, and wych elm. Availability of suitable provenance of minor species can often constrain specifications in reality.

Worrell, et al as above.

"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".

This analysis underlines the benefits of employing a consultant with a really detailed knowledge of Highland land types and a commitment to detailed planting specifications and supervision. It is to be hoped that diversity both between and within planting specifications will increase not only with increasing ability to identify the

subtly different site conditions but also in recognition of the potential to diversify timber and NTFP products and markets.

On the western and northern seaboard and islands of the Highlands and Islands there are significant areas of exposed and wet heath underlain by widely varying depths of peat. Many of these sites have been heavily grazed and burnt for over a century and they present severe challenges to the establishment of trees or shrubs of any sort. Often the thin peat lies on an even thinner bed of glacial gravel, clays and silts. Where these total profiles are less than 30 cm before bedrock they should not be planted with tree species. Such heathland demands a recovery period with cessation of grazing and burning. A slow restoration of fertility could be attempted through the use of nitrogen fixing gorse or broom although this would not be grant supported.

'Calcifuge mire indicator species' of such severe sites – usually in combination with thinnish and low heather – include bog asphodel or 'bone breaker' *(Narthecium ossifragum)*, hard or heath rush *(Juncus squarrosus)* and cotton grass *(Eriophorum spp.)* often combined with grey-green Cladonia species (a group of lichens) and the liverwort purple spoonwort *(Pleurozia purpurea)* forming a slimy growth on the peat surface.

Planting on peaty sites has come under close scrutiny over the last few years in relation to greenhouse gas emissions and the need to retain carbon sinks. Taking a precautionary approach, Scottish Forestry advises that new planting should not take place on soils with a peat depth of more than 50 cm. Nonetheless, naturally seeded birch, eared willow and Scots pine can be seen on peats of all depths throughout Scotland and bog woodland is recognized as an under-represented habitat type. There are, however, good reasons for keeping extensive areas of bogs that support important bird and plant communities, such as in the Flow Country, predominantly unwooded.

Avoid planting on peat over 500mm deep!

The following subsections look first at 'native' woodland types (naturally regenerated, native and mountain). There is an assumption that the goal is to create new woodland which mimics what might develop on the site through natural processes. The objectives will often focus on biodiversity, ecosystem services, amenity or landscape, but may include other outcomes such as production of timber and other forest products or shelter. Species selection for native woodland creation is normally led by the assumed woodland NVC type for the site.

Following the discussion of native woodland creation, a number of models for planting both native and non-native trees are described, for which the principal objective is timber production. Species selection will be driven by site suitability in the first instance, then by productivity and market potential.

Native and non-native species of proven suitability to the various microclimates and sites found in our region are described, but as the climate warms in the coming years, it may be possible to consider a small number of more thermophilic species for establishment. Two contenders are walnut and sweet chestnut, the latter being a potentially very valuable addition to our range of planting species. Its natural durability and excellent coppicing characteristics put it on a par with oak. However, this warming trend may be countered by increasing cloud cover and rain, in the west Highland mainland in particular.

'New' more thermophilic species.

NATURAL REGENERATION OF NATIVE WOODLAND

Whilst great strides have been made in the last 35 years in the protection of the last remaining scraps of semi-natural woods in the Highlands and Islands, there are still a huge number of unprotected remnants dying on their feet. From the viewpoint of conserving biodiversity – not just the trees but all their associated species – and delivering value for money, the priority should still be on protecting these remnants and creating the conditions for them to fill in and grow outward from their nuclei. These woodlands represent our gene pools and our seed sources and therefore the whole future of our ecosystems.

Saving what is left still the priority.

Ancient alder wood 'dying on its feet' heavily grazed by deer suppressing all regeneration yet easily fenced on flat ground.

Therefore when planning woodland work, whether at croft or estate scale, an immediate priority will be to identify existing semi-natural woodlands (and even small groups of native trees) and to assess their potential to regenerate and strengthen themselves within their existing boundaries. They also need space to regenerate into suitable adjacent ground. While taking account of other land management, this assessment will need to consider the likelihood of successful regeneration in relation to soil and existing vegetation. The main native tree species are prolific seeders in most years even into old age. A damaged or dying tree often throws a great deal of seed for obvious and poignant reasons. However the germination requirements of the light seeds, particularly alder, birch, and willow are very specific. If the ground and weather conditions are not suitable, it is possible that not a single seed will germinate.

Refer to section 13 'Woodland Ecology' for more on mycorrhiza.

When land adjacent to or within existing native woods is carefully examined, you will often find an extraordinary density of tiny, suppressed tree seedlings within the grass sward or heathland. This tends to reduce in density with distance from the existing woodland but may extend hundreds of metres on suitable ground. This suppressed regeneration may vary greatly in age and comprise seedlings of considerable age. Unsurprisingly, such pre-existing regeneration may be expected to 'come away' relatively rapidly on protection by fencing as it will have well-developed root systems along with extensive mycorrhizal associations.

Refer to section 6 'Grazing animals and woodlands' for more on balancing stock and woods.

In nearly all cases, the reason why a semi-natural woodland is declining in vigour or area will be found to be due to grazing pressure, whether by wild deer, domestic stock or a mixture of the two. Very often all that is required to allow woodland to regenerate is to control grazing and browsing for a period of time. A woodland without naturally regenerating trees in its understorey or around its margins is a woodland with no long term future. This applies to the majority of unfenced, semi-natural woodlands in the Highlands and Islands, unless found on small islands and the steepest inaccessible gorges. Current grazing pressure continues to destroy remnants of woodland that could form nuclei for future expansion.

Exemplary cases of reducing grazing pressure.

A very small number of estates have prioritized the regeneration of their semi-natural woodlands and are achieving satisfactory regeneration by reducing deer populations significantly on their ground. Notable success stories of this approach include Creag Meagaidh (SNH NNR), Glen Feshie (private), Abernethy (RSPB) and Mar Lodge (NTS). But these are exceptions.

The majority of upland estates are currently managed for deer stalking. The question of what level of grazing pressure will allow woodland regeneration (without fencing) has no simple answer because it depends at least partly on the amount of woodland and therefore the 'seed rain' in a given locality. Below a certain threshold of seed sources, an endless cycle of last minute woodland resuscitation by fencing and planting followed by slow decline seems destined to continue over significant land areas.

Protecting regenerating trees individually with shelters – note that 120cm shelters do not protect against red deer while 150cm shelters are too tall to be stable in most situations.

One of the main motivations for the regeneration of woodlands is a desire to provide domestic stock, wild deer, or both, with more shelter. Grazing exclusion is therefore only seen as a temporary tool to achieve effectively a single pulse of regeneration of recruits to the existing tree species and none other. It is not seen as a long-term measure, so it is anticipated that deer, and usually stock too, will re-occupy the wood as soon as the fence is breached. The period required to ensure that the regeneration is assured will vary greatly from site to site depending on rate of tree growth but it will be best to maintain the life of the fence as long as reasonably practicable and certainly at least 20 years which is also a grant condition.

For more on 'silvo-pastoralism' see section 6.

In occasional circumstances where red deer are absent, roe deer in very low numbers, and sheep are the principle grazers, it may be possible to utilize individual tree shelters to achieve some regeneration. Very well staked 120 cm tree shelters can be erected on selected self-sown seedlings within or at the edge of woodland. Clearly this will do nothing for understorey or herb layer unless grazing pressure is also lowered, but will at least preserve the integrity of tree species and canopy cover. It is a lot better than doing nothing. More information on suitable shelter types for different species is given below.

Rotational fencing

Planned rotational fencing of larger woodlands is a good approach where maintenance of grazing is an equally important management requirement, whether of sheep, cattle or deer. Taking the long-term approach, it may be decided to fence off convenient areas in say a 15 year rotational pattern. Thus a wood of say 45 ha could be fenced in three compartments and completely regenerated in the space of 45 years, with 30/45 ha or two thirds of the woodland always being available to grazing. The rotational fencing model illustrated in section 6 (page 118) is slightly simpler and doubles the size of an existing remnant wood in two phases over a period of 30-40 years always leaving 50% available to grazing animals.

A pulse of natural birch regeneration immediately after fencing before ground vegetation becomes rank enough to make it difficult for light seeds to reach ground and germinate.

Beware voles!

When fencing off predominantly grassy habitats one noticeable effect is the rapid growth of the herb layer. Aside from its competing effect on the young growing trees, this may well also provide a much enriched habitat for voles. Voles can do enormous damage to young trees by ring barking them close to the ground. This has to be closely monitored. Vole guards, or solid 60 cm tree shelters, should ideally be installed before such damage occurs but they can be quickly provided when and if damage becomes apparent. Once a tree is completely ring barked it will die. This can happen in the space of hours, so vigilance is required on many sites. Healthy raptor populations will help and artificial perches can be installed.

Beware rabbits!

Much the same can be said of rabbits, but no natural regeneration project should be undertaken without rabbit fencing where they are already known to be present.

More on this in this section below under 'birches' and under 'Site preparation'.

Occasionally, where ground conditions are particularly unfavourable to natural regeneration but seed sources are abundant, it may be desirable to carry out gentle site preparation. This usually involves some form of scarification to expose some areas of bare soil. Such treatment may be appropriate in leggy heather or in rank grassland and may be achieved mechanically or by use of animals. Where horse logging is undertaken, the ground will be lightly scarified by hooves and skidded logs. Cattle and pigs have also been used on some sites to provide site preparation prior to fencing for natural regeneration. Mechanical scarifiers can also be towed behind tractor units. This mimics a historical method of towing a badly snedded log behind a horse, perpendicular to direction of travel. It is also an effective technique for bracken crushing.

PLANTING NATIVE WOODLAND

Creating new seed sources

Although protecting and expanding remnants of semi-natural or native woodland is of the highest priority, planting 'native' species gives an important opportunity to establish new woodland in sites remote from seed sources and where site conditions do not readily allow for natural regeneration, even when fenced. New sites will act as new seed sources and contribute to the 'seed load' in the air. In due course these will lead to natural regeneration at any opportunity that the environment allows. In the future this opportunity should be presented more frequently as grazing pressures are reduced and woodlands expand. This should happen when a combination of education and legislation persuade more people to bring deer populations under control.

"In order to encourage more native woodland planting in the Highlands a specific target area for native woodland has been introduced to help meet the Scottish Biodiversity Strategy target of 3000–5000 hectares of new native woodland per year across Scotland". FCS Info sheet

Nativeness needs qualifying in time as well as space.

Defining what is a native species in itself is not always straightforward and certainly requires some qualification in both time and space. Because of the dislocation of woodland history by human influence (anthropogenic factors) and our incomplete knowledge of woodland history in this interglacial period, there is not total agreement on what may be termed native and what exotic. Nevertheless we have sufficient consensus on the subject to characterize native woodland types and the National Vegetation Classification (NVC) can guide us towards appropriate species choice and is used for the purposes of grant aid qualification.

More on 'nativeness' in Section 12 'Woodland Ecology'.

The most familiar woodland types in the Highlands & Islands as defined by NVC are:

- W4 Birch woodland with purple moor-grass: downy birch (with grey and eared willows)

- W7 Alder-ash woodland with yellow pimpernel
- W9 Upland mixed broadleaved woodland with dog's mercury: ash and rowan, but hazel and birch are often co-dominant. Often found in small areas and merging into W11 and W17.
- W11 Upland oak-birch woodland with bluebell: sessile oak, downy birch, wood sorrel. Silver and hybrid birches also frequent and hazel and rowan locally common.
- W17 Upland oak-birch woodland with blaeberry: sessile oak, downy birch, greater fork moss. Often with bracken grasses and ericoid shrubs.
- W18 Scots pine woodland with heather: glittering woodmoss characteristic.

It can be deduced from this classification that the main native woodland types in the Highlands and Islands are – broadly speaking – birch, oak, ash or Scots pine dominated, with varying amounts of rowan, hazel and holly, amongst other species with willow and alder on damp sites. The finer points of what comprises a native or natural understorey may seem somewhat academic when we are struggling just to establish the core element of tree cover in the face of heavy grazing pressures and nutrient poor soils.

As noted elsewhere in this handbook, the notion of 'planting a new woodland' is arguably a flawed concept, as all we are doing is planting the dominant tree species. In nearly all cases no attempt is made to introduce any of the other woodland flora that the NVC distinguishes in such meticulous detail for each type. The idea of 'native authenticity' can therefore only apply in a rather limited sense. What may be more important in choosing sites and species in relatively extreme and nutritionally poor places in our region is simply what is most likely to survive! The establishment of some sort of tree or even shrub cover will be more important than its precise species composition, and indeed, we may deliberately choose pioneer species as nurses to a future different set of species. In this way we may well step outside the conventions of the NVC for the sake of pump-priming long term woodland restoration. It was developed to help, not hinder.

Pioneer species are the first to colonize newly created bare ground whether after glacial retreat, natural catastrophe or human disturbance. They are often adapted to extremes of temperature and drought and capitalize on newly available nutrients. Later they will be outcompeted by other species as the environment develops.

Pioneer species and nitrogen fixing.

The current (grant supported) practice is to try and eliminate gorse and broom from planting sites in case it overwhelms young trees. However, the use of nitrogen fixing species such as alder, broom and gorse to kick-start soil formation and create a more hospitable or sheltered environment for others to grow might be a useful approach in the very poorest sites. Wet sites will inevitably be naturally drained within a few years by alder and willows. This will instigate drier site conditions suitable for other species. Extremely exposed sites will become more sheltered within a few years, which opens up the possibility of establishing less wind or salt tolerant species that might not have flourished at first. On poor and exposed sites it is better to be a little cautious rather than over-ambitious in species choice. Alder, willows and birch will often be the mainstays of planting schemes, with Scots pine added to a broadleaved mix on more sheltered or inland sites. Rowan, with its ready seed dissemination by birds, will almost always arrive on its own as may holly and other heavy-berried species that can fall through rank vegetation and germinate in protected damp soil or peat.

More on nitrogen fixation and nutrient cycling in Section 12 'Woodland Ecology'.

Think mosaics and patchworks.

Identifying the better soils in a larger site comprising a patchwork of heather, bog, degraded or saturated heath takes experience. But it allows the best pockets – very often dominated by bracken or grasses with herbs – to be planted with the more demanding species such as oak, gean, holly and hazel. The majority of ground may well be significantly less fertile or less sheltered than these relatively very small pockets.

The aim on all but the smallest or more uniform sites will be to create a mosaic of woodland and non-woodland or open habitats. This will often be easily

accomplished by leaving the wettest ground and the tops of rocky knolls unplanted, while planting all the drier slopes. Glacial features such as drumlins and other types of moraine and raised beaches are generally formed of relatively freely draining glacial rubble (boulder clays) overlain by varying thicknesses of peat. This will often support good growth of Scots pine but an over-representation of Scots pine, especially in coastal sites with high exposure, has been noted in native planting schemes and such sites are often more capable of supporting good birch or even oak growth.

For more on grazing amongst trees see section 6 under 'silvo pastoralism'

If the planting is successful, some trees will start to seed at what may be a surprisingly early age, often inside 10 years. Clearly this may then lead to some natural regeneration within exclosures, although the development of denser ground vegetation may sometimes militate against that. In the longer term though, with a return of appropriately light disturbance by herbivores, there will be further pulses of natural regeneration as the woodland becomes more 'naturalised' and in balance with herbivores.

Native woodlands can be productive in many ways.

The most common objective for native woodland establishment is probably a mix of conservation, landscape and recreation, combined in many land managers' minds with the promise of shelter for buildings, horticulture, domestic stock and deer. It has been said that there is little encouragement or guidance for the consideration of how to integrate such woodlands with other productive objectives. This limits possibilities and perpetuates compartmentalization of woodland management types. There is no good reason why a 'native' woodland should not also have productive management objectives such as firewood, coppice products, or quality hardwoods. Following sections of this handbook look at all these options, which may involve entirely native species or mixes of native and exotic species.

See section 8 for more on integration of several management objectives.

Clearly the possibilities are defined partly by the physical scale of sites and their soil diversity but also the scale of ambition and available management resources. But the aim where possible will be integrated habitat networks or mosaics, creating the diversity that will provide greater resilience to disease and climate change as well as greater long term adaptability to the evolving needs of owners and local communities. Many and varied types of woodland and its possible uses are discussed in Section 8 Agroforestry and NTFP of this handbook which, it is hoped, will encourage some people beyond the traditional management objectives of conservation, deer or sheep, and into some creative new combinations.

More on genuinely sustainable woodlands in Section 12 'Woodland Ecology'.

It goes without saying that all tree planting schemes in the Highlands and Islands need appropriate types of fencing to keep out red and roe deer (sika deer in places) as well as sheep and possibly rabbits. The endless cycle of fence – plant -decline – fence – plant – decline will continue until we put in place balanced land use systems that can accommodate both the needs of grazing animals and self-regenerating woodland networks. Until that day, properly developed woodlands within a fully functioning ecosystem will never be created.

TREELINE AND MOUNTAIN (MONTANE) WOODLANDS

Variable treeline

The altitudinal limits to tree growth are hard to define. Tree species can sow themselves and survive in a highly stunted, almost prostrate form, sometimes hundreds of metres above what is often called the timberline – the supposed limit to commercial timber production. Nowhere is the definition of a natural treeline more difficult than in the Highlands and Islands with the area's highly variable exposure over short distances from west to centre, from east to centre and from low to high ground. Nonetheless, the natural treeline is estimated at about 650m in the central Highlands to around 250 metres on the west coast. However in the Western and

Northern Isles as well as parts of the mainland coasts and smaller islands, the treeline may be at or close to sea level.

Treeline and mountain (montane) woodlands form a major part of mountain landscapes throughout central Europe and Northern Scandinavia where they constitute exceptionally species diverse habitats teeming with bird and insect life. Transition zones such as these are known by ecologists as ecotones and are noted for their bio-diversity with not only a mix of two ecotypes but often an overlaid or additional range of mobile species taking advantage of both. In Norway for instance this zone is notable for dense breeding populations of brambling, bluethroat, willow warbler, redwing and Lapland bunting. It also supports black grouse populations and many insects that are the food source for the nestling birds.

Despite, or perhaps because of, an almost complete absence of surviving natural treeline communities in Scotland, considerable interest has focused on them in the last 30 years as representative of a probably significant component of our upland ecosystems that we should be looking to restore. Long running 'mountain woodland' trial plots in Scotland are on Ben Lawers and at Inchnadamph in Wester Ross where fenced enclosures provide remarkable insight into the potential of high altitude scrub and shrub growth.

See mountain scrub action group for more on mountain woodlands www.msag.org.uk refer particularly to Best Practice Guide 3 for site requirements http://www.msag.org.uk/uploads/4/0/7/3/40732079/bpg3_site_and_species.pdf

Wind shaped holly close to West Sutherland coast where 'treeline' is almost at sea level.

Rather than forming an abrupt line at which tree growth halts, there exists a transitional zone (an ecotone) or band where woodland diminishes in height and merges with shrubby or scrub species and then finally with true dwarf heath communities. But this whole transition zone may be compressed and jumbled up in the space of a few metres in the highly exposed and coastal habitats common in the west and north areas of our region.

Despite this inevitable mixing up of habitats or 'ecotypes' and lack of clear boundaries, it is convenient to divide treeline woodlands into two main zones:
(a) scrub woodland where the hardiest tree and shrub species still survive: birches, rowan, hazel, Scots pine, willows and juniper.
(b) montane scrub (in the montane or alpine zone) where only the woody shrubs survive. These are a number of willow species (many of which are rare or very rare), juniper, and dwarf birch (a distinct species of birch). This zone will itself merge into alpine heath in some places.

Appendix 1 lists these native willows.

It is clear that these rich treeline habitats must have existed in the Highlands of Scotland at peak forest but that they gradually declined along with the declining

See Section 12 for more on peak forest.

lower forest. The pattern of taking the cattle to the hills in the summer (along with much of the human population) was as well established in Europe and Northern Scandinavia as it was in Scotland (the shieling system). It is possible that the smaller scale of the hills, and the associated easier accessibility of what is often a lower treeline zone in Scotland, contributed to the ease of its destruction here, as extensive areas of mountain woodland and scrub persist abroad.

© Duncan Halley

Typical mountain or scrub woodland in SW Norway comprising mixed blaeberry, cowberry, crowberry, bearberry and wooly willow with some birch.

Building on remaining high altitude fragments.

Putting even a wee bit back appears to be a lot harder than removing it, for a number of reasons. The shieling system was one of intensive stock management where the movement of cattle was carefully controlled not just by families but by dyke systems sometimes crossing whole glens. Since the introduction of sheep, stock movement has been far less controlled and sheep gain rapid access to the whole hill including the treeline and montane zones. Although cattle and sheep numbers have both declined in recent years, they have more than been made up for by increases in red deer numbers. Deer are now the main obstacle to the regeneration of treeline and all other types of woodland.

© B Planterose

A lone tea-leaved willow (Salix phylicifolia) *bush clinging to an island of rocks in middle of a burn on an otherwise treeless heath in the Fannichs, Wester Ross.*

Establishing new treeline woodlands – the practical realities.

In practical terms the opportunities for new treeline woodland establishment and regeneration may be very limited due to high grazing pressure of deer and or domestic stock. Fencing high altitude areas presents particular problems as well as hazards to birds such as grouse, not to mention the landscape and access issues that deer fences give rise to. But without fencing, regeneration will only be possible where sheep are absent and deer are culled to the levels that allow it.

Refer to provenance and origin in sub-section below.

As with other native woodland establishment, it will be easiest and most appropriate to build on existing fragments wherever possible, as they give a source of appropriate provenance seed. Many of the surviving high altitude and treeline fragments are to be found on cliffs and in gorges and it is here we often find the species that can form treeline communities. They will seldom hold all, or even most, of the species we might ideally be looking to regenerate, especially the rarer species of willow. Deficiencies in species can however be made up for by planting.

Applications for grant aid of new treeline woodlands has to be well supported by verified information including DAMS and ESC and will therefore most likely require professional input. FCS Guidance note No 13 gives the detailed requirements.

Selection of local provenance stock will be particularly critical if planting. Planting densities need to be relatively high to achieve rapid mutual shelter. Target stocking density for grant aid is at least 500/ha with plants at 2-3m spacing. Site selection will be more critical than ever and probably involve identifying micro-sites or pockets of better soil within a relatively rocky or boggy environment. The principle is to establish foci of shrubs, which may be able to expand naturally if grazing pressure can be kept to a minimum over an extended period of time. This sort of work takes a special commitment.

If looking to establish scrub woodlands in exposed coastal locations, you could consider gorse and broom for nitrogen fixation and salt and wind resistance. The range of native species for mountain woodlands or any of the list of exotics given at the end of Appendix 1 could also help establishment. However it has to be noted that most of these suggestions are likely to fall foul of current grant requirements and gorse and broom may be required to be removed.

PLANTING BROADLEAVED AND CONIFER WOODLAND FOR HIGH VALUE TIMBER

Consult the Scottish Forestry Map Viewer at an early stage of all woodland planning: https://forestry.gov.scot/support-regulations/scottish-forestry-map-viewer

Whilst standard commercial forestry models of Sitka spruce and Scots pine will continue to be appropriate for some land units within economic distance of big mills, it is often uneconomic to apply these models to more remote parts of the Highlands and Islands. In such areas it may be more economically and socially appropriate to consider local markets for firewood and higher value species that can be processed locally, adding value within our communities and supplying a mix of local needs and niche markets. Some of these niche markets may indeed be at a distance but the value will have been added locally.

Timber processing for local needs.

Firewood and coppice are obvious expanding markets in the Highlands and Islands, with great potential, and do not have to occupy the best of sites. In general terms, however, it should be recognized that the better the site for the chosen species, the faster the growth and the better form it is likely to have. We cannot expect to grow well-formed productive trees on the poorest ground and to use better ground inevitably requires adjusting the balance of grazing with woodland on any given land unit. The integration of woodlands and grazing is considered in some detail in Sections 6 and 8. Here we focus on the silvicultural aspects of establishing higher value species of both conifers (softwoods) and broadleaves (hardwoods).

See Sections 4 and 5 for more on coppice and firewood.

Whether starting from scratch planning a new woodland, or considering restructuring existing woodlands with quality timber production as the objective, it is wise

to consider both existing markets and any possible local uses including your own. There are small and highly discerning markets within the Highlands and Islands for high quality Douglas fir, larch and hardwoods for structural timbers, furniture, flooring and boat building. Estate and croft demands for fencing and external cladding might steer species selection towards the durable species while an interest in future development of secondary processing or manufacturing might suggest planting hardwoods. There may be existing local industries importing specialist timber that local woodlands could easily supply and such demand may influence species selection for new plantings.

More on uses for different timbers in Section 10 'Home-grown Timber'.

Whatever mix of species is chosen to plant, the quality of the logs eventually harvested will determine the economic viability of the woodland and therefore its longer term future. That quality will be determined not just by the site conditions but the degree of careful management (the silviculture) that has gone into the woodland over a period of many years. Establishment and the early years will be the most important but ongoing silviculture can significantly influence not just the final log quality of a rotation but the income from thinnings.

High quality hardwood logs fetch high prices. Example sawn and air dried prices are given in section 10.

The most valuable part of a tree for timber is the butt log. A clean straight hardwood butt log of 3m length can fetch as much as £1600 before drying and sawing! Though a more realistic average price is perhaps £300 to £500/tonne. The most important aspect is to be free of 'shake' (long splits down the grain manifested on the surface as a line down the stem) and asymmetric heartwood that causes subsequent warping and twisting during drying.

Different types of silvicultural regime, including continuous cover management, which is often highly suitable for production of high value timber, are examined in section 3 Woodland Management and Harvesting.

CONIFERS (SOFTWOODS)

Sitka spruce

Before examining the higher value softwoods, it is important to say that Sitka spruce may be the easiest softwood to grow, manage and market on many sites provided that access and distance to mills are reasonable. The high value of other conifers examined below is most readily realised either where a definite local market such as a small to medium-sized sawmill or a specific on-site use is identifiable.

The supremacy of larches for external local uses.

The two most familiar high-value softwoods which grow well in the Highlands and Islands are larch and Douglas fir. Two species of larch, European and Japanese, have been planted in our region and their hybrid, which has been the prevalent choice for many years, although European larch has also continued to be planted. Due to the natural durability of larches, logs fetch premium prices. They can be processed into fence posts and rails, decking and cladding without treatment or secondary processing. This makes these species the most useful on the croft or estate as well as the most readily marketable of all the higher value timbers. If you have suitable ground for larch, it is a big contender. However, the infestation of *Phytophthora ramorum* has currently brought new establishment to a near standstill throughout the country. Hopefully this situation will improve again in the future and, in the meantime, we should use the situation to consider alternative, durable, high-value species.

Phytophthora ramorum – a fungus-like pathogen – has been recorded as far north as Skye on the west coast. Follow the FCS Statutory Plant Health Notices map for updates on its spread.

Establishing larches by planting.

Larch is considered as a relatively difficult species to establish with mortality sometimes as high as 25% in the first year. Survival is best on more sheltered sites with moist to slightly dry soil conditions. With regard to soil nutrients, it has quite a wide tolerance. The stocking density target for larch is 2500 stems/ha at year five. Larch plantations should be carefully thinned to ensure a good crop of large stems at between 60 and 80 years depending on site quality.

The other high value conifer that grows well in many parts of the Highlands and Islands is Douglas fir, the heartwood of which is rated as 'moderately durable'. It scores a little over larch in the natural dryness of its heartwood and its slightly stronger bending characteristics. It finishes beautifully to a reddish tinge and often comes off the saw straighter than larch.

Douglas fir: strong, straight and dry.

More on post & beam design in Section 10 'Home-grown Timber'.

Establishing new plantations of Douglas fir, like larch, can be quite difficult but for different reasons. It is a shade tolerant species, naturally regenerating in its home-land of western Pacific USA and Canada under existing deep canopy. It therefore prefers at least some side shade and reasonable shelter and is best established in smaller groups as part of mixed plantings or as part of restructuring. It goes without saying that it is ideally suited to CCF in either small coupe or selective regimes. It will not tolerate wet or peaty ground and is said to be a favourite food of deer. This makes it necessary to exclude roe deer as much as red or sika.

Establishing Douglas fir.

More on continuous cover forestry (CCF) in section 3 'Woodland Management'.

A wide range of conifer species has been planted throughout Scotland in the last 200 years. Even within the Highlands and Islands there can be found examples of large and healthy exotic conifers, which have raised the hopes of foresters and still beg the question of why we are not more adventurous in our plantings. The answer is probably that although a variety of firs, cypresses and cedars (mostly though not exclusively from the Pacific coast of Canada) do all grow in our region, they do not produce timbers that show any significant advantage over those conifers already grown in abundance in Scotland.

The so-called 'minor conifers'.

Two other conifers do, however, produce timber with recognized niche markets and these are Western hemlock and Western red cedar. The former is prized for internal joinery as being stable and attractive in colour and grain. It requires shade and shelter for good establishment and will not thrive on peaty soils. There is some scope for admixtures with Sitka spruce and it should be considered in re-structuring operations. It should be noted, however, that it regenerates freely in some site conditions which, although a useful quality in CCF regimes, constitutes an invasive problem in others.

Western hemlock (*Tsuga heterophylla*)

Western red cedar (WRC) does bear some consideration, perhaps increasingly so in the event of an ongoing decline of larch due to disease. This species would substitute well for larch in the cladding market, and also for other external uses, without preservative treatment. There are examples of plantations in Argyll and on the east at Novar near Evanton (44 years old and GYC24) and Darnaway near Forres. Home grown WRC has been sawn in the UK for decking, cladding, glasshouse framing, shed and beehive manufacture. It is the cladding and roofing material of choice on the Pacific coast of Canada and the USA where it is hand or machine cleft into shakes (shingles). However there is some evidence that plantation-grown material from Britain is not as durable as old-growth Canadian material. This may just be a result of its considerably younger age. Like all softwoods it has less durable sapwood that should be discarded for external applications.

Western red cedar (*Thuja plicata*)

General Yield Class (GYC) is the standard measure of potential timber volume in m3/ha/yr of a given species on a given site.

It is a shade tolerant species, unsuitable for establishment in open or exposed sites, as it prefers deep, relatively fertile, soils. It is definitely not interchangeable with larch in terms of site requirements. Optimum conditions for establishment will be as enrichment interplanting or underplanting within mature conifer stands of open structure. Alternatively it could be established in small felling coupes on more sheltered sites, with adjoining retained stands of other species. In other words, it is another great candidate for CCF regimes. It may be possible to create suitable conditions for its establishment by using 'nurse stands' comprising faster-growing broadleaves (see immediately below in Mixes).

CONIFER/BROADLEAVED MIXES and CONIFER MIXES & ROTATIONS

Mixtures of conifers and broadleaves are possible but require detailed knowledge.

The establishment and management of intimate mixtures of conifer and broadleaved species represent a diametrically opposite silvicultural approach to that mostly pursued by commercial forestry in Scotland these last 100 years. There is not room here to go into the multi-faceted economic, political and environmental reasons why forestry is as it is in Scotland today. But we do need to underline alternative approaches that may be more appropriate to more locally controlled natural resources because they offer greater employment and greater diversity of useful products, as well as enhanced ecosystem services.

"There is good potential for combinations of Sitka spruce (SS) with productive hardwood species, principally on the better part of its site range (valley sites). Species in the genus Acer appear to have the greatest potential and deserve more trials e.g. sycamore (Acer pseudoplatanus) from Europe and big-leaf maple (Acer macrophyllum) from the Pacific Northwest". Scott Wilson

See section 10 for more on processing higher value timber.

It would be a mistake to pretend that managing mixes of tree species for timber and NTFPs is anything other than a highly skilled and labour intensive operation but is that not precisely what our economy and culture should be aiming at and all the more so in the remoter parts? This type of forestry is dependent on the production of several products, some of which need to be of high value from relatively small land units. This takes time to develop. Existing plantations that are uneconomic or marginal to clearfell offer great opportunities for restructuring into continuous cover mixed species woodlands.

It would also be a mistake to pretend that this type of forestry does not require significant investment in appropriate machinery and training. Removing large single stems or small groups from within woodlands requires considerable skill and the right technology. It also demands higher value markets for the timber.

Mixes to consider include: Western red cedar (WRC) with oak or sycamore (or beech in more neutral or alkaline soils); pine, birch and aspen managed for timber; Sitka spruce and sycamore with Douglas fir (DF) and Western hemlock; birch as a nurse to WRC or DF. There are many others but grant eligibility would need to be established on a case by case basis.

Broadleaved woods for high value timber need not be large.

'Nurse' implies removal of that species once it has performed its role in providing shade and shelter to the slower growing and presumed higher value 'crop' species. When sites and species are well understood, all sorts of permutations arise. Alder is so fast growing on damp sites it could be considered as a nurse to many less light-tolerant species and those requiring drier ground that the alder will gradually provide. Currently, however, a criticism of the grant support system is that it does not support many of these mixes. Indeed it is not yet well tailored for continuous cover forestry and the degree of flexibility (and sometimes experimentation) required to develop the wider range of productive and biodiverse woodlands that this handbook proposes.

BROADLEAVES (HARDWOODS)

Consult the FCS Map Viewer at an early stage of all woodland planning: http:maps.forestry.gov.uk/imf/imf.jsp?site=fcscotland_ext&

The Highlands and Islands encompass a huge range of microclimates, soil types and levels of exposure and the best of these can support broadleaved trees of a millable size and quality. Site and species selection, as well as long term commitment to careful management, are critical to growing hardwood timber suitable for joinery and furniture markets. It has to be recognised that outside of wealthy estates with their own foresters, few land managers will feel that they have the time, finance or perhaps knowledge, to embark on such an ambitious endeavour. But it is perfectly possible to start at a modest scale by planting the potentially larger broadleaved species as part of more familiar woodland establishment

formulae. In this way we should aspire to learn and experiment with the establishment and management of productive broadleaves as part of an evolving vision of more diverse and productive woodlands.

Relatively fertile, sheltered sites will be essential to grow good timber.

Suitable broadleaved timber species for our region from a climatic viewpoint include oak, beech, sycamore, birch, aspen, ash, elm and gean. We could also include lime and maple. As with the conifers, each species has its particular site requirements. It will sometimes be quite difficult to make species choices as it is assumed that only relatively sheltered and fertile sites will be chosen which may indeed be suitable for any or all of the above species. Soil pH and moisture content will also need to be taken into consideration as each has preferred ranges and these are outlined in Appendix 1.

Refer to Appendix for list of trees and shrubs – native and exotic.

Not all the species suggested here are currently considered for grant but, as with conifers, unorthodox proposals can be considered on a case by case basis.

For grant purposes, planting spacing is generally considered to give a minimum of 1600/ha for native woodland but should be higher for productive broadleaves. Birch needs to be planted or regenerated at much closer spacings (see this section below). Thinning, pruning and re-spacing are aspects of management which are discussed in section 3. All broadleaves are highly palatable to deer of all species as well as to rabbits and voles. Complete exclusion of grazing and browsing animals will be necessary, at least until trees are well above browsing height. Loss of the leading shoot in a tree being grown for timber constitutes severe impairment of quality and such individuals will be weeded out at first thinning if not before. Deer pressure over much of the Highlands and Islands acts as the major constraint on growing broadleaved trees for timber. Whilst red and Sika deer can be excluded by maintenance of a high standard of fencing, roe deer are wont to find a way through all but the very best fences. Assiduous and prompt culling is required where roe pressure is high.

The deer problem – again. Total exclusion of deer, including roe deer, is necessary for growing timber broadleaves.

Oak, birch, hazel and alder are the main native trees with perhaps the longest tradition of timber use in the Highlands and Islands. Establishment and management of hazel coppice is dealt with in section 4 Coppice Management. Birches are considered separately below. Alder will be mainly established in a riparian context (see section 7 Woodlands and Freshwater) and can also be coppiced.

See section 10 for uses of broadleaved timber.

OAK

There are two species of oak native to the Highlands and Islands: the sessile oak *(Quercus petraea)* and the pedunculate oak *(Quercus robur)* but the two species hybridize readily. In the most general terms, the main species of the north and west Highlands is the sessile oak and of the east the pedunculate variety, which grows well in north Aberdeenshire and further up the eastern seaboard into Sutherland. However in the Sunart woodlands, for instance, both species of oak are found, so a simple east-west division of the two species distributions is not correct.

The distribution of our two oaks spans the whole mainland of the Highlands.

Their distribution reflects the differing site requirements: sessile oak likes well-drained soils and tolerates acidic conditions. It is quite tolerant of waterlogged soils and tolerant of exposure and strong winds. It can even survive (albeit in very gnarly forms) in salt laden winds as evidenced by remnants clinging to western mainland cliffs. At Loch à Mhuillin NNR in west Sutherland it grows almost down to the shore and within 100 metres it develops into trees of about 15 metres in stature. Pedunculate oak is suitable for heavy clays and loams, but not acidic soils. Wet but not water-logged soils are tolerated. It is thought to be not as shade-tolerant as sessile oak but neither is more than moderately so.

The so-called 'Western Atlantic oak woods' form a stronghold and distinct NVC woodland type W17 (upland acid oak-birch woodland) or W11 (upland oak-birch woodland of medium fertility). There are significant remaining oak woods in Argyll,

The Atlantic woodlands of the Highlands and Islands are sometimes referred to as Scotland's temperate rainforest.

More information on oak in section 4 'Coppice' and Section 6 'Silvo-pasture'.

Lorne, Morvern, Ardnamurchan, Lochaber and Wester Ross, many of which were managed during the period 1650 -1850 as industrial oak coppice.
There is very little information on the establishment and management of oak for timber in Scotland, let alone the Highlands. The most relevant discussion of the options for 21st century oak management in our region is to be found in a report commissioned by Highland Birchwoods: The Sunart Oakwoods: a guide to their sustainable management by Peter Quelch. But even this does not deal with how to plant a new oak woodland from scratch!

We have to look to Ireland and England for examples of oak being planted for timber in our times. In the latter part of the 20th century Norway spruce/oak mixtures were favoured and, towards the end of the century, emphasis moved towards broadleaved mixtures. In Ireland since 1997 pure oak has been planted at the very dense spacing of 6600/ha or else in alternate lines with larch or Scots pine at 4550/ha. The conifers protect the oak from exposure and extremes of temperature as well as suppressing the side branches to promote clean timber at least in the butt log.

Scott Wilson (2011), Approaches to the retention of timber potential when restoring or enhancing PAWS sites.

"Oak timber production is possible in future, using low-impact silvicultural methods developed for the Sunart/Morvern oakwoods".
"In some situations, 'nursing mixtures' with pine, red cedar or another conifer can be used to establish a quality crop of native oak or ash, prior to planned removal".
Scott Wilson

Even in the more favourable southern climes it will usually be 100 years before 'mature' oak trees are harvested, although thinnings throughout that period can also produce useful timber. From this point of view it will be more economically viable to plant oak in mixture with faster growing species (such as birch, ash, gean or sycamore) that can yield income at an earlier stage. The art and science of management throughout this long period could be the subject of a book in itself but we return briefly to it in the next section of this handbook.

ASH

Refer to important legal restrictions on the planting of ash due to the disease 'Chalara'.

Ash is native to most areas of the Highlands and Islands, although it prefers free-draining, moist, fertile soils that are fairly neutral or alkaline rather than acidic. Despite its typically thin branching habit, it is reasonably wind-resistant and can put up with a degree of salt in the air so long as it has rich enough ground to grow on.

On the right site ash has always grown vigorously when young, putting on a surprising amount of height and weight each year for a tree that comes into leaf late and loses leaves promptly in autumn. The timber is strong, versatile and offers excellent firewood which would make ash an attractive proposition but for one thing. An epidemic of *Hymenoscyphus fraxina* (known more generally as 'Chalara') is sweeping the British Isles. What were thought to be buffer zones in Scotland have been penetrated by the fungus and new planting of ash is currently prohibited. Natural regeneration of existing healthy groups is to be hoped for. Older trees resist the fungal attack longer, and it is thought some will survive it. Monitoring and seed-banking of the full genetic range of the species are being undertaken by SF in the hope that the situation will improve in the future. In the meantime, the advice is to find alternative trees for new planting and to remove young ash trees that are infected and replace them with different species.

ELM

Of the three main varieties (and many more crosses) of elm in the British Isles only the wych elm *(Ulmus glabra)* is native to Scotland. Unlike its English cousins, it grows from seed rather than by cloning. This makes it genetically more diverse,

which gives it a degree more resistance to Dutch elm disease. This scourge is still taking out trees in northern counties of England, although in the south of Scotland the epidemic seems to be abating. Young elms are noticeably living past the 14 or so years they tended to last when the disease was at its height.

Wych elm will grow on most well drained and fertile mineral soils. Providing you do not live in an area where Dutch elm disease is still rampant, it can again become part of a mixed planting. It is wise, however, to space individual trees well so that if one becomes infected it will not automatically infect neighbouring trees via their root systems. It is fairly light demanding, so is suited more to woodland edges than deep within plantings. It roots well, so the stems are reasonably wind-tolerant, even though boughs of older trees are easily shed.

SYCAMORE

This grows well in many parts of Scotland and produces a valuable timber. Easy and quick to establish on quite short rotations, it is quite shade tolerant and the species often colonises the understorey of broadleaved woodlands. Cold-hardy and tolerant of exposure and salt spray, it is therefore suited to many sites in the Highlands and Islands. Sycamore grows on a wide range of soils but does best on deep, fresh to moist free-draining soils of medium to rich nutrient status. It is not suited to peats, heavy clays and poor sandy soils, as it does not tolerate water-logging and flooding, and is not drought tolerant. Improved material from breeding programmes may become available. Seed from good quality British stands or selected stands in western Europe should be preferred. It is subject to bark stripping by grey squirrels, which are effectively absent in the Highlands and Islands. It should not be planted under existing native woodlands due to its ability to over top many native woodland types and then suppress most regeneration.

GEAN

Also known as wild cherry *(Prunus avium)*, this species can produce valuable timber when grown on the better sites. It is quick and easy to establish and flourishes in short rotations. This is a pioneer, light-demanding species which spreads through seed and suckers. Cold-hardy and frost tolerant, it does not tolerate exposure and is sensitive to drought. It grows best on medium to very rich soils of fresh soil moisture status, including on more calcareous sites. Gean is not suited to dry or water-logged soils, as well as those of poor soil nutrient status.

It is usually grown in small or very small groups as part of mixed broadleaved design. It can be prone to canker and aphid damage. There is limited knowledge of provenance variation, so planting stock from identified sources should be preferred; one well-known Scottish nursery grows NE Highland provenance gean (zone 201). The next best choice would be certified British provenance. Avoid material from eastern and southern Europe which is not adapted to British conditions.

BEECH

Beech (*Fagus sylvatica*) was quite extensively planted in the Highlands and Islands throughout the last two centuries and is seen thriving in a surprising variety of sites. There are fine examples for instance in Lews Castle Grounds in Stornoway and indeed in the grounds of a great many estate houses. In the impending absence of ash and with the continuing difficulty in planting elms in any number, beech is well worth considering as another hardwood to add to new schemes. As the climate warms, the north may actually become increasingly suitable for this more thermophilic species.

Soils that are neutral to moderately alkaline are suitable for beech, providing they are reasonably well-drained but not too dry, as it is intolerant of drought. Beech does not thrive on peat or on waterlogged soils. Young trees need shelter as they

are susceptible to frost but they do well in tree tubes and, once grown, are reasonably hardy. Choosing more sheltered microsites within a planting area is probably wise.

Note that, like sycamore, beech should not be planted under existing native woodlands due to its ability to out-compete native trees and then suppress most regeneration.

The most widely distributed and numerous species in the Highlands and Islands.

SILVER AND DOWNY BIRCHES

The two birch species, downy birch (*Betula pubescens*) and silver birch (*Betula pendula*), are the commonest tree species in the Highlands and Islands. It could be argued that they offer the most assured productive woodland type on the widest variety of soils in the widest levels of exposure. For that reason alone they deserve particular consideration as productive species. Whilst downy birch is the prevalent native tree of the west and north, silver birch is prevalent in central and eastern Highlands. There is a band of hybridization where the two overlap in range and there are pockets of silver birch in the west, which become more frequent as you go south into Argyll. A third species, dwarf birch (*Betula nana*) is mentioned in the section on mountain woodlands.

Birches can produce both high value timber and firewood. It is being imported from Baltic states direct to the Highlands for OSB manufacture!

Birch of either species can be grown specifically as a firewood crop. Over the last 150 years they have mostly been seen as just that, combined with shelter for stock. However we should also consider them as timber species producing highly versatile and workable timber for making a multitude of products including fine furniture, flooring and linings. There are currently no mills specializing in processing birch even after extensive trials and promotion by Highland Birchwoods from about 1985. The resource is not thought to be quite large enough to support such an investment and its quality is probably too low, which is largely a feature of management or rather lack of it. Nearly all birch woods are literally shaped by grazing and browsing and therefore we seldom see the tree's potential, except in gardens and very occasional woods where grazing is rigorously controlled.

See section 3 for more on management of birch.

The minimum stocking density for birch is 2500/ha to promote high quality timber production but 3000/ha would be better. Birch is well suited to continuous cover systems (see section 3) with natural regeneration under a uniform shelterwood system, where retained trees – carefully selected for their superior form – are fairly uniformly spaced as seed trees (20-40/ha). Alternatively, small coupe felling in patches or strips can be carried out. Clearfell and re-planting remains a further option: one which has the advantage of greater control of stock but carries much higher associated costs than natural regeneration.

Select provenances carefully to optimize production and form.

Care should be taken to select planting stock of suitable provenance matched to your site. Silver birch is somewhat more demanding than downy birch. It is best restricted to sites below 350m altitude and to freer draining mineral soils. These would ideally be brown earths but could be podzols or drier surface water gleys. Peaty soils should be avoided for this species. Downy birch is more tolerant of peaty soils, wetter sites and higher elevations. However, as with all broadleaves, it will produce better quality timber at a faster rate, the better the site. As with silver birch, it is a mistake to expect it to produce good timber on infertile and exposed sites.

Birch needs early weed control.

Like most trees, birch is badly affected by competition when establishing, and weed control will be necessary. Some form of site preparation is usually also necessary for germination by natural regeneration and a light scarification is often the best. Where planting, inverted mounding (see below) will be preferable on the

more fertile sites where bracken or grasses are prevalent or on heathland with dense heather.

Although it seeds profusely in September to October, at as much as 500-40,000 seeds/m^2, most seeds fall within 50 metres of the parent tree and will need to germinate in the first year as viability reduces to just 6% after one year. Germination is highly dependent on seed remaining damp and in contact with the ground during the early stages of germination and seedling growth. Light levels must also be quite high equating to a birch canopy cover of 20-40%.

Beware voles… again!!

Voles can do considerable damage both to natural regeneration and planted birch and will kill or severely impair tree form and therefore timber quality. Weed control is the best way to keep vole damage down and is necessary in any case to reduce competition with the seedlings for both light and nutrients. Inverted mounding should create almost weed free conditions for one season, which, on a good site, may be enough to see young trees above weed height. Hand or chemical weeding of scarified sites may need to be continued for more than one season. Competing vegetation should never be allowed to out-top birch seedlings. Young birch do not do well in solid tree shelters but vole guards may be the only option where voles are causing significant damage (see this section below). Ongoing management of birch to produce a good timber crop is examined in section 3.

PROTECTION AGAINST GRAZING AND BROWSING DAMAGE

FENCING

As already stated, young trees may be damaged or killed by several different grazing and browsing species: all domestic stock, all deer species, rabbits, hares and voles. During the establishment phase of new woodlands these animals will need to be completely excluded by fencing. In many situations fencing will need to be combined with shooting where deer pressure on fence lines can lead to breaches at an early stage of fence life. Risks should not be taken as the costs of failure are high compared with the costs of doing a good job in the first place. Grants may be repayable if failure occurs or the full cost of replanting may have to be met.

Deer fencing with two types of Rylock and top wire on newly planted site.

Take rabbits seriously: they can devastate new plantings rapidly.

If there are only a few rabbits about, it is sometimes tempting not to bother with protection against them but this is unwise. Rabbits love to eat most species of young trees and will tend to home-in on them.

31mm rabbit netting should be used, in conjunction with rylock where stock are present. The netting should be either:
a) lapped outwards 150 cm at ground level with turves or bent line wire hoops holding down the lap at intervals or
b) placed in a trench 150 cm below ground level and 150 cm outwards and refilled.
In either case it is advisable to use 1050 mm netting to maintain sufficient height. 900 mm netting does not allow for sufficient lapping out, especially on undulating ground.

For small plantings, where both stock and deer have to be excluded by fencing anyway, it is worth comparing the cost of rabbit netting the perimeter of the plantation with the cost of protecting every tree individually. Netting has a potentially longer life than an individual guard (and will allow for the natural development of the ground flora throughout the wood), but it can be breached by a persistent rabbit population, sometimes with disastrous results. An individual guard, however, only rarely fails.

Refer to current grant conditions and guidance for detailed fencing specifications of all types. Note that markers are important on deer fences to reduce bird strikes in some locations!

The specification for most fence types will be familiar to crofters from CAGS *Design and Construction Standards* (formerly known as Standard Specifications) https://www.ruralpayments.org/publicsite/futures/topics/all-schemes/crofting-agricultural-grant-scheme/crofting-agricultural-grants-scheme-full-guidance/capital-grants-technical-guidance---menu/cgtg---design-and-construction-standards. The Forestry Research publication Forest Fencing gives valuable details. It is wise to use a woven wire type fence. Deer fencing will be 1.8 metres high with the lower half to a specification that keeps out sheep and lambs where necessary. Rylock C8-80-15, for instance, will ensure that lambs do not get through the fence. Line wire fences are not acceptable under grant conditions.

In areas where black grouse or capercaillie are present, it may be necessary to install marking, e.g. diagonal battens or bamboo canes, on fencing to reduce collision risk. The Forestry Commission technical note Fence Marking to Reduce Grouse Collisions provides guidance on this subject: https://www.forestresearch.gov.uk/research/fence-marking-to-reduce-grouse-collisions/

High specification deer and stock fencing with battens to increase visibility and reduce bird strike.

TREE SHELTERS AND GUARDS

Solid guards for protection from rabbits and voles.

Solid individual shelters are used on young trees for assured rabbit, hare and vole protection and to enhance establishment and early growth. They can be installed to achieve either one of these functions or both at the same time, as is likely in many situations on low ground. Well staked 60 cm shelters with double ties are recommended for this type of protection, though note that 75 cm shelters are required to protect against hares. They are also useful for marking trees for maintenance without being too visually intrusive. Most often they will be combined with stock fencing. Tubes should always be pushed well down through matted vegetation and into the top millimetres of soil or humus for assured vole protection.

Some tubes only come with a single tie, which is inadequate in many of our exposed locations. Order double ties!

120 cm and 180 cm tree shelters are entirely inappropriate to exposed sites and it is far better to exclude deer and sheep by fencing wherever possible. Indeed it should be noted that solid tree shelters of any height are not recommended by everybody in the Western and Northern Isles as they can provide too much resistance to wind and sheltering effect to young trees. A 60 cm mesh type guard is favoured in these locations although mesh dimensions vary with manufacturer and not all will prevent vole damage, so check this out before ordering.

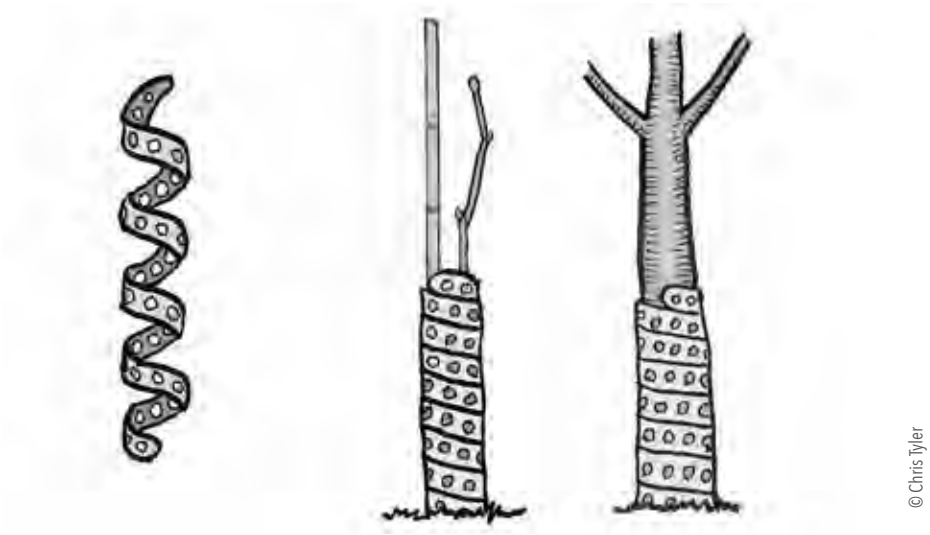
Site manually mounded with 120cm tubes.

Cheaper and faster to install than tree shelters, for rabbit and vole protection only, is the spiral guard. However, they should only be used on sturdy whips as they can do physical damage to smaller trees and deny sufficient space and light for proper growth. They are often installed with a bamboo cane for additional support. They need to be removed or re-wound once the stem starts to force them open. They are generally unsuitable for very windy sites and those with high rabbit pressure. Tubex 'Easywrap' tubes circumvent the problem of restricted space as the tree grows but the windage on more exposed sites can remain a problem.

Shelters are not generally recommended for conifers but can be used in certain cases. They work to best advantage on broadleaves such as oak, hazel and holly, all of which are tolerant of a certain amount of shade and are relatively slow growing.

Shrub shelters

There are special broad shrub shelters, mesh and solid, which are better suited to the naturally spreading species such as hawthorn, blackthorn, guelder rose, dog rose, and a range of exotic shrubs that are used for extreme environments.



Spiral guards :
a) the plastic spiral rabbit guard
b) installed on newly planted whip with bamboo cane for additional support
c) installed on a well established tree

Most 60 cm tree shelters will require a 75 cm minimum stake. A 75 cm shelter will require a 90 cm stake. Your local sawmill should be able to supply you 25-30 mm square pointed untreated larch or treated softwood stakes. Check for knots, they lead to broken stakes! Highly durable and strong cleft chestnut stakes (from English coppice woods) are also available from some nurseries. Most nurseries supply tree shelters, stakes, spiral guards, bamboo canes and mulch mats as well as trees.

To reduce global plastic pollution, biodegradable shelters are now available. All plastic type shelters should be removed before they start to degrade.

After trees are established and out of the top, tubes should be removed *if* it is certain that rabbits, hares or voles do not still present a significant danger. To avoid serious environmental pollution, they must be cut off *before* they start to break up by UV degradation. It is sometimes hard to judge when it is safe to remove individual tree protection but there is also danger of significant tree damage if they are left on too long.

Stakes should NEVER be installed higher than top of shelters!

Trees can suffer damage from abrasion against the tops of shelters and stakes (where the latter have been left incorrectly above the height of the shelter). This should be checked for and if damage is significant (most likely on a windy site) but rabbits or hares are about, it is worth considering removing the tree shelters and re-guarding individually with spirals.

Spiral guard grown into stem due to lack of early maintenance on remote site.

Spirals bring their own long-term maintenance problems, however, eating into stems as the tree grows. They must be checked at least once a year and 're-wound' around the stem where necessary. The age when a tree is beyond rabbit damage is not easy to define. Rabbits gnaw at the bases of trees of almost any age where they are abundant. The important thing is that a tree is not ring barked. Once the diameter of the stem is about 15 cm, the likelihood of terminal damage is fairly slight. The age at which a tree reaches this size varies greatly from site to site and species to species.

STOCK SELECTION

There are about 40 nurseries in Scotland growing forest trees and shrubs and they vary greatly in size and in the type and species of stock supplied. The decision on which supplier(s) to use will depend on who can offer precisely what you are after and, to some extent, where they are in relation to you.

ORIGIN AND PROVENANCE

The origin of a tree refers to its genetic make-up, which will have evolved in relation to the environment that the seed source population of trees has inhabited over generations. The provenance of a particular tree refers more simply to the site at

which the immediate parent tree was growing. Thus Scots pine seedlings of Wester Ross 'provenance' but of Deeside 'origin' could be grown when seed was collected from a plantation in Wester Ross established with Deeside stock.

Local provenance stock is critical in the relatively extreme environments of the Highlands and Islands. Nursery certificates of provenance are required for grant aid and local provenances are often mandatory. See https://forestry.gov.scot/forests-environment/biodiversity/native-woodlands/seed-sources

All seed and other vegetative plant material for forestry purposes is controlled under Forest Reproductive Materials (FRM) legislation which operates across the EU. This ensures that the provenance of all trees planted under grant aid can be verified as suitable to the planting site and helps to ensure the integrity of genetically distinct populations. This is especially important in the case of Scots pine, which has seven seed zones across the boundaries of which planting stock may not be transferred.

The Woodland Trust has recently set up a voluntary 'UK Sourced and Grown' (UKSG) assurance scheme in response to issues of disease arriving on imported stock. In Scotland, Alba Trees, Little Assynt Nursery, Taynuilt Trees and Christie Elite are signed up to the scheme. All the trees purchased by the Woodland Trust are UKSG.

The effects of local genetic adaptation are more pronounced in some species than others. In the case of trees whose seed is transported long distances by birds, we might expect less pronounced local adaptations to have evolved. Trees of local origin, being genetically well-adapted to local conditions, have the best chance of establishment and healthy subsequent growth. Local origin stock should, therefore, whenever possible, be chosen in preference to stock of distant or unknown origin. Failing that, stock of local provenance will be second choice and necessary in the case of non-local species.

The differences in climate between east and west Scotland are considerable. For instance, a birch of central Grampian origin will be genetically adapted to both early and late frosts, very cold winters but relatively dry summers. By contrast, a birch from the west coast will be adapted to mild winters, lack of severe frosts, extreme exposure and cool wet summers. It is to be expected that moving trees between these two extremes of climate will lead to failures and a potentially harmful pollution of local gene pools. Movement of trees from southern Scottish origins into the Highlands can also lead to problems with early flushing of leaves in the spring for instance.

The location of a nursery does not necessarily tell you what you need to know about the origin of its trees. There are nurseries in the north of Scotland importing seed from central and southern Europe and nurseries in Southern Scotland collecting seed from the north of the country to ensure a range of available stock to suit customers from all over the country. It is necessary, therefore, to ask the nursery about the origin of its stock and inspect the catalogue very carefully. Good nurseries can give you definite answers and their catalogue should give origins of different species.

CELL-GROWN OR BARE-ROOTED

Another important decision to be made in choosing trees and shrubs is between bare-rooted and cell-grown stock. There is no reason why a mixture should not be used and, in practice, due to availability of all the right species and origins from a single nursery, this may well happen.

Bare-rooted trees are generally grown in the open and will tend to be two (sometimes three) growing seasons old when sold. Cell-grown trees are generally grown under cover and are usually only one growing season old when sold. There are advantages and disadvantages to each type of stock.

© John MacPherson/WTML

A cell-grown hazel still in leaf ready to plant in the early autumn. Containerized trees extend the planting season at both ends.

Cell-grown stock is certainly easier and quicker to plant, though generally more bulky to transport to and about the site. The cell-grown tree does not suffer the same degree of shock on lifting, transporting and planting as a bare-rooted tree and there is considerably less danger of root drying and damage. Cell-grown trees can survive a month on site in a suitably protected place whereas bare-rooted stock may suffer from even a few days in the co-extruded bags in which they are delivered.

Against these advantages have to be balanced the relative softness of the cell-grown tree compared to the field-grown, bare-rooted transplant. The importance of this consideration will increase with the exposure of the site.

SIZE OF STOCK

Nursery catalogues typically show trees for sale in different size classes: 15-30cm, 20-40cm, 30-60cm, 60-90cm, 90-120cm, for instance. The decision on which size class to order will be based on a detailed knowledge of the site. The ideal may be influenced to some extent by what is available from the favoured supplier(s). Relatively short but sturdy plants are better than tall, spindly ones for exposed sites so assessment in the nursery is preferable if at all possible.

Balancing size of stock against weed competition.

As a general principle, the smaller the plant, the better the rate of establishment. But anticipated weed competition may lead to the choice of a larger plant. On peaty soils with predominantly heath vegetation, competition will be relatively slight. On these sites, with good screefing (see 'Planting Trees' below) or mounding, plants of say Scots pine and birch can be small – less than 30cm. When planting into rank vegetation or newly fenced pasture which will grow rapidly in the spring, a larger plant is essential – more than 30cm (unless rigorous weed control is guaranteed).

High exposure will generally rule out larger planting stock – over 90cm – as it will tend to die back from the top and even be dislodged. Use of individual shelters and good screefing or other weed control will tend to allow the use of smaller planting stock.

Different species have different responses to the trauma of lifting from a cosy nursery, transport and planting. Willows and alders, for instance, are relatively tolerant: birches and Scots pine, far less so. Detailed knowledge of such factors will also influence a consultant's or experienced planter's choice of the type and size of planting stock.

As a rule of thumb:
15-40cm for exposed locations and where weed competition is low.
30-60cm on more sheltered sites and where weed competition is high.

SITE PREPARATION

MANUAL GROUND PREPARATION

The majority of tree planting sites will be prepared mechanically to reduce weed competition but there will be cases where manual ground preparation is unavoidable or desirable. One such case will be where all mechanical and chemical means are prohibited by the Water Guidelines yet it is desired to plant up to water courses in order to mimic natural processes by adding (deciduous) leaf litter to increase invertebrate productivity. Other cases requiring manual site preparation include planting within small, already fenced areas, and beating up (replacing failures – see below).

See section 7, 'Woodlands and freshwater',for more on leaf litter and nutrients and also to see more about Water Guidelines.

Manual screefing.

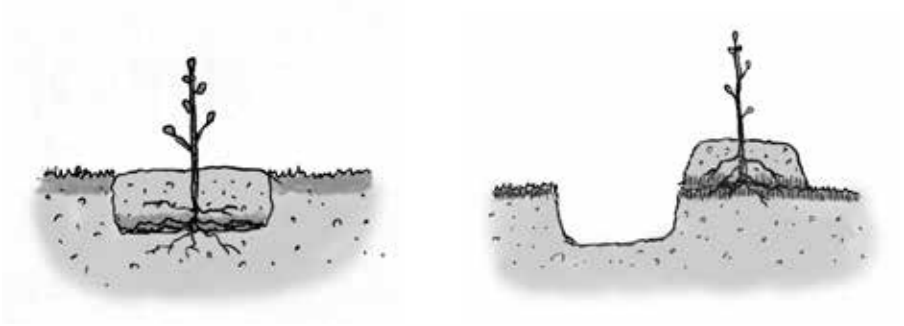
The simplest way to prepare a relatively weed free site for a tree is with a spade or mattock and the action is called screefing. The patch will ideally be 50 cm x 50 cm (at least 30 x 30 cm) and the tree may then be planted into the centre of the cleared 'screef'. If this action is done properly, it will give reasonable weed control for the first year and greatly assist further weeding in the second. Even on grassy sward, manual screefing is hard work but on rank heather and Molinia (purple moor grass) it is a tree planter's nightmare. Brushcutters with blades can be effective but also hazardous in stony ground.

Inverting a turf manually.

An alternative method of creating a weed-free patch is to cut a square turf with four clean cuts of the spade, lift it out, turn it over, split it in two and replace it. Tuck the roots of the tree between the two halves of the sod. Firm the sod back into the hole and the tree into the sod all at the same time. This method is difficult except in short grass where a turf is easily cut.

Manual mounding.

On wet ground it is sometimes appropriate to plant trees in inverted turves placed on the surface of the ground (mound planting). Turves should be about 50 cm square and 20 cm deep. This is a smaller version of mechanical mounding (see below) and subject to all the same rules and considerations. Mounds are ideally cut several weeks prior to planting to allow some consolidation and rotting of vegetation.



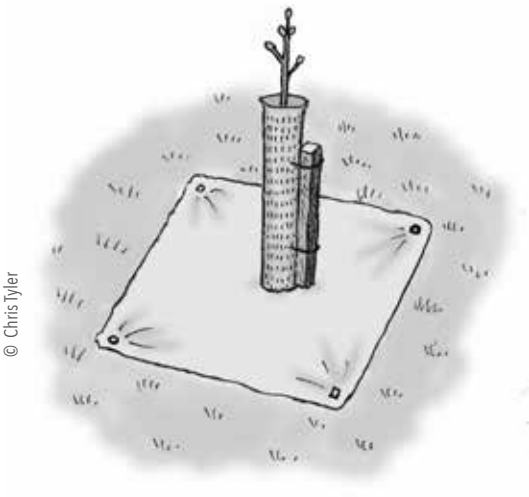
© Chris Tyler

Manual planting – (left) cut turf replaced into hole ; (right) placed beside hole (mounding).

The ground conditions have a marked effect on the speed of tree planting but, screefing properly as you go, an experienced tree planter will get about 300 trees into the roughest uncultivated ground on a short winter's day. On an easy, recently grazed grassy sward this figure will rise significantly and, on a mechanically mounded site, could rise to 2000. Do not therefore under-estimate the cost of labour in manual ground preparation.

MULCH MATS

Mulches are designed to suppress weeds and retain soil moisture. Bark mulches are increasingly used for amenity plantings of trees but are very intensive, costly, and will only be appropriate to the smallest projects around houses and buildings.



© Chris Tyler

Bio-degradeable mulch mat with biodegradable pegs used in combination here with a ventilated type of shelter.

© B Planterose

Plastic mulch mat over 25 years after planting which should have been removed after 2-3 years.

Mulch mats are also sometimes useful for very small plantings. A simple mulch mat is a black polythene square (often 1x1 metre) with a slit in the middle or running from the middle to one corner. It is either slipped over or around the tree and the edges tucked into the ground with a spade. They can only be installed easily on short grass and where the soil is not too stony.

With biodegradable alternatives now more available, plastic (eg black polythene) mulch mats should be phased out.

However, the introduction of non bio-degradable plastics into the environment has become largely unacceptable and new generation mulch mats made of non toxic, bio-degradable materials may become more available. In the meantime, recycled cardboard and fabrics are being used along with organic mulches including rotted seaweed, bracken and sheep's wool.

MECHANICAL MOUNDING

First generation mounding?

The majority of sites for new planting are currently prepared by excavator mounding. Over the last few years typically a 7 tonne or larger tracked excavator with a 50cm wide x 1m deep bucket has dug a 50 x 50 cm square turf and placed this at the side of the hole from where it came. Tractor towed mounders are also in operation on suitable sites. Whilst this technique (sometimes called hinge mounding) has created the better drained and weed free sites intended, it has not been without its own drawbacks. It has increased exposure, sometimes caused desiccation and certainly made subsequent access to the woodland unpleasant on foot. It also disrupts soils and ground flora. It has therefore been felt by some to be inappropriate to the creation of new native woodland.

Will this wet loving alder survive desiccation on such a raised unconsolidated mound?

Hinge mounded land for new planting – boulder clay not far below shallow peat. Remnant birch in background.

Next generation – inversion mounding?

More recently, the use of 'inversion mounding' where the mound is placed back into the hole and tamped down has rapidly gained greater acceptability. In this technique there are no air gaps and the soil surface is left facing up with the surface of the mound no more than +/-100mm off the level of surrounding ground.

Either form of mounding should be carried out a couple of months (no less than 6 weeks) in advance of planting to allow the ground to settle and preferably when the ground is drier, to lessen the risk of run-off and soil compaction. The mounding should not be in straight lines or a grid pattern for native schemes.

Simple method:
a) Randomly locate a number of 8m radius circular plots (ie 200m.sq)
b) Count the number of trees in the plot
c) Multiply by 50 to calculate stocking density/ha.

It is good practice to measure the average distance between sample groups of mounds and adjust spacing as necessary to ensure the overall stocking density is reached but not exceeded. Splitting the site into smaller areas/numbers of mounds required can help with this.

There are strong arguments both for and against mounding. The individual characteristics of each site, as well as longer term woodland management objectives, need to be considered carefully before specifying mounding or choosing a lower impact approach. The fact is that many native and other woodlands have been successfully established in the last 40 years without mounding, without chemical weeding and with only manual means. It is argued by some that mounding does not constitute the 'minimum intervention' deemed likely to result in the establishment and development of a woodland ecosystem. We may need to move beyond the use of mounding as a compensation for inadequacies in other aspects of establishment silviculture, including site selection, species and provenance choice and weeding.

Beyond mounding?

On the other hand there are many potential woodland planting sites in the Highlands and Islands where soils have been degraded and compacted under intensive grazing and burning and where critical nutrients are just out of reach under thin acidic peaty coverings. Careful inversion mounding may represent an appropriate prescription for such sites. It just should not be viewed as a panacea and should always be combined with best possible practice in species and micro-site selection.

GROUND PREPARATION BY ANIMALS

In natural woodland systems wild animals, especially of the hoofed variety, play an important part in the regeneration of trees and shrubs by exposing suitable ground for seed germination. Pigs, cattle and horses can all be managed to provide suitable conditions for natural regeneration under existing woodland. They can also be used to prepare ground for new planting.

See more on use of pigs in section 8 Agroforestry.

DRAINAGE

Mechanical drainage is generally not appropriate or necessary for the establishment of native woodland, as sites too wet for establishment should not be planted and species should be chosen to match ground conditions. However, due to historical deforestation, many of our hillsides are subject to much greater surface run-off than would occur with more tree cover, and it therefore makes sense in some situations to provide occasional cut-off drains across slopes to improve conditions for tree establishment.

Consult 'Forestry and water Scotland – Know the rules' for essential guidance on many aspects of freshwater environment protection: https://www.confor.org.uk/media/246355/on-line-printable-know-the-rules-booklet.pdf

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PLANTING BASICS

HANDLING TREES

Good handling of trees prior to planting makes a considerable difference to establishment success. Here are a few good rules for bare-rooted planting stock:

- Always keep trees in bags on site, preferably for not more than a week.
- Always keep bags of trees out of wind and sun.
- Use co-extruded bags – white on the outside and black on the inside.
- Never throw or drop bags of trees.
- Do not put bare-rooted trees in the burn as this will wash off moist soil and root hairs. Never let tree roots dry out in the first place!
- Although it is best to keep bare-rooted trees in bags for a few days rather than heeling in (sheughing), this should not be discounted as a holding method when longer is necessary. It can even be used for cell grown trees eg if the weather closes in on an autumn planting and the rest needs to be delayed till the spring.

PLANTING TECHNIQUES AND IMPLEMENTS

After all the planning, fencing and choosing of site, species and planting stock, the act of planting a tree may appear relatively simple. Even so, as with all practical tasks, there are certain knacks and certain tools.

If the ground has not been mechanically prepared, in almost all instances it will be necessary to clear a patch of ground of all vegetation by screefing or turning a turf as described above (manual site preparation). The usual method of planting a tree is to cut a V, T, H or L shaped slit with a sharp spade, the second cut being used to lift the ground and open up the slit. The tree is fed into the slit making sure that the roots are tucked well down into the hole. One hand is used to hold the tree upright while the ground is firmed up around the stem.

A cell-grown tree can be planted in the same basic way as a bare-rooted tree though a somewhat shallower slit is adequate. There are a variety of special planting tools on the global market for planting cell-grown stock but none can be used for screefing. These tools tend therefore to be used in conjunction with chemical weeding, pre-screefing or on mechanically prepared sites. In the Highlands the tools of choice are the simple and robust 'spear' and 'planting spade'. A spear is often better than a spade on a stony or mounded site for cell-grown stock, being easier to get into the ground. A planting spade is better for bare-rooted stock and necessary where manual screefing is required.

Planting harness for carrying cell-grown trees; narrow, treaded 'lady's spade'; spear (for cell-grown stock)

TIMING

Extend the planting season with cell-grown trees.

Opinions differ on when is the best time to plant trees. The answer is, as usual, that it depends on several factors. It is best to stick to the conventional tree planting seasons of spring and autumn, though cell-grown trees can help to extend the planting season slightly.

When planting bare-rooted stock, far more attention will need to be paid to local climate and the weather conditions on the very day you plant. In windy weather great care must be taken to prevent root drying. In frosty weather root hairs may be killed by freezing and it is also physically difficult to plant properly due to the hard soil.

A tree that is autumn planted has all winter for the soil to settle properly around its roots and recover from the shock of planting. A spring planted tree has no time to settle in before the growing season but avoids the lashing of winter gales in the first weeks after planting. Not having leaves in the winter, autumn planting is fine

for deciduous trees. Conifers, however, are ideally planted in the spring, particularly on exposed sites.

In tree planters terms, autumn refers to the months of November and December and spring usually to February, March and possibly early April. January is not so favoured in the Highlands, simply due to the foul weather alternating with frosts, neither of which are conducive to tree planting. On the mild west coast though, a January day may be as good (or bad) a day as any to plant trees.

SPACING

Spacing depends on many site factors as well as on management aims.

The spacing for planted trees tends to be led by grant aid requirements, which should be carefully consulted for the different types of woodland. Traditional spacings for initial establishment are from 2.0 – 2.5 metres for conifers and 1.8 – 2.5 metres for broadleaves. However, spacings should be reduced in areas of extreme exposure and where survival rates may be low. The management aims of broadleaved woods are particularly important to spacing as, where timber production is the aim, spacing may be relatively dense on establishment with the aim of progressive thinning. The special case of spacing for birches is described above (sub-section on Silver and Downy Birches) and the variable spacing within shelterbelts in section 9. Clearly the spacing for hedges and small shrubs is much closer and can be as low as 0.2 metre.

As this handbook underlines, however, our concept of woodlands is evolving and a greater diversity of types and management approaches are becoming accepted. A high degree of flexibility in spacing is required in the design of silvo-pastoral systems, mountain woodlands, riparian woodlands and the landscape scale habitat mosaics of an overall land use vision.

This table gives the number of trees required at different spacings: a spacing of 3.2 metres gives exactly 1000 trees/ha.

PLANT SPACING & STOCKING DENSITY	
TREE SPACING	QUANTITY PER HA.
1.50m	4,444
1.80m	3,086
1.90m	2,770
2.00m	2,550
2.10m	2,268
2.20m	2,066
2.30m	1,890
2.40m	1,736
2.50m	1,600
2.60m	1,479
2.70m	1,372
2.80m	1,276
2.90m	1,189
3.00m	1,111
4.00m	525

Guidance and grant mechanisms are responding to the increasing complexity of, and mix of, management objectives. Currently, there is flexibility for higher density

planting for some broadleaves as well as for native woodlands in exposed areas in the crofting counties.

The small scale and integrated objectives of croft woodland establishment and management will continue to challenge traditional divisions between farming and forestry and it is to be hoped will lead to even more flexible support in the near future.

FERTILIZATION

There has always been a range of opinion on the effectiveness of fertilization and which types are best. There is now a range of opinion on the appropriateness or need for fertilization in view of the prohibited planting of deeper peats, the (debated) global shortage of phosphorus, better site and species selection and better understanding of mycorrhiza and ecosystem nutrition.

Phosphate is often limiting on poor Highland sites: Refer to Section 12 'Woodland Ecology'.

There is little doubt however that on many sites in the Highlands and Islands where trees are planted (ie not on improved pasture) phosphorus is the limiting factor to tree growth. On some sites, however, nitrogen may also be limiting and boron deficiency has been noted occasionally. The pH of soils affects nutrient availability so it is not as straightforward as it might at first sound to correct deficiencies.

The traditional way to fertilize newly planted trees has been to apply 50g of rock phosphate or phosphate-based fertilizer in a ring around the base of the tree after planting. However 'new generation' coated, slow release fertilizer such as 'Albacote' or 'Nutreelite' is now generally applied direct into the hole under the tree at 10g/tree where it does not readily feed the weeds. These fertilisers are NPK blends and there are variants, for example with added boron, for acidic sites.

Observe water guidelines – no inorganic fertilisers within 5-20 metres of watercourses depending on width of watercourse. (see Keep your Distance box – section 7)

Rock phosphate can still be applied as a second treatment around the tree base if young trees continue to exhibit nutrient deficiency after two or three years.

There should be no need to fertilize grassy sites and, indeed, fertilizer will stimulate weeds to the detriment of tree growth on moderately fertile sites.

EARLY MAINTENANCE OF WOODLANDS

WEED CONTROL

Second only to the depredations of grazing and browsing animals (both domestic and wild), weed competition poses the severest problem to the establishment of young trees. Good pre-planting weed control by the methods discussed above will, in most cases, obviate the need for further weed control in second and third years. However, competing vegetation should not be allowed to out-top young trees and further hand or chemical weeding should be considered if this is occurring.

Bracken sites are often preferred for tree planting as indicators of reasonable drainage and fertility. However they present particular problems to young trees due to shading, mechanical damage and to lodging in the autumn. Control for the first two to three years after planting is therefore essential and trampling and or hand pulling is the safest method. Use of (120 cm) tubes to mark trees individually for weeding is effective for species that can withstand the shade. Scything or strimming after planting can clearly lead to severe tree losses unless trees are tubed!

BEATING UP

Beating up is the technical term for replacing dead trees in the early years of a plantation's life. Any number of dead trees can be replaced if resources are available but it becomes essential where mortality rises above about 10% of the original planting.

Where mortality is expected to be higher than average, such as in exposed or other poor sites, original dense stocking is sometimes utilized to avoid having to beat up later (See above: spacing).

OTHER MAINTENANCE

The various ways that tree shelters, tubes and spirals can damage newly planted trees and shrubs has been highlighted above. But quite a number of problems can develop in the course of the first year or two of establishment and it is therefore essential that new schemes, both planted and naturally regenerated, are checked as frequently as possible.

Here is a checklist:

- check fence lines for breaches especially at ditches and water gates
- firm up stakes, canes and shelters
- inspect for rodent damage at base of trees
- inspect for browsing damage higher up trees
- more major damage such as leader removal and thrashing will be obvious and will mean that the animal culprits need to be removed or culled as soon as damage is discovered
- remove non-biodegradable mulch mats
- replace organic mulches where necessary
- remove all forms of guard and shelter as soon as safe to do so
- re-fertilize only in cases of very clear nutrient deficiency – eg yellowing of conifer needles

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Formerly used extensively for bracken spraying, Asulam is now highly regulated by HSE with a permit system and is only being authorised on a year by year basis.
Bracken should not be considered as the tree planter's enemy. Far from it: it is an indicator of excellent soil conditions. It preserves relatively nutrient rich, basic, aerated and dry soil conditions, something one cannot say for heather. It may indicate the last places that trees died out on your land. NB. bracken spores are carcinogenic and face masks should be worn when weeding.

WOODLAND NVCs FOUND IN THE HIGHLANDS AND ISLANDS

Information drawn from Bulletin 112 Creating New Native Woodlands
Terms in brown font can be found in the glossary

Existing site conditions in the Highlands & Islands			Anticipated woodland type			
Soil	Terrain	Vegetation	NVC	Major tree species	Minor tree species	Shrubs
Wet, acidic, low fertility. Includes peat and some peaty gleys	Margins of bogs and flushes	Wet grasslands and rushy pastures. Wet heaths	W4 Upland birch	Downy Birch	Goat Willow Alder	Grey willow Eared willow
Wet, neutral-basic, medium fertility Includes some gleys and brown earths.	Slopes with flushes, along watercourses and in water-logged areas.	Tall-herb fens and rushy pastures	W7 Alder-ash	Alder Ash	Downy birch Goat willow Pedunculate oak Sessile oak Rowan Holly Bird cherry	Grey willow Hazel Hawthorn Elder Blackthorn
Dry basic. Medium fertility Includes some brown earths and gleys.	Gorges and valley sides, often on steep rocky slopes, sometimes with flushing	Damp grass-lands and tall herb vegeta-tion. Ferny banks	W9 Upland mixed broadleaf	Ash Downy birch Rowan	Sessile oak Pedunculate oak Wych elm Alder Holly Aspen Bird cherry	Hazel Hawthorn Elder Grey Willow
Dry acid, low-me-dium fertility Includes brown earths and podzolic brown earths	Valley sides and hill slopes and on well-drained river terraces	Grasslands and bracken/ferns	W11 Upland oak-birch with bluebell	Sessile oak Downy Birch	Silver birch Pedunculate oak Rowan Holly Aspen	Hazel Hawthorn Juniper
Dry acid, low fertility Rankers, podzolic brown earths and podzols	Valley sides and hill slopes, often steep and rugged	Grasslands and heaths, tall herb and bracken/ferns	W17 Upland oak-birch with blaeberry	Sessile oak Downy birch	Pedunculate oak Silver birch Holly Rowan	Hazel Hawthorn Juniper
Dry acid, low fertility A range of podzolic soils	Upland plateaux and hills slopes. River terraces	Heaths	W18 Scots pine	Scots pine	Silver birch Downy birch Rowan	Juniper

CASE STUDY

ISLE MARTIN, WESTER ROSS

by Bernard Planterose

BEGINNINGS

Isle Martin, which lies at the mouth of Loch Broom and is 160ha in extent, was given to the RSPB in 1981 to manage as a nature reserve. At that time the island had respectable seabird populations that included nesting gulls of three species, common and arctic terns, black guillemots, shag, fulmar and tystie (black guillemots). It also had a heron colony and a very small number of nesting ducks including eider and occasional merganser. However, by the end of the decade seabird declines had been so drastic on the island, reflecting population crashes in the wider area, that the RSPB had to re-assess their commitment. They gave the island to the local community in 1995.

In marked contrast to the surrounding marine ecosystem, on land a remarkably positive transformation had taken place in the intervening period of 14 years. In 1983, we (my wife, friends, family and volunteers) started planting native trees, mostly within small fenced exclosures, as the island was then teeming with rabbits. Plastic tree tubes had yet to become common and we used staked rabbit netting guards for individual shelters at first. We focussed on the sheltered east side of the island, which had better soils, but we also established a few smaller plots and groups on both north and south west facing sides on poor peaty substrates.

In 1981 the island supported almost no trees. By 2018 the east side of the island was well wooded.

For the first few years nearly all the trees were supplied by Peter Wormell and of west Argyll provenance, although the very first 500 Scots pines came from nearby Rhidorroch glen. Other than these, all Scots pine came from Beinn Eighe. In 1985 we set up our own native tree nursery at Duartbeg on the west Sutherland coast and thereafter it supplied much of the planting stock. We diversified the species as our knowledge, confidence and growing abilities evolved. By 1995 the list included hawthorn, bird cherry, gean, dog rose, holly, ash, and oak as well as the usual stalwarts, downy birch, hazel, rowan, alder, grey and goat willows.

TRANSFORMATION OF WOODS AND BIRDS

Buildings are now benefitting from shelter and the song of warblers and redpolls has replaced the cacophony of seabirds that have been so reduced in the last 40 years.

Development of the small woods and clumps has exceeded expectations and there is now vigorous natural regeneration within plots and to some degree outwith them, facilitated greatly by the demise of the entire rabbit population which succumbed to myxomatosis some time in the early 21st century. The tallest woods on the east side now reach about 10 metres in height.

One of the most exciting features of the woods is the carpet of natural regeneration of many species which one so seldom sees in the Highlands and Islands. Particularly vigorous is the regeneration of holly, which will no doubt form some dense understorey in the medium term. But cherry, ash and oak regeneration is also abundant beneath the canopy and it will be intriguing to see in the coming years which species can compete and make it to the top. Shading is not intense and willows are already splitting at low forks and falling apart to allow some pools of light beneath. Despite a complete lack of any grazing or browsing, for the most part the woods are still easy to walk through, although bramble is beginning to become impenetrable in some places. Rushes have been almost completely eliminated even though they were dominant in many planted areas. Heather and sedges have been largely replaced by Molinia under Scots pine, which is still quite low in stature.

Woodland now 35 years old at least 10 metres tall. The tallest being goat willows (Salix caprea) shown here. A wildlife and ecology trail is being created.

The woodland has led to an impressive transformation in the birdlife with a wide range of species not present at the start of the project. Birds now breeding or visiting the island regularly include sedge warbler, grasshopper warbler, willow warbler, spotted flycatcher, blackcap, redpoll, and siskin, as well as all the common woodland birds you would expect of our region. Particularly remarkable was the first breeding of woodcock in 2017.

THE FUTURE

The woodland is already yielding significant amounts of firewood to heat the island houses.

The Isle Martin Trust, which now manages the island on behalf of the community, is committed to further woodland restoration as well as its interpretation and use as a teaching resource. The island is open to visitors all year round and there is a ferry in the summer on Fridays and weekends with guided walks and a cafe. It is hoped to improve the path network in the future, perhaps even allowing easier access to the very top of the island at 123 metres. Up there are the remains of pine roots from the former forest that we can deduce once clothed most of the island. It is also hoped that interpretation of the woodland history and restoration of the island will extend to a small exhibition on Frank Fraser Darling. His work on Priest Island and Tanera Mor, both within sight of the top of the island, was a major

inspiration to those of us who started planting in the 1980s. He would be pleased to know that the Trust is hopeful of facilitating people to re-inhabit the island in the long term, both growing some of their own food and utilizing the growing woods for shelter, fuel, fruit and coppice products.

www.islemartin.org

All these trees and the juniper in the foreground are planted except the occasional elder and rowan that colonised ruins themselves. A mosaic of woodland and heath is the aim to maximise biodiversity and the breeding bird list already extends from woodcock to sedge warbler.

CASE STUDY

No. 23 BACK, A CROFT IN LEWIS

by Bernard Planterose and Boyd Mackenzie

CONIFER SHELTERBELTS

In 1995 Boyd Mackenzie, a forester with FCS, started to plant shelterbelts on his croft in the windswept and otherwise predominantly treeless in-bye area north of Stornoway. At that time the generally accepted wisdom was that the exotic conifers, Sitka spruce and lodgepole pine, were the trees most likely to survive in that sort of exposure. Encouraged by 'the Department's' shelterbelt grant specification of the time, and a few quite young but establishing plantations of these species elsewhere on Lewis, he duly planted 10m strips of spruce and pine down either side of his narrow croft. Some excavator mounding and drainage was first required but, since deer were largely absent, stock fencing was all that was needed for protection. Between the shelterbelts, his remaining fields became gradually more sheltered and a little drier, and he continued to cut hay by hand with a scythe to feed his small herd of cattle.

Starting point. The bare land croft in 1993.

TRANSFORMATION OF THE CROFT

But this was just the start of a project, ongoing to this day, that has utterly transformed his croft over the intervening period of 23 years. It is now nothing less than a haven for wildlife and offers a wholly unexpected walk in the woods. At the same time it provides a much improved environment for cattle and poly-tunnels. Seen from the air his achievement is somehow all the more extraordinary. It challenges the norms of crofting, and underlines the possibilities for change if only this miniature version of agroforestry were to become more generally adopted by crofters as part of their diversification and land improvement.

Aerial view of the croft in 2017.

OTHER SPECIES

Over the years, Boyd has introduced a huge range of other species into the mix of trees which developed from shelterbelts to woodland over about half the croft area. Species are both exotic and native, reflecting his forester's love and knowledge for trees. Along with the hardy natives – birches, common alder, grey and goat willow – he has established larch, Scots pine, Swedish and common whitebeams, wych elm, ash, sycamore, hawthorn, oak, Italian alder, cotoneaster, holly, elder and ramanas rose. These are all in an intimate mix that supports bees from two hives sheltered in the woods.

Boyd Mackenzie – forester and crofter on path through woods he planted himself over a period of over 20 years.

STRAWBERRIES, BEES AND TOURISTS FLOURISH

The woodland is now at an exciting stage. It is providing great shelter for livestock and the trees have begun to seed and regenerate naturally. They are attracting new bird species every year. For some years Boyd grew strawberries commercially in two poly-tunnels sheltered by the woodland. The bees, which helped to pollinate the three crops of strawberries each year, produced honey as a by-product. He hopes to re-start this venture in the future. As part of his Crofter Tourism business, the existing woodland walk that generously allows free access to the public, is being extended to include the species in the Celtic 'Ogham' tree alphabet. There will be an explanation of all the principal eight characters symbolised by trees, such as C 'col' (hazel) and F 'fearn' (alder). This will offer people a taste of the ancient Celtic rain forest.

In addition to all this, Boyd has created a one-hole golf course in the shelter of the trees. You can sit on a bench here and watch the willow warblers and finches flit about the trees. It gives a pause to wonder how many possibilities could open up for crofters and land-based innovators if in the future they were to create a more wooded environment. It could radically change even our supposedly most challenging locations.

The one hole golf course – between shelterbelts of a wide variety of both conifers and broadleaves.

SECTION 3
WOODLAND MANAGEMENT AND HARVESTING

CLIMATE CHANGE AND WOODLANDS

All forms of woodland and plantation management can and indeed should produce multiple community benefits and provide many ecosystem services. But some management regimes are better than others at maintaining and building stocks of carbon within the soils and vegetation and in minimizing the greenhouse gas (GHG) emissions inevitably involved in management and harvesting operations.

The Scottish Government encourages such 'lower impact' silvicultural systems as part of its carbon transition strategy along with systems that are more likely to adapt to climate change and mitigate against the spread of diseases which we are already experiencing. In the most general terms, low impact silvicultural systems (LISS), involve lower soil disturbance, working more with natural processes such as natural regeneration, utilizing smaller machinery and lower inputs of fossil fuels.

One particular suite of management types within LISS is known as Continuous Cover Forestry (CCF) and within CCF there are several distinct management regimes. Although widely practiced in Europe, and in places from the Tropics to the Canadian Pacific forests, this is a relatively new field of interest in Scotland and therefore much of the evidence for its possible environmental benefits in the Scottish upland context is yet to be understood in detail. Its potential to increase local employment, deliver locally useful products, increase skills and integrate with farming and crofting is much clearer. If properly supported, it is likely to become a cornerstone of evolving rural development forestry.

> *"In terms of positioning Scotland's forest estate to minimise the risks of future climate change the best way forward is to use an appropriate combination of even-aged management and CCF… Areas should be designated for CCF within Forest Design Plans where this approach is considered the best way of delivering pre-determined management objectives".*

Forest Research (2009), The evidence supporting the use of CCF etc.

Increasing Scotland's contribution to GHG sequestration by new woodland establishment is covered in section 2. In terms of management, the focus of Scottish Government strategy as stated in the SFS 2019-2029 is quite specifically on native woods and includes:

- *Restoring approximately 10,000 ha of native woodland into satisfactory condition in partnership with private woodland owners through Deer Management Plans*
- *Increasing the amount of native woodland in good condition (upwards from 46% as identified by the Native Woodland Survey of Scotland).*

These objectives quite clearly acknowledge the need to reduce grazing pressures in order to achieve the Government's climate change goals.

INTRODUCTION

As already noted, woodland management and harvesting is a vast subject and this handbook can only hope to introduce the aspects most relevant to the Highlands and Islands. Within our region we have a well-established model of what might be termed 'industrial forestry' in that it serves a large timber processing industry around which silvicultural systems have co-evolved over a period of about a century. This large scale, mostly conifer-based, plantation forestry may be appropriate to land holdings nearer to the big mills and markets but is outside the scope of this handbook. This section does however look at some ways of managing and restructuring existing conifer plantations to increase local value.

In keeping with the emphasis of this handbook, this section focuses on smaller scale management and harvesting operations which are often more appropriate to community and crofting enterprises. Estates involved in multiple land-use objectives which include a strong element of ecological restoration or wildlife conservation, will also find the section useful.

Although they are sometimes key elements in woodland management, informal access and recreation are not addressed as separate subjects in this handbook. Neither is the way in which woodlands contribute to landscape considered in any specific detail. This is because good landscape, access and informal recreational opportunities should, in general terms, result from the kinds of woodland creation and silviculture advocated throughout this handbook. There is a good deal of literature available on these specialised subjects and interested readers are advised to start with the UK Forestry Standard before consulting the range of SF guidance documents on these subjects.

Much of what is described in this section requires skilled labour, detailed silvicultural knowledge, a host of motor-manual skills, and some specialized equipment. It can create employment in many different aspects, delivering high job satisfaction, healthy, vigorous physical work, and diverse products to support rural enterprises of a variety of scales. Smaller scale and higher labour input woodland management systems can support a number of business opportunities. They are examined in section 8 of this handbook.

A central role for Crofting forestry in RDF is examined in Section 1.

The greater complexity of woodland management systems and their closer integration with agricultural and horticultural systems that this handbook suggests take time and training to develop. This underlines a need for the programmatic development in our region of Rural Development Forestry (RDF) in which Crofting Forestry has the opportunity to act as a core component.

LOW IMPACT SILVICULTURAL SYSTEMS – some principles

More on processing of local timber in section 10 'Home-grown Timber'.

Nobody wants to do more damage than absolutely necessary to their environment, especially not the one they are dependent on for their living and want to hand on to their children. But there are some ways of establishing, managing and harvesting woodlands that are more benign than others. So-called LISS seek to minimise disruption and compaction of soils, disturbance and displacement of wildlife, and pollution and damage to watercourses in all woodland and forest operations. Yet LISS is not just about protection of the environment. It is very much about better utilization of local resources for greater local benefits including high quality employment, healthy and varied lifestyles, and compatibility with other land-based activities.

A great deal of the guidance on LISS and the grant aid available to support it has been developed in relation to the re-structuring of existing softwood plantations.

However, its principles are entirely appropriate to the relatively small scale of croft and estate woodlands, whether broadleaved, conifer or semi-natural. We are also at a point in time when woodland management can play a central role in re-imagining and re-organising upland land use. Declining hill sheep farming in some areas and changing attitudes to extractive sport shooting are gradually providing opportunities for an increasing diversity of sustainable land-use systems.

The smaller scale woodland manager and practitioner of LISS can call upon a great range of modern machinery and equipment designed specifically for farm forestry operations and small scale, or part time, timber processing. But small scale economic woodland management is not just about the right tools for the job. It's also very much about methods, systems and skills that make a virtue of small scale. It's about products and outputs that actually work best at small scale rather than large. Coppice wood is one such system and is thus explored in a separate section.

See section 4 'Coppice management'.

© Jake Willis/Sunart Oakwoods Initiative

Characteristics of LISS: small, low ground pressure machinery; selective harvesting; high value logs.

Likewise, broadleaved management for timber is best carried out by folk with a very long-term commitment to a place and the breadth of skills that can only be attained with time, patience and study. The much greater knowledge and potentially more sustained labour input that continuous cover forestry and management for high quality timber require has to be paid for by the sale of high value services and products. Such products include large, straight and clean stems of broadleaves, Douglas fir and larch. To grow these takes long rotations. These tend to develop more complex ecosystems and support wider ecosystem services, including wildlife biodiversity, educational and recreational opportunities.

There are direct analogies with organic vegetable growing where high labour inputs demand the support of discerning and high paying markets as well as local people committed to supporting local business.

Low impact forestry involves harvesting individual trees and small groups in a highly selective and relatively on-going manner. This means long term planning, especially the thoughtful creation of access at establishment stage, when this is much easier to do. Probably due to a combination of cost and a lack of engagement with what seem like distant future needs, rather few native schemes planted in the last 30-40 years have made adequate provision for on-going or longer term management.

Without well-developed access, a forester cannot prune trees, selectively extract big trees, maximise crops by thinning efficiently and at the right time, extract firewood economically, or cull deer on a sustained basis. Good access is absolutely

key to good silviculture, as well as to wildlife management and the development of educational and recreational opportunities.

Refer to Section 12 'Woodland Ecology' for more on nutrient cycling and acidification.

To summarize: low impact forestry means more than just taking care of our soils, freshwater systems and wildlife habitats. It means managing woodland intelligently to build soils and fertility, build carbon stocks, increase biodiversity and counteract the effects of nitrification and acid rain. This involves the sophisticated silviculture of long rotations, progressive thinning, species mixes, and managed natural regeneration.

CONTINUOUS COVER FORESTRY – some principles and sub-types

Continuous Cover Forestry involves a group of silvicultural regimes which can be classified as low impact systems (LISS). These systems stand in marked contrast to the prevailing model of Scottish conifer plantation forestry which can be characterized as 'clearfell and replant'. However these two approaches should not be seen as mutually exclusive. Large enough woodland units can accommodate both types to maximize economic gains and to offer a greater diversity of products and uses.

Based on Forestry Commission Information Note 29: What is Continuous Cover Forestry?

According to SF guidance, four principles pertain to CCF:

1. *Managing the forest ecosystem rather than just the trees*: giving equal weight to harvesting of timber, habitats, wildlife, and landscape considerations.
2. *Using natural processes as the basis for stand management:* natural regeneration is favoured over planting to give greater species diversity and fewer even-aged stands.
3. *Working within site limitation:* site variation respected as a source of species and growth diversity, often leading to more intricate mosaics of woodland and non-woodland habitats.
4. *Creation of a diverse stand structure with a range of species:* management to achieve stands of a range of age and species and therefore size structure and associated wide range of ecological niches.

From the above it will be clear that the creation from scratch of a forest fulfilling all the characteristics of a continuous cover silviculture would take a great many years. That is why most literature relating to Scottish CCF focuses on the re-structuring of existing plantations in the direction of CCF over time. Indeed you will see many, especially state owned plantations, currently undergoing a re-structuring process.

However, in most cases re-structuring is not aiming at the full range of CCF objectives or principals defined above. Felling coupes may be quite large, so restocking is almost always by planting, which creates even age stands, usually of single species, albeit within a mosaic of different aged stands.

With a true continuous cover system, no single felling coupe will have an area of more than about 0.25 ha (with the exception of shelterwood systems, see below). The cleared space will then be about 50 metres across so no part will be more than 25 metres from a remaining tree that can give shelter and supply the seed for natural regeneration to take place. This is quite fundamentally different from the prevailing method of re-structuring industrial conifer plantations which primarily produce logs for chipping or pulping.

Four types of CCF can be defined but mixtures and intergrades are also possible within a large enough forest unit. The following definitions are reproduced with

permission from the FCS Practice Guide, Achieving Diversity in Scotland's Forest Landscapes.

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. Not considered true CCF by all!

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. (more likely therefore to apply to shade tolerant species). 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 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 and value. Little or no disturbance of the forest. Requires expert forest marking and selection but avoids restocking costs. A mature 'steady-state' forestry system which will often increase biodiversity and soil building.

"CCF will help adapt the forest to changes to the climate, especially by providing structural diversity and retaining soil moisture.... 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". FCS Practice Guide Achieving diversity in Scotland's forest landscapes

Thinning hardwoods.

We need to be realistic, however, in assessing the suitability of CCF to the small scale of many land units and the conditions of the Highlands and Islands. There are

aspects of CCF which are easy and wise to implement in the majority of woodlands but full-blown profitable CCF management cannot be implemented unless:

1. A network of permanent extraction racks is set up, these areas being sacrificed to leave the rest undisturbed. Such access racks could constitute almost 20% of the wooded area. Disturbance of soil profiles has profound and lasting effects on soil fungi, mycorrhizal associations and invertebrates.
2. The value of the products – a mix of firewood, high value species sawlogs and venison – at least meets the management costs.
3. Skills (training), labour and commitment are all available.
4. Investment in appropriate equipment is adequate.
5. The risk of wind-blow is at an acceptable level
6. Deer pressure is lowered to a point where natural regeneration and/or planting within a forest is possible.

For more information on the development of CCF in Scotland refer to the website of the Continuous Cover Forestry Group at https://www.ccfg.org.uk

In the face of the above constraints and qualifications we can nevertheless aspire in favourable situations to apply CCF in the coming years to the management of both existing planted native woods and low species diversity conifer plantations. In the case of native woods the aims will include to:

- increase species diversity
- diversify age structure
- create better-organized group structures to facilitate future group fellings
- restock at appropriate coupe/stand sizes
- provide income stream from firewood
- start to select for better form of trees
- introduce higher value species such as oak into the best sites

In the case of existing single age and/or low species diversity conifer plantations the aims will include to:

- initiate transition to higher value species whether of broadleaves or conifers
- initiate restructuring to increase diversity of species and age structures

Just as importantly, we can design and establish new woods now with CCF management as the objective. This will involve quite different layouts and scales of stands, as well as more intricate or considered access to achieve future management demands. Woodlands to be managed under CCF regimes need to be designed around efficient, ongoing deer culling as this will be critical from the start. Venison should be viewed as an income stream as much as a silvicultural necessity. The planting design must capitalize on the very best sites in terms of fertility and shelter, making certain of easy access to these sites for management and the extraction of the high value crop. It is important that they be planted with the highest value species that they can support.

Selective thinning by mechanical harvester to create uniform shelterwood with natural regeneration of Scots pine

Good access does not mean lots of roads but it does mean a well thought out network of rides, tracks and landings suitable for small machinery and in some cases horses. The costs saved from large harvesting operations and replanting are used in CCF for the more labour intensive, longer term management required.

The conditions for natural regeneration – or indeed planting in clearings – must be created for any CCF systems to succeed and deer numbers will therefore have to be brought down to appropriately low levels. Once more we meet the constraints and costs imposed by current high deer populations and their obstruction of sound and sustainable land-use systems. In some specific circumstances, tree guards or internal and temporary fencing within forests can be used. Some roe deer damage will be almost inevitable in most woodland situations but red and sika should be completely excluded. Income from venison will help to offset costs of intensive management and should be exploited to the full.

See section 6, 'Grazing animals and woodlands'.

MANAGING EXISTING CONIFER PLANTATIONS

Thinning conifers

This section is just the briefest of introductions to the silvicultural theory and practice of thinning, which is a huge subject and is generally planned by consultants and executed by contractors. In keeping with the emphasis of this handbook, the subject is approached here mainly from the point of view of small scale plantations of potentially high value species.

Principles of thinning

The main purpose of thinning is to reduce the density of trees in a given stand so as to improve the rate of growth and quality of the remaining trees. It can be applied to hardwoods and softwoods but this section focuses on softwoods, as hardwood management is considered in other sections. Thinning can also be used to achieve additional objectives such as a change in the relative proportions of different tree species or as part of scarification to promote natural regeneration, or to gradually reduce stand height to ensure long term stability (see CCF). It is often valuable in providing an intermediate crop of firewood to help finance forest management.

Beware -risks of windthrow!

In practice in our region many conifer plantations beyond easy reach of markets have been left un-thinned and it is risky to embark on thinning after about 30 years due to the high risks of windthrow. Thinning of low value conifers has been considered uneconomical in many situations especially on difficult, steep or remote ground, indeed anywhere except with good access and within about 60 miles of mills.

Types of thinning

Two main types of thinning are 'systematic' and 'selective' but they are often combined or undertaken in quick succession. In systematic thinning, trees are most commonly removed in rows or strips. This opens up access for subsequent management but does nothing for individual stem quality improvement, species selection or development of structural diversity. Its use is therefore limited to forests being grown for particleboards or pulpwood, and to the early stages of stand conversion to CCF.

Selective thinning, by contrast, is designed to maximize both the yield and the quality of stems in order to produce constructional and furniture grade timber. There are three main systems of selective thinning: low thinning, crown thinning and intermediate thinning:

- Low thinning: remove suppressed and sub-dominant trees which are still competing with the dominants. Co-dominants are also removed at a later thinning to give stands of relatively evenly distributed trees.
- Crown thinning: remove a proportion of dominants or co-dominants to maximize growth of remaining trees, and in some cases to reduce stand height to promote stability (top grading). Subsequent thinnings tend towards intermediate thinning.
- Intermediate thinning: a combination of low and crown thinning where suppressed and sub-dominants are removed at same time as some competing dominants to open up canopy and achieve a relatively uniform stand structure.

Thinning Scots pine: forwarding by 4WD tractor with trailer and jib.

If you already have standing woodlands of higher value conifer species (not Sitka spruce or lodgepole pine) you may wish to consider thinning these and processing the logs on site. The higher value conifers – Douglas fir and larches – are often worth thinning if they have not already developed poor form. If they are over 30 years old, this will only be safe on the most wind-firm sites.

Thinning cycles

Thinning is not a one-off operation as is often thought! It constitutes an ongoing management regime at intervals (thinning cycles) that vary with species and site. As a rough guide, conifers are first thinned at 10-12m in height although this will be more likely determined by the girths required. There are advantages to an early start in terms of stand stability on the more exposed sites typical of our region. Length of cycle will depend on speed of growth and available resources, with a short cycle producing the highest yields and best growth form but costing the most. A compromise will in practice be sought and a realistic target would be 10-15 years for high value conifers. These should only be grown for timber on sheltered sites of reasonable fertility and soil depth.

See section 10 'Home-grown Timber – Markets & Uses'.

Such high value species will ideally be milled on site and the produce sold as locally as possible to maximize added value to the grower. The biggest value is added at secondary processing so this could be considered by growers with sufficient sustainable timber resources to merit the investment.

MANAGING EXISTING BROADLEAVED WOODS – in general

There are many types of existing woodland in the Highlands and Islands that may broadly be described as 'broadleaved woodlands'. These include predominantly native woodlands of the uplands, woodlands with intimate mixtures of native and

planted broadleaves, and those invaded by rhododendron. There are former coppice woodlands and there are ancient woodlands that have been under-planted with conifers or non-native broadleaves, and there are those invaded by beech or sycamore.

The control of Rhododendron is outwith the scope of this handbook. Refer to *Forest Research, Managing & controlling invasive rhododendron, 2006.*

Each of these types requires different types of management, suited to site and species and to overall long-term management aims. These will cover a huge spectrum from restoration of wood pasture to conversion of stands to high quality timber. One or more models of CCF as described above should, in many cases, be appropriate to broadleaved management.

The following specific species and management types are covered in this handbook:
Planted Ancient Woodland Sites (PAWS – see section below)
Oak (this section, below)
Birch (below but also see also Section 2, Woodland Establishment)
Coppice Management in section 4
Treeline and Montane Woods in Section 2.
Woodland for shelter is covered in section 6 Grazing Animals and Woodlands.
Section 2 also gives some further detail on other broadleaves as minor components in mixed woodlands.
In the most general of terms, management for high value timber comprises:

1. total protection from grazing and browsing animals (see establishment section)
2. pruning (see below)
3. thinning (see above)
4. selective harvesting (eg CCF regime of choice – see above).

© John MacPherson/WTML

On better ground in the Highlands, intensive broadleaved management would provide logs of respectable quality for milling. Most often, however, they are lightly managed for shelter, drainage, game and firewood.

MANAGING OAK WOODS

Before looking at oak management in the Highlands, some observations from England and Ireland over a period of planting and managing oak for timber since the 1970s are worth a mention. Generally oak has been nursed by conifers, often spruce but more recently by Scots pine and larch. Whilst the principle of nursing the slow growing oak with faster growing trees to give early shelter and inhibit side branching is agreed, it is now questioned as to whether species such as birch and alder might do just as good a job and allow better ground flora development. They are also easier to remove. Whatever the species of nurse, it is essential for it to be removed before it starts to suppress the oak. It is also considered by some that very densely planted pure oak stands are easier to manage and to thin selectively in several operations over time, leaving a suitable density of trees to grow on to maturity. It is worth remembering that while our own region may not be blessed with the most favourable soils or climate for growing timber quality oak, at least we do not have grey squirrels, which can decimate whole stands in England.

Also refer to sub-section 'Oak' in section 2 'Woodland Establishment'.

Oak woods have a scattered distribution around the Highlands and Islands from west Sutherland to east Aberdeenshire: many are very small and some are designated as NNRs. The most extensive in our region survive in Argyll and what follows is based on *The Sunart Oakwoods: a guide to their sustainable management* by Peter Quelch. This should be consulted where any oakwood is to be brought under management for whatever objective.

In some situations, "nursing mixtures" with pine, red cedar or another conifer can be used to establish a quality crop of native oak or ash, prior to planned removal. Scott Wilson in PAWS

The guide defines five 'management models', which endorse the general point made in the preceding section of establishing clear objectives before the prescription. Different models may be followed in different areas of the same woodland if large enough.

Our Atlantic Oakwoods have been artificially manipulated over centuries to favour oak for smelting and tanning – see Section 4

- Ancient Oak Forest *(Long-rotation high forest model)* see above
- Native Timber Stands *(Standard-rotation high forest model)*
- Coppice *(Coppice model)*
- Wood Pasture *(Wood pasture model)*
- Natural Reserves *(Minimum intervention model)*

The Sunart Oakwoods Guide is available at: http://ec.europa.eu/environment/life/project/Projects/index.cfm?fuseaction=home.showFile&rep=file&fil=ATLANTIC-OAKWOODS_Sunart.pdf

All models except 'Natural Reserves' may involve at least some timber production. It is possible that a model could change over a period of time but mostly this will be undesirable as it takes time and concerted effort to establish an efficient silvi-cultural system or to develop optimal biodiversity in the case of reserves.

Although these five types were designed primarily with oak woodland in mind, they could also be applied to the other woodland ecotypes, with some modifications. The Native Timber Stand model involves felling of various size coupes with natural regeneration or re-planting as in CCF. Alternatively it could be applied to completely newly planted stands on good fertile soils or to enriching existing birch stands. The conversion of felled conifer sites to this type is also ideal.

See also Section 6 for more on 'Silvo-pastoralism'.

In order to be sustainable, the Wood Pasture Model requires 'change in the stock-man's attitude to look at vegetation and tree condition as well as the husbandry of his or her animals'. Grazing will need to be very carefully controlled on a seasonal or rotational basis as described elsewhere in this handbook.

MANAGING BIRCH

With permission, this sub-section is based on *Growing Birch in Scotland for Higher Quality Timber* by Price A. and MacDonald E. Full citation is in the references.

Establishment of birch is considered in Section 2 and here we look at its ongoing management to produce timber and firewood. Birch management is worthy of its own section due to the prevalence of this woodland type in our region. An internal report to FCS by Price and Macdonald (2012) suggests that birch is well suited to CCF. It advocates a uniform shelterwood system, in which seed trees are carefully selected for their superior form. They need to be spaced at between 20 and 40 per ha. An alternative is to carry out small coupe felling in patches or in strips to allow natural regeneration. These methods are clearly cheaper than clearfell and replanting, but perhaps require more experience.

Also refer to sub-section 'Silver and downy Birches' in section 2 'Woodland Establishment'.

In a shelterwood system they recommend leaving well-developed seed trees at an even spacing of 20 -40 per ha. In a group selection system their suggestion is that the coupe size or strip should be a minimum of 20m to give adequate light levels, and a maximum of 60m to be within seeding distance of parent stock. Smaller coupes should be used for warmer, drier sites, and larger ones for cooler wetter ones.

Initial regeneration may be very thick, of up to 11,000 stems/ha, so it will need to be thinned. If you want high quality timber, this is best done when the trees reach 1.5 to 2m. At that stage you can select the straightest and most vigorous trees with the best crown form and give them fairly even spacing. It is possible to leave this thinning process until the trees are up to 6m in height but the quality and growth rate of the timber may be affected if it is done late. The aim is to maintain a living crown at above half the height of the tree. Growth will decrease significantly if this falls below 40% (Worrell, 1999). You need to remove approximately half the trees at each thinning in favour of dominant and co-dominant trees of better form (Cameron, 1996).

Birch is extremely light-demanding and neglected stands do not respond well to late thinning. They need to be taken into management when relatively young

(15-20 years old). It is probably only worth doing this with trees that are generally of good form and in areas that are adequately stocked (2000 – 3000/ha).

Birch is mostly self-pruning if these careful thinning regimes are followed. When uneven growth develops and live branches do need to be removed, they should be cut as early as possible in the tree's life. It must be done between mid-July and October, (in between the heavy sap flow of spring and autumn leaf-fall) to reduce the risk of discoloration of the timber. Wounds should be left to heal naturally.

PLANTED ANCIENT WOODLAND SITES (PAWS)

This section draws on *Restoration of Native Woodland on Ancient Woodland Sites* by Thompson et al FC 2003.

Planted ancient woodland sites are known as PAWS and are sites that have a long history of woodland cover: that is sites of ancient semi-natural woodlands on which the original, 'natural' woodland was cleared and replanted or underplanted with non site-native species.

Sustainable management to protect and enhance PAWS woodland is an important part of contemporary overall improvement of our country's biodiversity and specifically the recovery of our native woodlands. Some PAWS sites will have obvious remnant features, such as old native trees, or flora associated with ancient woodland. In other cases we may presume that remnants survive in less visible forms such as soil microbes, seeds and mycorrhizal fungi. The aim of restoration management is to retain remnant features of ancient semi-natural woodlands and to restore woodland over a longer period of time to species considered to be native to the site. This will not be easy on some sites and the approach needs to account for the, sometimes profound, changes to site conditions that previous human interventions may have caused.

Conifers were established on many ancient semi-natural woodlands from the Victorian era, and, notably, between 1950 and 1980: for most people these probably typify PAWS. Plantations of several species of exotic conifers were established on a variety of site types but some native woodland in the Highlands was also planted with, or has been invaded by, beech (Fagus silvatica). This casts a dense shade and can have a severe effect on the growth of other native trees, shrubs and herbs that would normally grow on the site.

Deciding how best to manage a PAWS involves careful survey work and the application of several ecological criteria including relationship of site to Forest Habitat Networks (FHN). Some non-native woodlands and exotic components of semi-natural woodlands support notable wildlife habitats that should be conserved. Specialist advice will be necessary in assessing prescriptions for PAWS sites.

An FHN has been defined for instance for the Atlantic oakwoods in the Highlands, see: https://www.forestresearch.gov.uk/research/habitat-networks/forest-habitat-network-in-scotland/highland-forest-habitat-network/

An ideal restoration will involve natural regeneration of native species after removal of exotics. The same criteria for success as for any natural regeneration scheme apply. That is to say that there should be sufficient seed sources throughout or bordering the site to achieve the desired restocking. This should include remnant understorey and herb species, as well as the principle tree species.

There may be major practical and economic constraints to be considered too, including access for the removal of the harvested logs. And there may be designated species or sites within the woodland that require protection, or there may be particular difficulty in fencing or funding the essential deer culling effort.

A phased transition to native woodland by gradual removal of the introduced species will be the ideal. A single major felling operation is to be avoided as it will

Contrary to the ideal scenario of 'phased transition' described, where the native woodland remnants are very limited and windthrow is a danger, it is sometimes the best option to clear fell. Indeed, a distinct problem is often created by nearby spruce (in particular) that is left standing which can regenerate rapidly and densely into disturbed ground.

cause sudden disturbance to flora and fauna with the rapid change of light and wind intensity that can make retained trees unstable.

A range of CCF systems may be considered, from those which produce regular stand structures (such as seed tree or uniform shelterwood), to those which create more irregular stand structures (such as group selection or irregular shelterwood). Where seed sources limit diversity of regeneration, subsequent phases of restoration may include enrichment with late successional species (e.g. planting up gaps in birch regeneration with oak).

As in other native woodlands, timber production may be part of a diversity of objectives so that re-spacing and thinning of regeneration may be desirable. Re-colonisation by non-native species, some of which may have been present as seedlings, will need to be removed, and control of grazing will be ongoing. Fence maintenance and deer culling are critical for this type of woodland restoration.

PRUNING TO IMPROVE TIMBER QUALITY

This section draws substantially on the authoritative *SAC Technical note TN594: Pruning to Improve Timber Quality. Copyright retained by SRUC*

Both hardwoods and softwoods can be pruned to improve timber quality but as the labour input is high it is generally only hardwoods that are pruned in Scotland. It takes some experience to do a good job but, more than that, it takes long-term commitment and time.

Whilst conifer timber quality can be improved by pruning, this is not usually carried out as a commercial operation. Close early spacing with progressive thinning is the general silvicultural method to improve conifer stem quality. At a small scale however, where it is practicable and labour is available, pruning Douglas fir and larch will help to achieve the highest value sawlogs.

There are two main types of pruning:
(a) formative – carried out from an early age to improve form
(b) high pruning – applied to older trees to remove defects

Pruning of broadleaves is worthwhile at any scale of operation and where there are perhaps only relatively small coupes of trees being managed for high quality timber within mosaics of different types of woodland it will not be a huge task. Yet such pruning should significantly increase the value of the final logs produced. Without pruning it is quite possible that a hardwood crop that might have made furniture grade sawlogs will end up merely as firewood. All species of broadleaves will require pruning to achieve their maximum potential timber quality and therefore value.

Early "singling"

The aim is to help a tree develop a single straight stem as free of defects and knots as possible. In the Highlands and Islands we will do well in many situations to grow one good butt log of 5-6 metres. Formative pruning and 'singling' is carried out early in stand establishment usually between 5 and 10 years old. Singling (ie removing multiple stems or forks to leave just one leader) will be necessary if damage has occurred, such as that inflicted by voles or rabbits. It may be necessary within 5 years. If you have early deer damage then something is profoundly wrong, as deer must be excluded completely.

We are not aiming at veneer quality but we can aim at furniture or visual grade post and beam frame quality. Within limits, the knottiness of timber is a matter of taste, and many creative furniture makers committed to the use of home-grown timber are able to utilize, and indeed make features of, knots and burrs. Nevertheless

hardwood mills will generally pay higher prices for straight clean logs as the timber from these is much more stable, workable and therefore marketable.

Formative pruning

Formative pruning is usually necessary for the first 10 years of a tree's growth but because of relatively slow growth rates in our region it may be that this is possible from the ground for more than that. It can be carried out every year or every other year.

The technique is to remove all crossing and rubbing branches, all coarse lateral branches, all dead branches, and to remove forks that are developing in the crown. However, as growth is dependent on the sunlight reaching a good crown of leaves, a balance has to be struck between removing branches and leaving a vigorous and well-formed crown for stability and photosynthesis. Never remove more than 30% of the live crown.

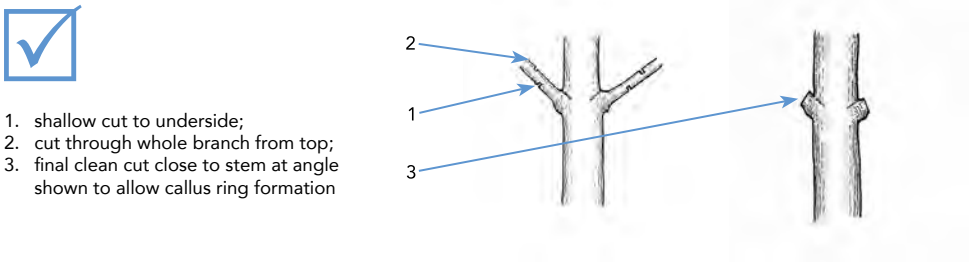
High pruning

High pruning is the removal of all lower branches on a tree at anything up to 10 metres but due to relatively lower tree heights in much of the west and north Highlands, a reasonable target might be 5 or 6 metres, the length of the butt log. A manual high pruner or extendable pole saw is used from the ground with the operative wearing suitable head protection. Hydraulically powered pruning chain-saws are also available.

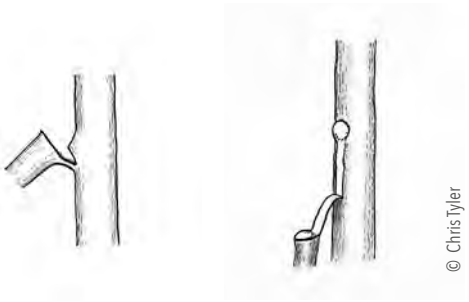
Refer to BS 3998 Tree Work

Cutting technique

Technique is very important in pruning as wounds are potential sites for infection. Target pruning is shown in the diagram below. It avoids damage to the tree's bark and ensures that the branch bark ridge and branch collar are left intact. Either leaving a peg or flush cutting are both highly detrimental and may lead to infection. A peg will produce a knot in the timber in any case, as the tissue grows around it.



1. shallow cut to underside;
2. cut through whole branch from top;
3. final clean cut close to stem at angle shown to allow callus ring formation



Never attempt to cut a branch of any size through in one go from the top as, apart from being dangerous, this is usually the result.

Timing

The best times to prune are late winter before bud burst or in full leaf in late summer. Important exceptions to this are birch which 'bleeds' if pruned between January and full leafing. And it is recommended to prune cherries in early summer to reduce risk of certain infections.

HARVESTING WOODLANDS

Currently in the Highlands & Islands, all but the smallest harvesting operations will probably be planned by consultants and executed by contractors. In this way the

sale of the timber is handled for landowners and all the regulatory requirements can be addressed most thoroughly.

A small number of estates have their own foresters and some farmers carry out their own farm woodland operations. They mostly use 4WD tractors with winches and some have their own dedicated forestry tractor units.

There are currently only a small handful of contractors specializing in small scale and environmentally sensitive harvesting operations in the Highlands and Islands. In the context of a more wooded future, with a wider diversity of management objectives on a wider range of scales, there will be business opportunities for more such enterprises.

SMALL MACHINERY

Most harvesting operations carried out by contractors will utilize harvesters and large forwarding equipment and this section does not cover such operations. Smaller scale harvesting operations, some of which will be in environmentally sensitive sites, are carried out by motor-manual methods, by qualified chainsaw operators. This section deals with machinery that can be used for forwarding the felled timber from woodland to roadside.

© Bernard Planterose

Iron Horse with powered winch but without jib or trailer being used to skid logs out of forest. Photo : anon

© David Petro Forestry Services

Alstor 8 x 8 with powered trailer and jib

© Skogsforum.se

Vimek 630 with its own trailer and powered jib.

© Ian Collier

Chainsaw milling attachment.

Mini machinery (under 2.5 tonne payload) includes a wide variety of forwarders which can be wheeled or tracked, sat on, sat in, or pedestrian led. They can be skidders with or without trailers, with or without powered jibs. In practice there are very few machines of this type operating in Scotland and perhaps only one or two

Highland based outfits offering machines with operators. The most common mini machine is the pedestrian led and tracked Jonsered/Lennartsfors Iron Horse. It has a maximum load capacity of 500 kg and is essentially designed for thinnings and firewood operations in very sensitive or difficult sites. It has exceptionally low ground pressure and is relatively dangerous to operate but has both small (20 metre cable) powered and manual winches. Newer versions have a powered jib on a trailer but it can be used to skid logs too.

The Alstor 8 x 8 wheel drive with 2 tonne payload is also used in the Highlands and is essentially a sit-on 4WD mini tractor unit with revolving seat and double-axled, driven-wheeled trailer with jib. Its only problem is it is cabless. The Terri 34c 8 x 8 is a tracked unit with tracked trailer and payload of 2.5 tonnes and a full cab. The Vimek 630 is an open ATV paired with a power-driven, double-axled, wheeled trailer and jib to make a superbly manoeuvrable combination from a company that makes a full range of forwarders. All the above machines are Swedish-made from the land of largely flat, dry and mudless forests!

One problem with mini machinery is its inability to stack high once at the landing where a road lorry can, when necessary, collect. The Iron Horse without jib cannot stack at all. Excavators with grapples are sometimes used to stack logs in yards.

In Scotland the felled timber of small and farm woodlands is mostly forwarded using 4WD tractors with powerful winches. There are various forestry trailers with powered jibs on the market that can be paired with such tractors and these combinations are very flexible for estates and farmers who may use the tractor for a variety of jobs.

Purpose built or modified tracked excavators above six tonnes are also used and these have the versatility of using both harvesting heads and grapples for lifting and loading logs.

HORSE LOGGING

Horse logging is the ultimate, low impact method of timber extraction from woodlands where it is critical to minimize environmental disturbance. It is also useful where there is a high degree of public access and a more sensitive and public friendly alternative to machine extraction is required.

Horse-drawn forestry systems are capable of harvesting timber effectively at all stages of forest management, from primary thinning to removal of the final crop. They are ideal for continuous cover forestry where small amounts of timber and even individual stems need extraction from within standing woodland.

Specialist draft-equipment enables a range of timber dimensions and volumes to be extracted or forwarded, from firewood to high-quality sawlogs. Given reasonable extraction distances and terrain, and good quality timber, horse systems offer a cost-competitive alternative to machinery. Logs are usually skidded using an arch, which can be wheeled or not. Horses are also sometimes used to pull trailers that have independently powered loading jibs.

Existing infrastructure including footpaths can be utilized with minimal damage, without the need for excessive felling or major earthworks, thereby reducing harvesting costs substantially. Access over steep, wet and rough terrain can also be gained, promoting active management of smaller or remote tracts of woodland. In addition, the action of logging by horse lightly disturbs the top layer of soil encouraging conditions suitable for natural tree regeneration. It is easy to alternate

routes and expand the pattern of distribution throughout the site, making horse-logging the perfect tool for CCF shelterwood systems for example. With new perspectives on the value of ecosystem services and greater emphasis on sustainable practices, horse-drawn forestry systems are playing an increasingly significant role in woodland management and are especially popular in community woodlands where they can provide an engaging and child-friendly spectacle.

CASE STUDY

THE HORSE IN THE FOREST

by Simon Dakin

From working in the forest as a woodcutter, I have seen the adverse impacts that certain mechanised operations can have on the forest ecosystem, primarily as a result of timber extraction. Seeking to work in greater harmony with the forest and offer an alternative, sympathetic method led me into the world of horse logging.

© Alex Henderson

Fuelled on solar energy, in the form of hay and grain, there is an inherent grace and humility to logging the forest by a living machine, which to me is simply incomparable with the mechanical equivalent. It is this, and the knowledge that horses have a far lower impact on the forest, that drew me into the profession almost four years ago now.

I began with my first horse Tarzan, a compact and seasoned logging horse standing at 15.3 hands and weighing close to 650kg. His breed, a Comtois, is well renowned for its strength, endurance and calm temperament – qualities highly suited to the demands of forest work.

I am often asked how much he can pull, whether in a day or in one load. As with machinery, much depends on ground conditions, gradients and extraction distance. He can skid individual sawlogs weighing up to 500kg and pull a fully loaded 2 tonne trailer. Two horses can be harnessed to pull up to 3.5 tonnes. Our daily extraction volumes range between 10-25m^3 for skidding and 30 – 40m^3 for forwarding.

© Alex Henderson

Extracting 60 cubic metres of Douglas fir sawlogs for cob house build in Cannich.

Autumn generally signals the beginning of the logging season for us, and we are often harvesting timber during the winter months. Summers have also become particularly busy, with demonstrations proving very popular. Over the last few years, horse-logging has taken me across the Highlands, working on private, community

© Alex Henderson.

Simon Dakin with his horse Tarzan.

and trust owned sites from my training base here at Dun Fionn Wood near Aigas, in Strathglass.

Classed as a PAWS, it is a narrow 3 hectare corridor of riparian woodland that I have been managing using CCF principles since 2015. Still in transition to full native woodland cover, it supports both productive birch and conifer stands and diverse habitats including old growth hazel and alder carr.

In common with many other forests in the region, it also has difficult terrain and sensitive ecology that can often limit access to otherwise productive stands of timber. However, this is prime horse-logging territory. Here at Dun Fionn, the horses' ability to overcome these constraints has been instrumental in improving opportunities for small-scale timber production.

This sets the scene for my wider vision in the Highlands – to promote greater acknowledgment and consensus for the use of horse-drawn systems in the Highlands. Dun Fionn Wood will serve as a working model to demonstrate the full capabilities and versatility of these systems, from the traditional skills of tushing (skidding) to using specialist draft equipment to forward and even skyline timber.

It was quite a struggle to gain planning permission for a small (37 square metre) cabin (under BS3632 'caravan standards') and 76 square metre byre. I had to produce much more survey data than would be required for a house. I cannot say that I felt supported by 'the system' in my endeavour to establish a base in the woods. Hopefully this will change as planners and policy makers start to appreciate the requirements of small woodland owners and their contribution to the rural economy, as well as to demonstrating genuinely sustainable management methods.

© Peter Lowe/WTML

PAWs thinning for Woodland Trust Scotland in Newtonmore. Scots pine sawlogs extracted to mobile sawmill. Processed timber used to restore black house at Highland Folk Museum.

Work is already underway with the re-structuring of the larch and Sitka spruce stands and these will supply both the main structural timber and cladding for the buildings. Douglas fir, cedar and birch will be used for internal applications. I have purchased a chainsaw mill and will mill all the timber on site, making the buildings as close to zero carbon as possible.

With education featuring highly in the project, once completed, the buildings will function as a training facility. I look forward to offering training courses and apprenticeships to inspire more people to enter the profession.

In the coming years, I hope the project as a whole will encourage more landowners and managers to see the benefits and viability of harnessing horse power to promote healthier woodlands.

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SECTION 4
COPPICE MANAGEMENT

CLIMATE CHANGE AND COPPICE PRODUCTS

Coppicing trees for a wide variety of purposes is probably as old as the Scottish forest itself, as one can hardly fail to notice the vigorous re-growth of cut, browsed or burnt stumps of almost all broadleaved tree and shrub species. New coppice shoots would have provided easily cut and conveniently sized poles for many purposes and, although not documented until the 13th century, coppicing was probably the first method for harvesting fuelwood without the need to fell whole trees. Coppice wood has a special place in Highland cultural history as it supported the major industries of iron smelting and tanning for about two hundred years and helped to shape a great many of the woods that survive today, albeit in neglected forms.

In recent times an industrial version of coppice management has been developed in several parts of the world, mostly to feed power stations, and is known as 'Short Rotation Coppice' (SRC). It involves intensive management, planting and harvesting with specialized machinery, and the use of fertilizers. Research and trials have been carried out in the Highlands but it has not been taken up with any great enthusiasm as no power stations in our region currently take the product. The scale of land unit, machinery and flattish ground required is not likely to be compatible with the vast majority of crofts and hill farms.

However, findings from SRC trials may feed into 'short rotation forestry' (SRF) and a revival of coppice management that is appropriate to our times and region including the Northern and Western Isles. It is therefore briefly considered from that specific viewpoint below.

Refer to Section 5 'Energy' for more on SRF.

Meanwhile traditional coppice has been seen as having some potential for re-development throughout Scotland to feed a growing domestic renewable fuelwood market as well as delivering multiple other benefits. It could, therefore, play a part in Scotland's low carbon energy strategy. This section focuses mostly on traditional coppice and ways this may be re-invigorated and adapted in the coming years in all areas covered in this handbook including the islands.

Significant damage to epiphytes can result from cutting neglected coppice woods so seek advice from SF or SNH! See Atlantic hazel woods below.

The substitution of a myriad familiar artefacts currently made of fossil fuel-based plastics for those made of coppice wood may sound idealistic. But only a hundred or so years ago they were indeed made from this resource. Substitution of even a proportion would help reduce demand for oil and, critically, help reduce oceanic pollution and landfill which have become major environmental issues. Rapidly developing technologies that modify timber with heat, acetylation, or new bio-chemistry, offer great potential for replacing plastic with timber-based products. Potentially huge markets for wood may open up, which it would be foolish to ignore.

SHORT ROTATION COPPICE (SRC)

COPPICE TERMS ARE IN GREEN TEXT IN GLOSSARY

SRC involves growing any fast growing woody vegetation on a repeated short coppice cycle, specifically for biomass production. Short in some locations means 3-4 years but that might be a little longer in poorer or more exposed sites of the Highlands and Islands. It differs from traditional coppice in its shorter rotations, limited objectives and use of any species including hybrids and clones. The short rotations and heavy cropping require artificial fertilizers which may prove costly to apply in the long term and are questionable in terms of resource use, pollution and GHG emissions.

Refer to Section 5 'Energy" for more on wood as fuel.

In some parts of Europe the wood from this sort of coppice is chipped and dried for power stations. Until recently there have been no power stations of this type in the Highlands and Islands, so this form of coppice has been little pursued. However, one is being built at Killin in Perthshire, so this may change. The various, mainly willow, hybrids that have been bred for SRC may be of some use in our region as many grow quite well, but caution needs to be exercised at this point as resilience to disease and exposure is not yet understood for these clonal plants. Native willows from local provenance may perform better in terms of survival, even if slower in height growth. Case studies in this section illustrate how short rotation coppice at croft scale is used to produce material for basket and sculpture making.

Chipping coppice wood for small scale boilers on farms or small local district heating systems is a possible future development as also illustrated in a case study in this section.

'TRADITIONAL' COPPICE – the history

As old as the forest itself

It is more than likely that coppicing in an informal or un-systematic sense was practiced by Mesolithic people in Scotland as, at a basic level, it simply involves cutting a broadleaved tree at ground level and then utilizing the shoots or 'poles' that regrow from the base. Nearly all native broadleaves can re-sprout from a cut stem though the different species do so with differing vigour. The stool (the remaining root and stem) lasts a variable amount of time and can go through varying numbers of cutting cycles, depending on species and site.

Coppice wood in early construction

Over the centuries it can be surmised that greater understanding will have led to greater use of this form of woodland management and we know that, by the 13th century, coppice wood was being used in large quantities for construction wherever it was available in the Highlands and Islands.

T.C. Smout 2005

"In the 13th and 14th centuries some houses and barns in both towns and countryside were "flimsy constructions of turf, wattle and thatch utilising pole wood (hazel, ash, willow) which seems to imply ready enough access to coppice materials".

Richard Tipping

"Whole houses were made up of twigs/wattling covered with turf, heather or straw. They might be thatched with rushes and only last 1-2 years ! Known as "creel houses" – a small one needed 2000 straight young poles".

Different forms of wattle construction with or without crucks, rafters and posts were remarkably widespread even in the 19th century. Wattling was sometimes plastered on both sides with boulder clay and whitewashed with lime.

It is hardly an exaggeration to say that wood was used to make most artefacts and structures and that thin poles from coppice were a major type of timber. This list

for birch alone is not exhaustive: houses, beds, chairs, tables, dishes, spoons, mills, carts, ploughs, harrows, gates, fences, ropes, turnery, wheelwork, lasts, patterns, shoes, pit props, sleepers, waggonways, bobbins.

Coppice wood for most artefacts

Coppiced willow wands waiting to be woven at All About Willow.

Hazel and willow were also used in buildings in the same way as the birch. Hazel was particularly favoured for fencing, hurdles, creels, baskets, and barrel hoops. Willows could likewise be woven into many artefacts and constructions, from fencing and hurdles to baskets. Alder was also coppiced throughout Scotland and, due to its rot resistance when immersed in water, was favoured in crannogs, water wheels, clogs, piers, bridges, and bank revetments, as well as for gunpowder charcoal.

Oak for charcoal to smelt iron and tan leather

But it was in the early 1600s that industrial iron smelting began in Scotland and brought many oak woods into coppice management in areas where the species was abundant. Bonawe, near Taynuilt in Argyll is the largest site and Letterewe in Wester Ross is another major one. Smelting also took place in Lochaber, Loch Lomond, Perthshire and the Trossachs. Bog iron may in fact have been smelted as early as 2800 BP or 2400 BP in NE Scotland! While the coppice wood was used to make charcoal to fire the smelters, the oak bark was sold to a rapidly expanding tanning industry. The coppice cycle was 19-30 years for oak and involved exclusion of cattle for 5-8 years after cutting. Standards of oak or ash were sometimes retained (see below for coppice with standards).

In-cycle oak coppice.

During this intense period of industrial activity, non-oak species were even removed from woodlands, as oak was so much favoured over other timber species. Oaks of different provenances were planted within the existing oak woods sometimes altering the relative proportions of the two species, pedunculate oak *(Q. robur)* and sessile oak *(Q. petraea)*.

Smelting and tanning using oak thrived for two hundred years between 1650 and 1860, when coal tar started to replace oak bark as a tanning agent and coke-fired smelting replaced charcoal. Many coppice woods were abandoned leaving a legacy of artificially even-aged stands and a higher density of stems than might be natural.

From T. C. Smout …in 1827 Monteith taught "…oak and nothing but oak is the only profitable tree for coppice cutting and…nothing else should be reared". "Coppice management may have helped to conserve oak but at the expense of structural and species diversity".

A further steady decline in coppicing as well as wood pasture took place from 1815 to 1915, partly due to massive depopulation of the region but also due to progressive loss of 'folk memory' and practical skills. Increasing sheep numbers, deer stalking and grouse management all contributed to the loss of woodlands in the same period and into recent times. In the latter 19th century there was a general decline in all hardwood management in Scotland, with abandonment of coppice, as imports of tropical and temperate hardwoods became cheaper and easier to source.

MANAGING AND RESTORING COPPICE IN THE 21st CENTURY

A Scottish coppice network is currently hosted by Reforesting Scotland.

New or restored coppice woods will be most appropriate in locations with developed access and where markets exist or can be developed. They can be of almost any size and of a variety of broadleaved species. Different coupes can be of different species within a site, so that the most appropriate species for varying soil conditions can be chosen. Growing more than one species will also reduce the risk of disease or crop failure for any other reasons. Coppice woods of various species should become highly productive and intensively managed elements within a mosaic of the diverse woodland types that this handbook promotes.

© Eleanor Garty / WTML

Neglected coppice – not cut for over 50 years and beyond restoring from the same stools.

Choice of site

The creation of new coppice woods will be best achieved from scratch (on new or re-stock sites) although there is some potential for restoring existing coppice. This can happen where coppice has been managed within living memory and is in a condition to re-sprout from existing stools. However, it is not appropriate where

coppice is of special conservation importance for its associated epiphytes and other flora.

See sub-section below on Atlantic hazel woods and conservation of important epiphyte communities.

New coppice woods will be most successful and economically viable when designed and established in relation to existing or intimately linked local markets. These might be fuelwood, charcoal, specialist manufacturing such as basket and hurdle making, or turnery. It will be most reliable where both fuelwood and at least one other market are being supplied. Developing the precise management regime and the markets together in an integrated way will be the path to sustained success.

Vertical integration of woodland management with market

Species choice, cutting cycles and other details of coppice management will derive from the requirements of the market or markets to be supplied. The domestic stove firewood market will require smaller logs, while batch boilers will take lengths up to a metre. If produce is going to be chipped, the diameter range and species will be less important. Small diameter fuelwood should not require splitting.

Coppice for fuelwood is covered in section 5 'Woodlands for Energy'.

Site conditions may constrain species choice to some degree. Special attention will need to be paid when growing willows or alders to ensure that soil conditions can provide sufficient water to a high density of these particularly water demanding trees. Ash and hazel will do best on more fertile and freely drained sites.

Due to ash dieback disease (known as Chalera) there is currently a ban on planting ash. Observe SPHNs and follow guidance at https://scotland.forestry.gov.uk/images/corporate/pdf/Management-of-Native-Ash-Policy-Guidance.pdf

As with all silvicultural systems, the better the ground in terms of fertility, drainage and shelter, the faster the crop will grow and the better the economics will become. You should not try to establish coppice on poor peaty sites just because they are available. Instead you could look to the many croft fields that have gone to rushes and are ideal for new coppice woods. These are often damp and quite fertile and can be planted with modest site preparation. Rushes should be turned over mechanically and well covered. Do not drain new sites unless saturated, as clearing existing ditches will usually suffice. All animals including rabbits and deer must be totally excluded by a very high standard of fencing. Early weed control and vole protection will be required for good establishment.

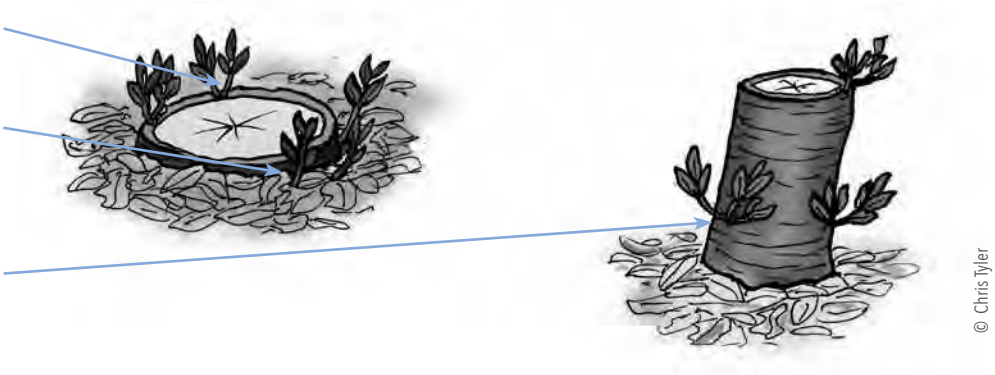
Final cut close to ground to stimulate stump sprouts as opposed to adventitious growth which can be prolific on willow. Use of chainsaw as this wood has been left uncut for 29 years !

Ideally the length of rotation is established in relation to known markets and the woodland divided into a number of coupes equal to the number of years in the rotation. One coupe is then cut each year. Clearly one way of establishing coppice from scratch would be to plant a coupe a year for the same number of years as the cycle.

Types of bud

There are three types of buds that can sprout after cutting: epicormic growth from the side of the cut stem; prolific growth from the callus ring, much of which may be short lived. The 'stump sprouts' formed from 'suppressed buds' (which are

sometimes just below the surface) are the important ones for vigorous coppice growth: hence cutting close to the ground is important.



© Chris Tyler

Timing

The timing of cutting influences timing of new shoot production as well as survival and it is better when trees are coppiced during the dormant season between late autumn and early spring. Birch is best coppiced before the turn of the year as it will weep if cut after that. Ash may not sprout in the first year if cut after the New Year.

Cutting tools

Trees should be cut close to the ground in the case of first cuts, and subsequently as close to previous cutting height as possible, to encourage stump sprouts and overall stability. Do not cut into old wood. Ideally use billhooks or loppers in preference to chainsaws.

Cycle or rotation

Cutting cycle or rotation will depend on the size of poles required and will vary with rate of growth. Hazel rotations are generally less than 10 years, oak less than 30 years, alder 25-30 years, ash 10-25 years, sycamore less than 25 years, wych elm about 25 years. Birch varies considerably between 3-20 years, depending on the product required. Willows vary greatly in growth rates, depending on species and uses, but can be as short as 5 years or nearer 10 if for firewood.

Thinning shoots

It is sometimes useful to reduce the number of shoots on newly cut stools to encourage a slightly faster growth of a smaller number. This will depend on diameters required and the rotation length, which will come back to site and species. To some extent new shoots are self-thinning in any case.

Longevity

Birch is unpredictable as a coppice tree and stools are liable to die after 2-3 rotations. Restoration of neglected birch coppice is therefore seldom successful and new planting will be required. Hazel responds poorly to cutting if left for more than 50 years but can live to several hundred years if managed continuously. Oak stools can survive repeated cycles for more than 200 years.

Browsing exclusion

Browsing by deer, domestic stock and rabbits can completely destroy young coppice growth. All these animals will need to be completely excluded from coppice woods in the immediate years after cutting. Where longer rotations are being employed, for example oak on a 25 year cycle, it may be possible to allow some access to domestic stock but monitoring for damage will be important. High specification and well maintained fencing combined with shooting are the highest costs of coppice wood management. Vole guards will often be essential even within rabbit fenced plots to protect newly planted trees.

© Les Bates

Lobaria Spp. *growing on neglected hazel coppice that should be conserved.*

Many neglected coppice woods have not now been cut for 150 years and will not respond well. Furthermore they now support impressive amounts of wildlife, including many lichens, and you should not cut these without first seeking advice from

SF and SNH. Felling licences are required unless the coppice is still in active management and stems are less than 15 cm in diameter.

Establishing new coppice by planting is best at 2500/ha, which will be thinned to an eventual stocking of 1750 to 2000/ha. This would be suitable, for instance, for willows on a 7-10 year rotation. The spacing could be wider if the rotation was longer, and regrowth therefore larger, before re-cutting. A good crop of hazel is given as 25000 rods or poles/ha but this is probably a figure for a Lowland site.

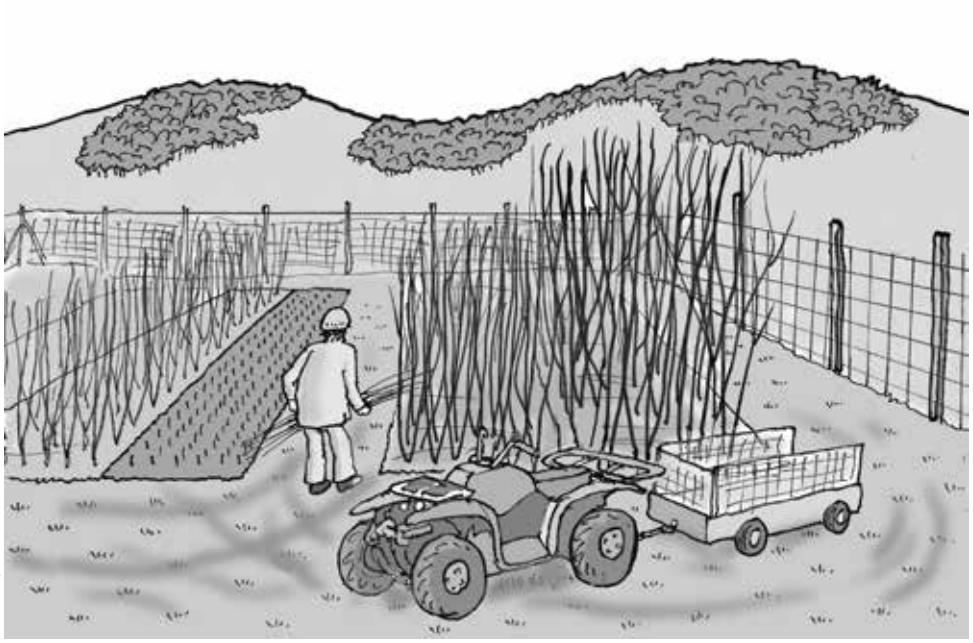
Access design

New sites should be set out in relation to frequent access of machinery of a known size. This will often be a mini-tractor or ATV and trailer. Access lanes may be around 4-5 metres apart with adequate turning heads at each end.

Beware of damage to old woods and seek advice! See Atlantic hazel woods below.

Coppice with standards involves leaving some trees standing as single stems to maturity at a wide (100/ha max) and even space throughout the coppice wood. This traditional system was developed to utilize sites more fully, providing some sawlogs from the same pieces of ground. In Sunart woods there are examples of oak, ash and birch having been grown as standards in former coppice. In England oak standards were commonly grown amongst sweet chestnut or hazel coppice. However this system is less likely to be suitable for sites in the Highlands and Islands, due to our higher exposure. Open grown trees do not produce the best sawlogs in any case.

Establishing new coppice



© Chris Tyler

A simple, croft-scale layout, well fenced against deer, stock and rabbits, suitable for several types of enterprise: a tree nursery, perhaps specialising in bare-rooted cuttings for sale or for on-croft planting schemes; growing willows on very short cutting cycles for basket making; or on a slightly longer cutting cycle with larger beds, providing logs for firewood or chipping; or even all three products with varying sized beds within a single plot.

Wildlife benefits

Coppice management creates excellent wildlife habitat as it favours light and warmth demanding plants. It is good for insects including butterflies and in creating irregular edges known as 'ecotones', ideal for instance for hunting sparrowhawks. Occasionally coppice is managed principally for wildlife as it is for the chequered skipper at Glasdrum, near Oban. In such cases, coppice with standards can provide an especially rich habitat with the widest range of spatial heterogeneity and therefore ecological niches.

Standards should not form more than 30% of the canopy at the start of each cutting cycle or they will seriously reduce growth of the coppice stools by shading.

Peter Quelch who has studied coppice extensively ponders : *"Could coppice with pollarded veterans be an example of imaginative new thinking on the future silviculture of native woods?"*

CONSERVATION OF ATLANTIC WOODS AND EPIPHYTES

COPPICE TERMS ARE IN GREEN TEXT IN GLOSSARY

Hazel woods, especially those in the wetter, oceanic climate of western Scotland, support a rich diversity of lichen and bryophyte (moss) species. Many of these are not found elsewhere in Britain, and some are globally rare.

Coppicing in these long-established woods can have catastrophic effects on lichens, which colonise new stems only very slowly, and only occur in conditions which have retained a degree of ecological continuity over time. Young, smooth hazel stems support crustose lichens (Graphidion community), while the older, rougher stems support mosses and foliose lichens (Lobarian community) – the most easily recognised of which is Lungwort, with its great, lobed 'lungs' hanging from branches. 'Old woodland' lichens also occur on other tree species, notably oak, however coppicing is rarely practised on mature specimens.

While the prevalent traditional coppicing method involves cutting all stems in a coupe, in our region a variant was practiced where individual stems were cut as required.

When a hazel is completely coppiced, all of the lichens will be lost with the stems, and only a few, more common, pioneer species will be able to colonise the new growth. A regular clear–cut coppice cycle will permanently destroy the rich diversity of lichens and bryophytes associated with hazel. Nonetheless, most of these old woods have been cut for various purposes over centuries, but it seems likely that this has been on a selective basis, cutting a few stems from each stool, which allows continuity of habitat. For the cutter, there may be some advantages too:

- New stems are forced to grow up straight between the retained stems in order to reach light. These straight-grown stems are the ones that have the greatest number of uses.
- Stools that are clear-cut will sprout prolifically from the base, but the stems tend to grow crooked and are much branched, and take a longer number of years before the required straight stems begin to form.
- Selective cutting from a sizeable stand of hazel means that stems can be cut on a yearly basis, whereas complete coppicing of stools means waiting for a period of up to 7–12 years before suitable stems are formed.
- Retaining stems within the stool offers some protection of new shoots from grazing animals.
- Mature stems will provide nuts each year.

This list is reproduced with permission from Coppins A.M. & Coppins, B.J. (2010). Atlantic Hazel: Scotland's Special Woodlands. Scottish Natural Heritage

Two metre tall native grey willow re-growth one year after coppicing in Wester Ross, on formerly wet rush-infested ground.

A TABLE OF COPPICE TREES

Species	**Site requirements**	**Longevity** (must be cut regularly to attain longevity)	**Cutting cycle** (rotation) – depends on product required	**Uses**
Exotic willows and clones	Damp with good water supply	No firm information	2-5 Yrs	Basket making mostly
Common osier	Damp with good water supply	No firm information	2-5 Yrs	Basket making mostly
Native willows: grey willow, goat willow	Damp with good water supply	Prone to rot where splits occur but can still last many decades	2-10 Yrs depending on product required	From temporary fencing to hurdles to baskets – many uses
Native oaks	Relatively fertile	Very long – 100 yrs or more	<30 Yrs	Charcoal making, firewood but also turnery and durable poles for many exterior uses
Hazel	Relatively fertile, well drained	Very long – 100 yrs or more	<10 Yrs	Fencing, hedge laying binders, creels, baskets, barrel hoops
Common alder	Damp with good water supply	Very long – 100 yrs or more	25-30 Yrs, much shorter if for fuelwood	Charcoal, firewood and turnery. Due to rot resistance can be used in external items
Exotic alders	Damp in the case of red alder, well drained and drier for grey alder	No firm information for our bioregion	5-10 Yrs	Can be very fast so contenders in short rotation coppice as fuelwood
Sycamore	Tolerant of wider site conditions	No firm information for our bioregion	10-25 Yrs	A hard white fine grained wood ideal for turnery and household items, sometimes spalted.
Wych elm	Relatively fertile, well drained	No firm information for our bioregion	C. 25 Yrs	Tight grained and water resistant. Good for turnery.
Ash	Neutral to alkaline ph, drier sites tolerated	No new planting permitted due to disease	10-25 Yrs	Ideal for turnery and furniture making. A beautiful hard, pale wood. The 'queen of firewoods'
Birches	Tolerant of wider site conditions including peaty and acidic	Liable to die after 2-3 rotations ! Not recommended	3-20 Yrs depending on product required	A very wide variety of indoor household items and turnery. Beautiful hard wood, sometimes spalted.
Sweet chestnut	Neutral to alkaline ph but not generally grown in the highlands	Very long – 100 yrs or more	10-20 Yrs in southern england	Natural durability makes this a highly valuable species for tree stakes and fencing

CASE STUDY

ALL ABOUT WILLOW, EIGG

by Iona Hyde, Catherine Davies and Pascal Carr

When Catherine Davies and Pascal Carr moved to the Isle of Eigg in 2000 they were still learning the craft of basket weaving. However, four years later their skills had developed to such an extent that they formed the basis of their business case when they applied to the Isle of Eigg Heritage Trust (IEHT) to take on the tenancy of a 6ha new croft at Cleadale on the west of the island. In 2008, they established All About Willow and are now highly skilled, internationally known basket weavers with a business that provides them both with full-time employment. They produce a wide range of baskets from willow grown organically on the croft and sold throughout the world.

Willow field in foreground leading down to the house and workshop with the Isle of Rum in the background.

BECOMING CROFTERS

In 2004 when Catherine and Pascal were awarded the croft tenancy for Croft 18, Cleadale there was no house or outbuildings, no services and no vehicular access. They had to invest a high level of personal capital and hard work to get things going. Initially, they had to bring all of the materials and tools needed for the fencing and for creating trial willow beds to site on foot. It was not until 2009 that a Crofting Agricultural Grants Scheme (CAGS) award allowed the development of road access to the site and the creation of a further larger willow bed.

In 2014 the pair finally moved onto the croft, albeit into a 16 feet caravan without running water, electricity or sewerage. Since then, with support from the Crofting Housing Scheme, they have built a new house. After another successful CAGS application, this was followed by the construction of a workshop and store, which is necessary for drying, grading and storing the willow. It is worth noting that there was a significant delay in processing this latter application because, as a novel

Willow field from the air.

diversification project, the growing of willow for basket making was subject to screening under the Agricultural EIA Regulations by RPID. Fortunately no EIA was required. Four years on, in addition to the house, workshop and store, the crofters now have a gallery, 3 willow beds supporting approximately 5000 stools, extensive vegetable gardens, and a thriving basketry business.

Pascal and Catherine weaving a coffin with willow from the croft

SELECTING & PROTECTING WILLOW VARIETIES

Willow varieties were selected by trialling and several were discounted as unsuitable for the climate on Eigg. Approximately 20 varieties are now grown with 'Flanders Red', 'Harrison', 'Slender Tip', 'Brittany Green', 'Packing Twine', 'Continental' and 'Dicky Meadows' being the most useful. Most material for cuttings comes from plants grown on the croft, or when they are trialling new varieties, from other well-known and trusted willow growers. The willow is grown in a 0.3ha bed which was prepared by removal of surface plant material and overlaying the site with a permeable, UV stabilised geotextile through which the willow has been planted. There

are no deer on Eigg and the rabbit fencing erected to protect the willow beds also excludes neighbouring sheep and cattle from the croft. Voles, rabbits and wind have been the main obstacles to establishment. On-going trapping of voles has been necessary to protect the plants. The bracken surrounding the willow beds and gardens grows to a height of over five feet in the summer but provides an effective windbreak for the willow and gardens during the growing season when shelter is needed most. The croft is completely organic and no fertilization of the willow has been necessary.

A selection of baskets in many varieties of willow

COPPICING & PROCESSING

The willow is coppiced annually and then completely dried for storage. Later it can be soaked for use in creating the traditional and contemporary baskets as well as coffins for which All About Willow is now well known. Each stool has a coppicing life of about 25-30 years. The bark is left on the cut willow rods and they are not processed in any way to allow the natural colours of the different varieties to be used in the design of the basket. As well as producing baskets, Catherine and Pascal teach basket-making by running courses both on Eigg and elsewhere, including in France and Spain. Catherine also offers courses in weaving baskets from recycled materials such as juice and milk cartons, newspapers, magazines and plastic bags.

OTHER PLANTS FOR USE & SHELTER

Other plants that are used in basketry are grown and encouraged to colonise the croft including dogwood, field rush and flag iris. 500 hazel have been planted to provide future material for craft production as well as firewood. The crofters grow a wide variety of vegetables in two poly-tunnels and a large vegetable garden, producing enough for the pair to be self-sufficient throughout the year.

MARKETING

All About Willow produce is marketed principally through the business website and by word of mouth but also through international and national craft fairs, galleries and specialist outlets. Social media is also playing an increasingly important role in promoting the business and its products to a global market. For the past few years, All About Willow has been the basket maker and supplier for the US television series Outlander, a historical drama set in 18th century Scotland.

REMOTENESS AN ASSET

Catherine and Pascal consider their remote island location and the existence of the crofting system to be business assets. Although there are additional travel and transport costs associated with their location, the ability to access affordable land and the security of tenure offered by the crofting system have been hugely advantageous. The crofters acknowledge that this has been largely possible thanks to the community buy-out of Eigg in 1997 which has provided the opportunity for their landlord, IEHT, to create new crofts. They see their viable croft and successful business as examples of the important contribution that crofting has to play in land management, sustainable living and the survival of traditional crafts in the 21st century.

https://all-about-willow.co.uk

CASE STUDY

MUSINGS OF A COPPICER

by Mike Ellis

MUSINGS OF A COPPICER

Coppicing is probably the oldest form of sustainable forestry, dating back thousands of years. The incidence of coppicing in the far north is, and has probably always been, very limited. This is mirrored by its perception as a dark, if not dying art. Yet for thousands of years it was the engine room that provided material for smelting iron and the making of everyday items from domestic tools to timber frames. In the last century, like many traditional trades, it was slowly consigned to mere glimpses of our past.

My first contact with coppicing and its products came in the 1990s when, as a hedge layer, I needed hazel stakes and binders. I would travel many miles from my base in Nottinghamshire to obtain them from a Hampshire coppice merchant. Even then I was aware that the amount available was small. This was, and still is, a result of the huge decrease in the area of land under working coppice. Coppice products are thus scarce. With some effort they are possible to find south of the border and almost impossible in the far north.

Coppicing with a traditional billhook.

The times though may be 'a changing'. Hedgers and thatchers still require coppice products to ply their trade, not to mention hurdlemakers, but the sad truth is that the majority of their needs are supplied from material that is imported. To my mind this presents an opportunity to supply a home market that has been on the increase in the last 20 years or so, with the rise in conservation and biodiversity awareness. The benefits of coppice to a croft, regardless of the ups and downs of the trade market have not changed, though, and my croft in Helmsdale will serve as an example. In area less than two acres, and already blessed with a handful of mature beech and sycamore trees when we bought it over 10 years ago, I have planted and worked regrowth to the great benefit of the holding.

SHELTER

The croft is exposed to the prevailing wind, so the need to establish shelterbelts soon became obvious. To this end I began planting hazel and willow. They are not in a rigorous coppice regime, as there simply is not the space when the house, veggie garden and outdoor greenwood workshop are taken into account. The plan was to plant a series of mini screens that, with coppicing, would increasingly thicken and thereby diffuse strong winds. This has had the effect of creating a calmer microclimate that enables other plant material to be grown.

FUEL AND CHARCOAL

Material that has been regularly coppiced has been corded and used to provide woodfuel, charcoal and par char (material not completely charcoaled during a burn). The benefit of par char is that the partial charcoaling process removes most of the pyroligneous acids and moisture from the wood, negating the need for seasoning. It produces a clean burn with more of the calorific energy from the logs released as heat on combustion. Brash from the coppicing has regularly been reduced to ash and used as a soil sweetener. I have also been making charcoal for some years now, using two metal kilns, and selling it locally for the BBQ market.

COPPICE PRODUCTS AND MARKETS

Coppicing, by design, will produce long straight stems that, depending on species, will be suitable for the making of a variety of products such as tool handles, baskets, fences, gates, hurdles and many others. I have supplied gates for a variety of folk including the Forestry Commission (Forestry Scotland) and Woodland Trust, as well as private customers. However, the market remains niche. In case of coppice materials, the demand is largely determined by the number of craft or trades folk requiring them locally.

© John MacPhersib / WTML

Mike Ellis in the Helmsdale Woodlanders 'shed'.

© John MacPhersib / WTML

A young hazel coppiced once.

THE PLEASURE OF BEING A WOODSMAN

The woodsman or coppicer by nature has a holistic view of the work undertaken: nothing is wasted; brash is turned to ash; stems suitable for products are made use of and the rest becomes fuel. Nature provides an additional bonus, as the leaf litter from the coppice will break down and enrich the soil, providing more vigorous growth. In terms of biodiversity the coppice, forever alternating between states of light and shade, produces a richly biodiverse environment.

Last but not least, for those who are open to them, there are the physical, mental and emotional benefits of working in woodland. I devised a traditional woodsman's course for the National Open College Network, which I ran for about six years. It served to promote woodland culture and provided me with a modicum of income. These days I instruct a voluntary group, the infamous and slightly bonkers Helmsdale Woodlanders.

NUTS AND BOLTS

So far so good, there are two crucial points to note, however. Firstly, no matter how much you apply best practice in your species choice, planting, spacing and cutting cycle, it will all be for naught unless you prevent browsing pressure. Secondly the establishment of coppice to full rotation (max number of stems) takes time. Be prepared to be in it for the long haul: just an example, hazel normally takes three coppices at 5-7 year intervals to achieve full rotation.

SUGGESTIONS OF WHAT TO PLANT

The species of choice for coppice value are well known: hazel, ash, oak, and sweet chestnut are the most used. One common factor is that they are ring porous and therefore easy to cleave. From the perspective of the far north, however, I have noted that birch and rowan also coppice well when young. In my opinion, of the chosen species, sweet chestnut would be a very, very good choice, as there is no reason why it should not thrive in the north.

In conclusion, for those who choose to manage a woodland croft, you will begin to see what best to plant as a resource. It may or may not earn you a wage, depending on the scale, markets, and location, but it will almost certainly save you money. Of more import, you will be on your way to becoming a woodsman!

www.facebook.com/Helmsdale-Woodlanders-203638826400771/

CASE STUDY

NORTH HARRIS TRUST: COPPICE TRIAL

by Bernard Planterose & Gordon Cumming

COPPICE ON UNUSED CROFTLAND

In 2007, with the support of The Woodland Trust, North Harris Trust embarked on an ambitious coppice trial close by Scalpay bridge to assess the potential of several tree species for woodfuel production. It was first coppiced in 2014 using chainsaws. Many households have wood burning stoves that currently use imported wood and peat so a ready market for locally grown fuelwood undoubtedly exists. Unused croft land was prepared for planting by 'taking a modern approach to the traditional lazy bed system', in the words of Steven Liddle who masterminded the project. The site was drained and the peaty ground turned over mechanically. Four metre wide beds were created with new drainage between. A selection of non-native willow species, black poplar and sycamore were planted as well as the native grey willow and common alder.

Site preparations undertaken in 2007. A contemporary approach to 'Lazy beds'.

RABBITS!

Unfortunately the area suffered an explosion in the rabbit population and, despite the installation of rabbit netting and culling efforts, the willows and black poplar suffered major losses. Willow slips were harvested on site and used to re-stock, but the rabbits continue to be a problem. Finally, areas were stocked with common alder. The alder is clearly less attractive to rabbits and is establishing well. Indeed the trial is showing that the native willow, alder and non-native sycamore are best suited to the site, with common osier *(Salix viminalis)* also performing reasonably well. This is very much in agreement with observations on the mainland west coast in similar sites. Black poplar *(Populus nigra)* grew reasonably well but produced rather straggly stems, which were harder to cut and process and was not so exposure tolerant.

BIOMASS DATA

The intention is to carry out harvests in 2020 and 2021, allowing data to be gathered on the biomass production of the various species trialled. Perhaps these data will generate enough confidence to promote more widespread biomass planting.

The coppice trial period will end in 2021 when management of the land is returned to the crofters. NHT hopes the crofters will continue to manage their coppice woodland, providing firewood for local use. One of the crofters is seeking to take part in a trial to install a Biomass Combined Heat & Power boiler with the intention of heating the family home with croft-grown fuel.

Common alder in foreground growing well about four years after first coppicing.

A mix of alders, willows, black poplar and sycamore, coppiced once after six years.

The project has demonstrated that unused croft land can be turned over to the production of biomass. Currently, the limited annual production on Harris makes investment in expensive harvesting and processing equipment non-viable, but for the self-sufficient crofter looking to put their ground to good use this is clearly an option worth considering, even in the windswept Hebrides.

www.north-harris.org

SECTION 5
WOODLANDS FOR ENERGY

CLIMATE CHANGE AND TREES FOR ENERGY

The different carbon terms defined: 'Carbon' (the element) is often used as shorthand for the gas carbon dioxide (CO_2), which can be confusing. Carbon dioxide emissions make up a part of all greenhouse gas (GHG) emissions. Carbon sequestration refers to the extraction of CO_2 from the atmosphere through photosynthesis by vegetation including trees. Carbon fixation refers to the conversion of CO_2 into carbon rich solids such as cellulose which make up most of timber. This can then be stored, for example in furniture and timber constructions, for as long as those items do not rot or combust. Carbon capture and storage (CCS) refers to technological solutions still under development that may offer opportunities to extract carbon dioxide from the atmosphere and from fossil-fuelled power station flues and store it for the very long term underground in geological formations.

Heating our homes, offices and work places and heating the water used in them accounts for about 40% of Scotland's energy needs. Part of the Government's low carbon strategy of recent years has been to reduce these needs through insulating our homes better and promoting airtightness in all new buildings. These changes have been driven by Building Standards, education, and grant aid, particularly for home insulation.

The use of renewable energy at all scales including domestic has been seen as the other major route to lowering fossil fuel requirements and therefore greenhouse gas (GHG) emissions. As wood is considered a low carbon and renewable energy source, the UK-wide Renewable Heat Incentive (RHI) currently subsidizes biomass boilers including solid log, batch boilers and wood pellet stoves in both domestic and commercial installations (but not domestic wood-burning stoves for space heating).

Growing trees specifically to burn for energy is known as energy forestry (EF) and comprises three woodland management types: short rotation forestry (SRF), short rotation coppice (SRC), and traditional coppice. The first two types have been under investigation in Scotland for several years with the hope of developing silvicultural and management systems to feed power stations or district heating schemes. Traditional coppice can produce firewood for burning in domestic appliances and small industrial units. Whether burnt in a power station or in a domestic stove, wood can substitute for fossil fuels.

SRC and traditional coppice are considered in Section 4 'Coppice woods'.

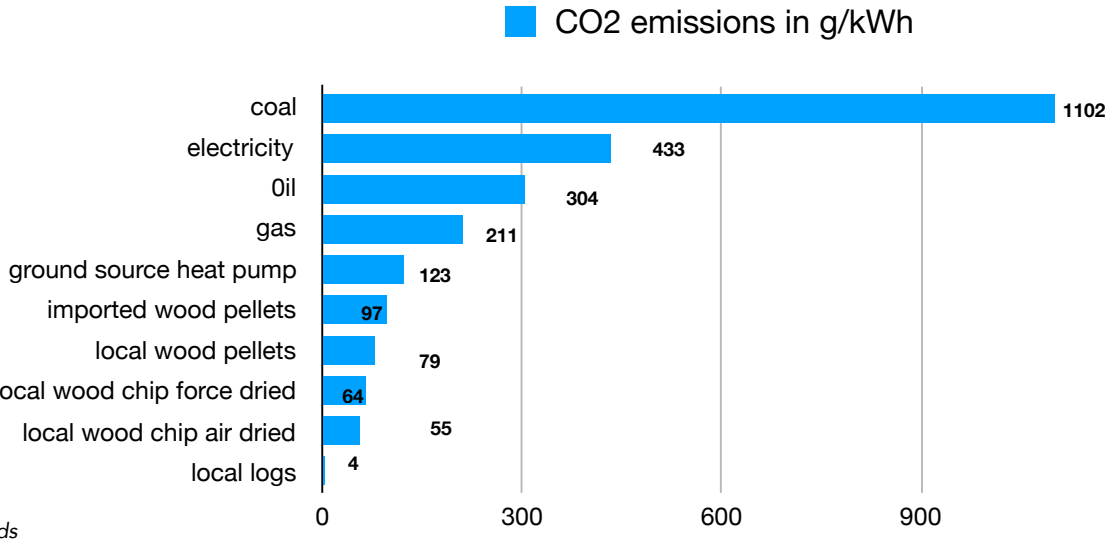
Wood is a renewable energy source and although rich in carbon it is considered to be a low or neutral carbon fuel source. This assumes that every tree that is cut is replaced by new ones which will remove (sequester) carbon from the atmosphere and store (fix) it in wood tissue.

BUT deforestation – when trees are cut for agriculture or other development and not replaced – contributes 15-20% of global man-made emissions, more than the world's entire transport sector. This is why you will find a presumption against removing trees in Scottish Government and Local Authority planning policies.

Refer to https://scotland.forestry.gov.uk/images/corporate/pdf/control-of-woodland-removal.pdf

The shorter the distance firewood is transported and the fewer the power tools used to process it, the nearer it becomes to being a truly carbon neutral fuel.

The emissions from 'local logs' (locally cut, processed and used close to source) may be considered as contributing about 4g/kWh compared with oil at 304g/kWh. Clearly this is a huge saving in GHG emissions!



Reproduced from Highland Birchwoods The carbon balance of woodfuel.

INTRODUCTION – history and resurgence

The first energy source

Wood (along with peat) has been used as a source of home energy in the Highlands and Islands for millennia. It was also used commercially for long periods of time in some parts of the Highlands for making the charcoal used in iron smelters, and the kindling needed when coal is used for lime-burning.

Loss of local woodlands, relatively cheap oil and electricity, and the ready availability of coal have all contributed over the last two hundred years to a huge decline in the use of wood for energy. Today the relatively large amount of human time and energy that needs to be put into firewood, even in the few places where it is readily available, means that it is not a major domestic fuel in log (or any other) form.

However there has been a resurgence in the use of solid logs brought about by the increasing price of fossil fuels. Modern wood burning stoves are efficient and clean. They come in a great range of designs and heat outputs. In addition we have seen the development of batch boilers (some self-feeding or 'semi-automatic') at domestic and small commercial scales. These are usually for whole logs and are combined with large accumulator tanks for efficient storage of hot water. They are often integrated with other renewables like solar power.

There has also been some development of wood chip processing at farm and estate scale in the region, mostly for own use, and a small number of enterprises can supply locally. The slow growth in the wood chip market in the Highlands is due to problems of supply, the investment required in equipment for processing and storage, and some quality issues that have bugged both the product and the user installations.

Where firewood is used to heat space and water and to contribute to cooking and baking, it can make a significant contribution to the home economy. This will depend on good building insulation and air-tightness, well insulated water storage

and use of modern, efficient appliances. Old housing stock and old appliances remain a problem in this regard.

Burning wood can cause pollution when wood is not properly dried, or is burnt too slowly, or is held overnight on slow burn. Modern batch boilers rely on fast and hot burns, burning at intense heat to ignite all gases efficiently. Hot water is stored in well-insulated 'accumulators' – tanks that can take more than one source of heat and stratify water intelligently to maximize efficiency.

A mix of fuels is important in the Scottish energy economy for fuel security and only a small part of the region's needs is ever likely to be met by solid log. Nevertheless, for those areas of the Highlands served by abundant and accessible woods and/or not well served by other renewable energy sources, firewood represents an economic and low carbon option. Community biomass heating schemes can therefore be subsidized.

It may be that the time for local firewood production in our region is only just returning as the woodland resource recovers and becomes big enough again. It is a question of appropriate investment in processing capability and sustainability of timber supplies. The relative ease and cheapness of fossil fuels has probably played a part in saving a few woods from complete destruction, but now its increasing cost and carbon footprint may help us to value our woodlands more highly for their renewable energy supplies. This could bring about an increase in our area of woodland and encourage its more sustainable management.

WOODLAND TYPES FOR FUEL

Different woodland types for producing firewood

Almost all woodland, of whatever scale or species mix, softwood or hardwood, with careful management, can yield some firewood on a continuous basis. As more woodland is protected and regenerated and more plantations are established, the potential firewood resource of the Highlands is slowly but surely increasing. Amounts of woodland in the Western and Northern Isles, as well as the smaller islands to the south, may always be limited but even in these places significant increases can be made if it is seen as a priority. As is being shown already, there is a place for both traditional and novel fuelwood coppice systems in all the island communities.

This section considers woodland management for solid logs for individual domestic stoves, with or without back boilers, and for batch boilers that may be used to heat water for individual houses, groups of houses or small business premises. Most of what follows would be the same if the wood was to be chipped for wood chip burners but this is not specifically dealt with in this handbook.

Three quite different types of woodland management and firewood harvesting and processing operation will be required for

(a) softwood and hardwood plantations of different rotation lengths including Short Rotation Forestry (SRF) (see sub-section below)
(b) semi-natural broadleaved and mixed native woodlands
(c) coppice woods (SRC)

Refer to Section 4 'Coppice woods' for growing fuelwood by 'traditional' coppicing.

This last category is examined in its own section and represents a potential way forward for community woodlands and others looking for commercial opportunities. Whereas coppice woods may sometimes be managed exclusively for energy, softwood plantations and semi-natural woods are more likely to be managed for multiple purposes and firewood may be more of a co-product than a primary

objective. SRF is however a dedicated type of energy forestry (EF) and is considered separately below.

In south west Norway, a reduction in stock grazing and muirburning around one hundred years ago has resulted in a large expansion of native woodland. Most of this woodland, though not managed primarily for timber, is exploited in many ways. Some timber is extracted and it is the main source of the fuel wood used in Norway. This has a declared income (much – perhaps most – is in the 'informal' sector) of £37 million in 2009, or 816 kg per Norwegian household and increasing by 9% annually. In Scotland, it has been shown that birch can produce a return in not much longer than the normal 45 year rotation used for Sitka spruce plantations. Helen Armstrong in FPG website paper

SHORT ROTATION FORESTRY (SRF)

A recently constructed 44GWh/yr biomass power station at Killin, Perthshire, will chip softwood.

SRF involves growing single-stemmed trees of fast growing species over short rotations (typically between 10 and 20 years), using conventional forest establishment and harvesting techniques. Because trees planted for SRF could potentially be grown on in the event of a change in the market, and because this management type can make use of more marginal agricultural land than SRC, it is the option currently thought to be the best for Scotland as a whole.

Refer to *Short Rotation Forestry Trials in Scotland*, Forest Research, progress report 2017.

Forest Research set up trials on six Scottish sites between 2010 and 2012 and the results of these trials are updated each year. Results of trials so far indicate that the fastest growing species are not coincident with those with the highest survival rates. This makes it harder as yet to say definitively which species are best. There is generally a gradient of growth rates from north to south and east to west. However, this is an over simplification as exposure, soil and sunlight conditions all make significant differences and in very individual ways, to a range of trialled species.

Refer to *Energy Forestry Exemplar Trials Establishment Guidelines* FCS 2009 for detailed information on all aspects of SRF.

In one trial in the Highlands, the fastest growing four species (out of 10 trialled) are red alder, hybrid aspen, hybrid larch and native common alder. However both alders ranked low in terms of survival while the slower growing sycamore and ash showed the highest two survival rates. As aspen and larch were ranked 3rd and 4th for survival they are rated as the current front-runners. It has been suggested by some trials that native goat willow *(Salix caprea)* is also a contender while eucalypts have not shown much promise.

WOODLAND MANAGEMENT TYPES FOR FIREWOOD (other than coppice)

Softwood as firewood

Softwood plantations of all species, mixes or monocultures, are ideally thinned progressively to increase yields. Softwood thinnings are nearly always best utilized as firewood and will help to pay for woodland management costs. Where processing facilities and assured markets exist, mature softwood plantations beyond economic distance to be sold for particle board or pulp, could be clear-felled for firewood. They can be replaced with better planned and more economic multi-use woodlands, under management regimes that this handbook advocates.

Potential of existing native woods

In the Highlands and Islands large areas of native broadleaves and Scots pine have been planted in the course of the last 30-40 years. Many of these woods have the potential to yield local firewood supplies if carefully managed. The majority have rather undeveloped access, as most were established with a minimum of road building. Their future management is in many cases unplanned. They may revert

to wildwood or, as is more likely, they may be slowly destroyed by grazing. Hopefully some will be valued as firewood resources and managed sustainably to that end.

Importance of access and planning

Good access will be key in order to reap the potential rewards of firewood and other Non Timber Forest Products, and the local employment that goes with these. To manage such woods for firewood sustainably it will be necessary to map the woodland and divide into compartments or coupes. Rotational felling of coupes will be ideal, as it will allow replanting or regeneration, depending on species and site conditions. Clearly the idea will be to ensure a sustained flow of produce from the woodland. That would allow a functional business model to be drawn up, which would take account of the size of demand, along with drying, processing, storage and delivery capacities. Some local development companies are already engaged in such enterprises.

Mosaics of management types for reducing risks while improving biodiversity

Mosaics of birch in small coupes, to be clearcut and replanted or naturally regenerated, alongside coupes of oak, hazel, ash, willow or alder coppice will be excellent for wildlife and amenity, as well as for firewood. Scots pine will prove to be less useful for firewood and, left unmanaged in open grown situations, will not make sawlogs either. It will probably best be left as wildwood.

As ever, none of this productive forestry enterprise can happen unless red deer and domestic stock can be excluded and roe deer brought down to very low levels. The larger the site and the higher the surrounding deer densities, the more difficult this will be.

See sections 2 'Establishment' and 3 'Management' for details of growing birch.

If you intend to establish woodland with firewood as a major intended product, either as coppice or on a short rotation, whilst choice of species will certainly be site dependent, it should also take account of the heat energy (calorific value) and market value of the different species. In many cases in the Highlands & Islands, birch will be a reliable choice as main species. This lends itself well to a continuous cover forestry (CCF) regime, in which small coupe felling followed by replanting or natural regeneration is to be used.

Well stacked softwood logs protected from direct rainfall, lifted clear of the ground and well aerated at each end of the log.

CALORIFIC VALUES

Not all firewood is the same

Birch, oak and ash are all great firewoods – see table of calorific values, which shows that conifers (softwoods) have lower energy than broadleaves (hardwoods). In broad terms, it will take 4 conifer logs to produce as much heat as 3 hardwood logs of the same size. But to get the full calorific value out of any log, it is essential that it is dry and that you use an efficient appliance. The table below shows that the moisture content of your firewood will actually be more important than its species with respect to the heat you get out of it. One cubic metre of fresh felled timber weighs about one tonne of which about 60% is water!

Burning wet wood is a drastic waste of energy!

All hardwoods have roughly the same calorific value (refer box below). Oak, beech, birch and ash have amongst the highest but oak is a bit slower to grow unless on optimum sites, as in parts of Argyll and the east of the Highlands. Birch is not the best for coppice but it may be the best all rounder in sense of assured growth, nativeness and calorific value. Hazel, aspen, rowan and indeed the other native broadleaves can all be used as firewood in efficient closed stoves.

Calorific value of wood depending on water content		
Condition of wood	Water content as % weight	Calorific value
fresh timber	50-60 %	2.0 kWh/kg
timber stored 1 year	25-35%	3.4 kWh/kg
timber stored more than 1 year	15-25%	4.0 kWh/kg

Hardwoods give off more heat than softwoods

Species (air dried)	Heat output Gj/m^3
Beech, Oak	6.3
Ash, Birch	6.1
Sycamore, Elm	5.5
Larches	5.4
Douglas Fir	5.1
Pines	5.0
Spruces	4.6

PROCESSING SOLID FIREWOOD

Whilst the humble axe is great for exercise and upper body strength, for the less fit and strong, there is a large choice of cutting and splitting equipment both for home and commercial scales. Independent home or croft scale hydraulic splitters can be electrically or combustion engine powered and vary significantly in power and speed.

At the next scale up are tractor-mounted, PTO driven crosscut and splitting units which can be linked to conveyor belts and various storage and air drying systems. The beauty of coppice wood is that if cut at the right diameter it may not even need splitting. The length to be cut will depend on a knowledge of local markets. Many domestic wood burners will only take a 300 mm log, whereas batch boilers will take up to 1 metre.

At domestic scale, producing high quality firewood will be all about stacking, ventilating and protecting well. As already noted, drying wood properly is more important than what species it is. Air-drying can be as simple as stacking outside,

but off the ground, to ventilate both ends of all logs. The top of the stack must be protected from direct rainfall. It will take at least a year in the Highlands and Islands but some species dry faster than others. For example, Douglas fir is relatively dry from the start but Scots pine holds moisture keenly.

Commercial ventures occasionally use solar (eg poly-tunnels) or even electrically powered kilns to get a faster turnover and an assured high quality product. They will need to get a relatively high price for their product and must work at a scale to cover these investment and running costs.

Tractor PTO powered firewood processor

MARKETING FIREWOOD – commercial opportunities

After in-depth analysis of firewood markets and potential in the Highlands and Islands, the key findings of Highland Birchwoods (in 2003) centred on deficiencies in the 'supply side'. There was an absence of the development of firewood as a management objective of woodland owners. It also pinpointed a lack of sustained and well-targeted subsidy for private woodland owners. It concluded that development work was urgently needed at appropriate community and local scales. It recognized a need for radical change in emphasis and intensity of woodland management across the whole range of woodland types, from low grade conifer plantations to new native woodlands, towards fuelwood orientated systems. This would require research and education. Several years on, it is doubtful that significant progress has been made in the development of firewood, which is still crossing the Highlands from east to west and even being imported from abroad by some firewood businesses!

Nevertheless a few community groups lucky enough to secure their own plantations, or access to them by agreement, have established firewood operations. We can expect to see more in the coming years as forest land becomes more readily available through the Community Transfer Asset Scheme (CATS). Such businesses will be helped by the ever increasing price of grid energy which in turn drives up the price of firewood.

The Highland firewood market has not been discerning in the past but with new generation stoves has come much better general understanding and consumer expectation. Suppliers can continue to supply wet firewood at their peril but the more savvy will differentiate between wet and dry, and between softwood and

hardwood. This will assist the economic viability for suppliers and will encourage growth of the market which, it is widely agreed, has potential.

The holiday rental business is an increasing market for stoves and the firewood to fuel them. Supermarkets and garages sell both kindling and logs in bags at relatively high prices and there are real market opportunities for woodland entrepreneurs in some locations.

A firewood business dovetails well with other woodland related work such as forest contracting and tree surgery. There are good commercial opportunities for private and community run enterprises in the future, as the woodland resource gets bigger and the demand for low carbon fuels develops. Business viability will be improved by driving up the quality of the product through proper drying and differentiation in price between hardwood and softwood.

KEY POINTS – a summary

- Wood is a renewable energy source IF woods are managed carefully (sustainably). Woodlands of all types can be carefully planned and managed for long term sustainable firewood yields – softwood plantations, semi-natural woods or coppice woods.
- Wood is a low carbon or near neutral energy source IF cut and processed locally.
- The self-regenerating, semi-natural wood or the well managed coppice wood, both giving continuous cover and sustainable yields, will provide the nearest to carbon neutral energy as we can get.
- IF firewood is cut from woods that are not managed to allow regrowth, restocking or regeneration then wood is NEITHER a renewable resource NOR a low carbon fuel.
- Solid logs should be burnt in modern efficient wood burning stoves or batch boilers NOT in open fires.
- Drying wood properly is more important than what species or whether softwood or hardwood. Burning wet wood wastes huge amounts of its energy, pollutes the environment, and reduces stove and flue life.
- Planted and existing semi-natural woods can be sources of firewood providing that sheep grazing is carefully managed. However, deer grazing at current prevailing levels will, in most locations, prevent restocking or regeneration, leading back into the cycle of decline, fence, re-plant, decline, fence….
- Local firewood production, including revival of coppice management, offers significant economic development opportunities on a sustainable basis IF we can support investment in modern equipment and get on top of deer management.

CASE STUDY

CORRARY FARM, GLENELG

by Neil Hammond

Since 1997 when Neil Hammond and Amy Floweree bought a share in Corrary Farm, they have been restoring ecological balance to this 280ha holding that occupies both the bottom of the glen and steep hill ground above the brochs of Glenbeag near Glenelg. The process has accelerated recently, diversifying the farm to include a variety of activities.

© Neil Hammond

Looking north over Glen Beag. Most of the south facing slope above and to left of farm is planted with native trees which join up fragments of existing woods.

CURRENT LAND USE AND ECONOMIC ACTIVITY

Poly-tunnels produce organic salads and vegetables to supply the local pub, shop and other outlets. WWOOF volunteers help out throughout the growing season. Fruit from the orchard and soft fruit bushes is sold to the public either fresh or as homemade jams. A café located in a vintage Showman's Wagon sells tea, coffee and homemade cakes to visitors. It is usually open from Easter until October and attracts custom from visitors to the adjacent brochs. A brewery produces both cask and bottled beer for the local market and has been very successful during its first year of operation. Two holiday houses, one newly built timber frame, the other the original stone farmhouse, provide an income from holiday lets and accommodation for volunteers. Letting silage and grazing on the in-bye land to a neighbouring crofter provides further income. There is no grazing on the open hill.

© Neil Hammond

A very wide range of native species planted on the fertile south facing hillside includes oak, cherries, ash and hazel.

WOODLAND CREATION

In 2015 thirty-five hectares of new woodland was planted on the upland ground, funded through the Forestry Grant Scheme. On the south facing slopes the soil is deep, fertile and well drained and, given a chance, trees grow very well. Deer pressure from the neighbouring 'sporting estate' is intense and seven kilometres of new fence was erected along with substantial river gates and cattle grids. Despite these efforts the biggest threat to the scheme still comes from deer, both roe, which are difficult to control, and red which still manage to get in occasionally and cause damage to the young trees.

The new woodland links up fragments of existing woodland, merging broadleaf-dominated lower slopes into Scots pine dominated slopes above. The new deer fence now protects veteran trees and valuable oak-birch woodland with bluebells, along with many other types of ground flora. The new native woodland will contribute to carbon sequestration, have a positive impact on landscape character and provide protection against soil erosion.

An area of 35ha was planted with 48,800 trees at a density of 1600 trees per hectare. Downy birch comprises about 43%, rowan 11%, oak and Scots pine just over 5% each. The remainder is a mix of hazel, gean, hawthorn, blackthorn, aspen, wych elm, bird cherry, willow and juniper with 15% open ground.

© Neil Hammond

Two poly tunnels and some outside beds supply salads, herbs and vegetables to inhabitants, volunteers and holiday makers with surplus sold to local hotels.

GLENBEAG FOREST

In 2016 Neil purchased a neighbouring 158ha plantation of Sitka spruce, with some Douglas fir and larch. Within it are two areas designated as Plantation on Ancient Woodland (PAWS), which contain a high proportion of broadleaved trees. There is also a significant proportion of native species in other areas of the woodland.

Much of the dense Sitka plantation at the west end is now too mature to be thinned and will have to be commercially harvested. Once that is complete there will be no further clear-fell operations. Although an unattractive option, it does mean that income can be generated from the sale of timber. This can then be used to fund up to eight kilometres of new deer fencing. And to restructure the woodland to the east end, where the trees are less mature and there is more diversity.

A twenty year plan for the forest has just been completed and approved with the very long term aim of re-establishing a forest of diverse species. This will supply the future firewood requirements of the farm and also high value timber for on site milling for building projects. It is proposed to restock the clear felled areas with 50% birch, 30% Scots pine, 15% mixed broadleaves, and 5% larch and Douglas fir. Different species will be in small coupes as well as intimate mixtures and will follow soil types and conditions.
Some upper areas where growth has been poor or checked in previous stands will be planted to create a montane scrub habitat. This will include shrub willows, dwarf birch, hawthorn and juniper. This will create a transitional habitat to the open hill, mimicking natural woodland structure. These species could also be included in small groups in the main body of the wood on poorer soils.

ENERGY AND BIOMASS HEATING

With the purchase of the plantation the opportunity to become self-sufficient in energy supply has become a real possibility. There is already a 5kW micro hydro scheme, which provides electricity for the owner's off-grid house. This is supplemented by a 2kW PV array and a 4m^2 flat plate solar collector. After a decade of constant repairs, however, a 6kW wind turbine was abandoned.

In 2016 a 60kW log-fired boiler was installed and commissioned to provide heating and hot water for the two rented properties. The boiler is linked to a 4000 litre thermal store from which hot water is circulated to the houses through a mini district heating system. Wood for the boiler comes from the forest and is mostly Sitka, although it is regularly mixed with grey alder, which has proliferated along the forest tracks.

Producing firewood in the quantity required was not practically achievable without a firewood processor. There was already a 100hp tractor available on the farm so a PTO driven processor was the best option and a second-hand 'Posch 350' was purchased. The machine takes rounds up to 400mm in diameter and can produce split logs in lengths up to 500mm, which is the optimum length for the wood boiler. Two people can comfortably produce ten cubic metres of firewood in a day and certainly more if required.

TIMBER USE IN BUILDINGS

Over twenty years ago the first new buildings were erected on the property using locally sourced timber in a post and beam construction, with timber cladding. The timber was purchased in the round from Forest Enterprise (now Forest & Land Scotland) and milled on site. At the time this was a radical approach to building in the Highlands and met with substantial opposition from the local Planners. Times have changed and our most recent domestic dwelling, again built with Scottish timber, went through the planning system without comment.

Neil Hammond loading the solid log batch burner with split grey alder logs harvested on the farm. The accumulator tank behind stores all the domestic hot water and underfloor heating water for two houses.

The most recent building, completed in 2018 was a 280m2 shed. The frame is Douglas fir, which was sourced and milled off site as there are no suitable trees within the forest. The larch cladding, seven cubic metres in total, was all produced

here from our own timber. In order to move felled logs from the forest a timber trailer with grab has been purchased, which is operated with the farm tractor. The timber is milled using a portable 'Lucas Mill'.

www.corraryfarm.co.uk
www.dunbrewing.co.uk/contact

CASE STUDY

COGLE WOOD CROFT, CAITHNESS

by Ros Nash

CREATING A NEW CROFT

In January 2015 my husband Rab and I bought Cogle Wood in the heart of Caithness. These 12 hectares, predominantly of Sitka spruce and lodgepole pine (now known as Cogle Wood Croft) were planted in 1981 and are typical of plantations of that time.

Rab and I were both born townies; we had lived in the centre of Glasgow since our student days in the 1990s. When we stumbled on woodland crofting, we knew almost immediately that it offered a framework around which we could build a new life for ourselves. After a couple of major trips travelling around Europe, it also felt like the right time to put down roots.

An aerial view of Cogle Wood (near side of road) showing mix of Sitka spruce and Lodgepole pine.

CHAINSAW SKILLS

We made things official by creating a new croft with the Crofting Commission and Rab got his chainsaw tickets, soon securing part-time work at Dunnet Forestry Trust, a community-run forest on the north coast. That gave us the impetus to move into the woods. Well, almost. We arrived in January 2016 with our 18-month-old daughter, Zoe, in our trusty Hymer campervan, and spent the first six months living just

inside the gate next to a single track road. It was a very effective way to meet the locals!

We love Caithness, its quiet beauty and big skies. We have found Caithness folk to be particularly helpful and we nearly always have time to get the craic. Living and working in a forest within a community where there is relatively little tree coverage means people are curious about what you're doing. We're never short of visitors.

We have planning permission for a small croft house and have recently received our building warrant. The house will be off-grid, using solar, wind and wood fuel. We'll be relying on a borehole and rainwater catchment for our water.

FIREWOOD BUSINESS

Our business, Watten Firewood, has been expanding at a healthy rate since its soft launch in November 2016. We quickly realised we needed a wood-splitter rather than just an axe! It soon became clear that restricting sales to smaller split logs (rather than lengths and rounds) was the best way to maximise the income from our limited resource. We've worked hard to streamline the processes, from harvesting logs to allowing customers to order and pay online. We are still making refinements and we'll need to invest in a forestry crane and trailer to help move logs.

Judging by current sales, firewood will account for at least 70% of our total income in 2018/19. Having our own woodland resource offers us protection from fluctuations in timber prices, which can vary significantly, whereas processed firewood prices remain stable. It's also good to sell a product that people need. Customers like knowing that their wood is grown, harvested and seasoned just down the road.

A family affair supplying a hungry local market.

GRANTS FOR WOODLAND CROFTS

The downside of woodland crofting is that you have all the responsibilities of the traditional crofter without (yet) necessarily enjoying all of his or her rights. For example, we were told we weren't eligible for the CAGS scheme to help fund our firewood store, because the business wasn't agricultural. Legally, the Crofting Commission does not distinguish between woodland crofts and any other kind. But it takes time for government agencies to catch up with the idea of a modern crofter who might deal in trees, rather than cattle or crops.

NTFPs

We intend to make the most of our forest resource by establishing revenue streams based on non-timber forest products such as edible mushrooms and honey from beekeeping. We also plan to tap into the glamping accommodation market currently being rejuvenated by the North Coast 500 tourist route. We look forward to the day when all our income is croft related and we're confident we'll achieve this – it's just a question of when.

ACCESS TO WOODS

One of our biggest achievements is making the woodland safer and more accessible. We've improved access tracks and made them vehicle-friendly, as well as dealing with almost a hectare of the windthrown trees. Windthrow will be an ongoing issue as the Sitka trees are already reaching a critical height, especially considering the frequency of stormy weather in Caithness.

© John MacPherson/WTML

Softwoods from the croft are cut by chainsaw and split with a petrol driven vertical log splitter.

IMPROVING BIODIVERSITY

We plan to replant gradually, practicing continuous cover silviculture, creating coupes as we go, and improving biodiversity by taking a lead from what grows well locally. We'll introduce species such as willow, rowan, birch, alder, aspen, cherry, sycamore and Scots pine, many of which are currently being nurtured in our tree nursery.

There are strong geographic and cultural connections to the Nordic countries in this part of the Highlands. Living and working among trees has allowed us to embrace 'friluftsliv' (literally meaning 'free-air living'), a term popularised by the Norwegian poet and playwright Henrik Ibsen in the 1850s. This is one of the best and healthiest aspects of our new life. I have also had long phone chats with a handful of people keen to become woodland crofters, as part of our role as woodland croft champions. I like the idea that Rab and I are inspiring others to follow in our woody footsteps.

As this handbook demonstrates, there is an incredible diversity of woodland types across the Highlands and each natural resource can be carefully managed to reflect the economic, environmental and social needs of those who are closest to those woods. There are endless possibilities. Our 1980s plantation might not be as pretty as some woods, but it provides us with shelter not only from the weather but also from the stresses of modern living. It gives us warmth, an income, breathing space, amazing sights and smells and even helps sink our carbon footprint. People have a long and rich history of working and living among trees. The modern woodland crofter can tap into all this, as well as enjoying the additional benefits of a chainsaw and 4g internet connection. What could be better than that?

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SECTION 6
GRAZING ANIMALS AND WOODLANDS
SILVO-PASTORALISM ancient and modern

Definition of terms

Agroforestry refers to any system that includes elements of managed agricultural or horticultural production integrated with tree or woodland management on the same unit at the same time.
Silvo-pastoralism is a subset of agroforestry where domestic stock grazing takes place within woodlands at varying densities and canopy cover (and often with wild herbivores too in Scotland). (occasionally called silvo-pasturalism but this is anomolous).
Silvo-pastoralism in Scotland has led to what is referred to as *wood pasture* and this is a habitat type with no specific NVC code as it can be based on a number of woodland types but generally with a canopy cover of 20% or less. It represents a highly valued cultural landscape and is a priority habitat in the UK Biodiversity Action Plan.

Agroforestry (other than silvo-pastoralism) is examined in section 8.

CLIMATE CHANGE AND GRAZING ANIMALS

About a quarter of Scottish greenhouse gas emissions (GHG) come from agriculture and the related land use sector and this represents more than Scotland's entire total statutory permitted greenhouse gas emissions for 2050 from all sources. The task, therefore, of meeting targets is immense. One straightforward and subsidized way the agricultural sector can contribute is by planting more trees and woodlands to sequester more carbon.

"Agriculture is responsible for almost a quarter of Scotland's greenhouse gas emissions, producing 12.5 $MtCO_2e$ in 2013 – almost as much as transport and energy production." Scottish Government Land Use Strategy

Yet the Scottish Government plans that farming will develop much further than this and it has committed to facilitating a *"step change to climate friendly farming and crofting… (which) will promote carbon efficient agriculture, environmental benefits and increasingly integrated land use"*.

This section of the handbook focusses on various ways grazing animals and woodlands can be integrated to give farmers and crofters the benefits of improved livestock conditions, as well as woodland produce and services. Agroforestry refers to different levels of integration between a variety of forms of production, including livestock and woodlands, while silvo-pastoralism refers specifically to integration of grazing and trees or woodland on the same unit. Grant assistance for agroforestry is available for sheep and conifers or broadleaves within strictly defined criteria but may become more flexible as the imperative to meet targets intensifies. Such woodland options may look increasingly appealing to farmers and crofters as incentives increase in relation to declining real incomes from upland grazing.

Another strand of climate change policy revolves around the inputs and outputs of nutrients from ecosystems and the intention of the Scottish Government is that *"By 2030… most farmers… will be implementing best practice in nutrient management and application"*. Whilst efforts will focus on methane and direct fertilizer reductions, there will be increasing interest in the nutrient budgets of uplands beyond improved grazings and in-bye. The significance of these huge

areas cannot be underestimated as they cover around 80% of the land in the Highlands and Islands. Climate policy has yet to fully acknowledge the real, ongoing carbon and nutrient losses from the uplands by soil and peat erosion, muirburn and harvesting of wild and domestic grazing animals, which all take place without balancing inputs. The regeneration of all upland vegetation, including the carbon neutral process of natural regeneration of woodland at the landscape scale, would add considerably to the already major contribution that new woodland planting is able to make to meeting carbon sequestration targets.

Deer management in Scotland: report to Scottish Government, SNH 2016.

"The Scottish Government has a number of high-level objectives relating to woodland expansion and biodiversity which depend on effective management of deer. The present reliance on fencing to achieve these objectives comes at a cost to the public purse, with wider implications for biodiversity and deer welfare".

Forest Policy Group website: 'Upland deer range – climate plan omission'.

"…the Climate Plan's apparently thorough analysis of options for reducing net emissions… neglects the vast area of Scotland dedicated to the hunting of deer and grouse… The Plan acknowledges the carbon sequestration benefits of forestry. However it ignores the potential for natural regeneration of woodland in the uplands, many parts of which have been degraded by grazing and browsing for generations".

'TRADITIONAL' or HISTORIC SILVO-PASTORALISM

This prehistoric co-evolution is described in more detail in Section 12 'Woodland Ecology'.

As woody vegetation spread and evolved after the Ice Age throughout the Highlands and Islands it did so under the influence of aurochs, wild white cattle, deer (including elk) and boar. Mesolithic people, wolves and fire all made their mark, too. These were the principle agents which gradually shaped the forest. The displacement of those wild animals by domestic cattle, sheep and goats over millennia was slow, complex and unfolded in different ways in different places. Differences in local human influences and variations in soils and micro-climates resulted in marked local variations in woodland cover and type.

Modification by Mesolithic hunter-gatherers implies that agroforestry is as old as the forest itself. See more in both NTFP and Woodland Ecology Sections.

However, and in the most general terms, we can say that by about 1000 BP a widespread woodland type was of an open nature with spreading trees. These would have been predominantly birch and Scots pine in some areas, or oak (with other broadleaves) in others. In our upland region this would have formed a mosaic with bog and open heath. The more fertile sites had already been cleared for agricultural settlements. There is evidence that Orkney was largely or almost wholly deforested by 3500 BP. Deliberate clearance, largely for cattle, probably combined with deteriorating climatic conditions, was responsible. We can be sure that in such an extreme environment, woodland loss would rapidly cause loss of shelter, loss of soil protection, loss of leaf litter fertilization and increasing soil saturation, leading to a feedback loop of accelerating woodland decline.

T.C.Smout et al. *The history of the native woodlands of Scotland, 1500-1920*

In an environment without fences, it is not hard to imagine woodlands merging into heathlands at the upper margins and into grasslands at their lower margins, with no hard boundaries, forming continua of tree density. In some areas domestic stock and woodland co-existed in some kind of tenuous balance comprising, as T.C Smout puts it, *"… just enough trees …to provide shelter, local timber and leaf drop to replenish the ground but not too many trees to shade out the best grasses on the pasture".*

T.C. Smout, A History of the Native Woods of Scotland, 2017: "The woods evolved with grazing stock, and the distinction between a wood and a wood pasture is functionally meaningless. The latter term has come to mean a very open wooded area with 20% or less canopy cover where animals are grazed but almost all woods were essentially pastures and certainly all woods provided shelter".

Such a happy balance prevailed in fortunate areas, perhaps for several hundred years. Smout gives examples of historical descriptions of sylvan and pastoral idylls from various locations in Scotland during the 15th and 16th century, when the wolf may have helped to keep stock and deer on the move. He also gives accounts of rapidly declining woodlands and declining herbage in the same period. Whilst some woodlands were protected by good herders and occasionally, where valued for smelting for instance, by enclosure, regeneration seldom happened. In the majority of situations, it was prevented by grazing, so an inevitable decline and disappearance of trees followed.

Whether we can really call this synchronous occupation of land by stock and widely spaced trees and copses a management system worthy of the name silvo-pastoralism is debatable. It was more a compromise of objectives that resulted at some point in time, in a landscape somewhere between forest and heath. It appears quite idyllic in retrospect but never had a future without concerted and deliberate management or intention.

See box below for more on effects of sheep farming in the 19th century and refer to 'Two hundred years of farming in Sutherland' by Reay Clarke (2014).

Winter sheep in open birch woodland.

As it turned out, the arrival of the 'Great Sheep' in the Highlands (as opposed to the small, native sheep already present in small numbers) gradually replaced cattle throughout much of the area. This started around 1760 in the southern edge and took another 20 years to reach NW Sutherland. Linked increasingly with the use of fire, it ensured that the possibility of viable tree regeneration was virtually terminated. The idyll of silvo-pastoralism, if ever it held, was over.

When, with the advent of import markets such as Merino wool from Australia (around 1820), the price of sheep's wool and mutton fell through the floor, many flock masters and a few lairds were bankrupted. Whilst some sheep farmers were able to readjust their scale of operation and survive, many estates turned to selling opportunities for deer stalking as a means of making their land pay. Once again people were cleared primarily, but not exclusively, to coastal margins and islands where crofts were established.

Clearly this is a gross simplification of a complex social history that varied from place to place, interacting with locally diverse climate and soils to give the wide variations in ratios of woodland to open ground we see today. Compare the relatively wooded Argyll to the largely treeless Sutherland, Northern and Western Isles.

See section 13 for a detailed comparison of SW Norway with the west Highlands and Islands.

Nobody however, even from the more wooded areas of our region, could sensibly claim that upland sheep farming today represents a contemporary version of silvo-pastoralism. In some areas of Norway, however, it still operates and unfenced woodlands, grazed by both sheep and cattle, are still able to regenerate. However the sheer Norwegian topography, combined with well distributed, diverse seed sources and more intensive stock management (including winter housing for sheep), are all significant contributors to its viability.

Cattle in open woodland, SW Norway.

By contrast, in most of the Highlands and Western Isles where sheep are still managed, we have to say that there is little or no programmatic integration of stock and woodland management. Sheep still graze remaining scraps of unfenced, native or semi-natural woodlands. They benefit from the shelter but assist the deer in preventing natural regeneration. Woods thus continue to disappear off the map, including some on the Ancient Woodland Inventory. Sheep continue to have free range in many areas, from the coast to the highest montane habitats. Muirburn is utilized at all altitudes (even in upland SSSIs) to keep heather shorter and younger and to achieve an early bite of grasses. Fires quite frequently get out of control, burning extensive areas, getting too hot and damaging soils. Nearly all former arable land that fed many people has been turned to rough grazing. Rushes have encroached on large areas of in-bye and winter feed is imported from the east coast. Red deer grazing both the in-bye and the former grassy shielings in the hills further reduce available nutrition.

There are no easy answers to maintaining hill farming in either an economic or environmentally sustainable state in our region. To secure its place in a vibrant,

diverse economy and ecology an imaginative approach is required. This handbook suggests some ways in which hill sheep farming can be strengthened by the addition of shelter, enhanced nutrition, improvement of micro-climate, nutrient status and drainage. These are all biophysical ways of improving stock performance. To them must be added the potential for woodland related income. Some farmers have re-introduced cows, or even switched from sheep to cattle. History shows that this may also be part of the answer to better maintenance of hill land. Yet critical to its good health are woodlands, which can so naturally and freely bestow the essential fertility on it.

All the quotes in this box are from: *Two hundred years of farming in Sutherland* by Reay Clarke (2014).

Glendhu and Glencoul in NW Sutherland were stocked with the 'Great Sheep' (Cheviots) in 1801 and cleared in 1870 to create deer forest. In 1818/19 several farms in the parishes of Eddrachillis, Assynt, Unapool and surrounds were brought under the one tenancy of Charles Clarke, involving eviction of 58 sub-tenants to create 60,000 acres grazed by 14,000 sheep. The flockmaster was bankrupted in 1824 due to fall in prices of wool and mutton.

"Despite all the careful management of the flock masters and the diligent herding of their shepherds, the grazings were going back. The rich variety of sweet grasses, herbs and clovers of the shielings, which had been inherited from the transhumant husbandry of the cattle, was replaced by heather and deer's hair and bracken. Muirburn was now being regularly practiced on the grazings and the sheep were continually defoliating and weakening each and every edible plant".

"The continuous single species grazing by sheep slowly destroyed the store of wealth" …"The hills of Sutherland needed and still need most careful pastoral husbandry. They did not get it under the management of the flockmasters".

In the closing paragraphs, Reay Clarke laments, *"No serious steps have yet been taken to re-build the fertility of the soil of these mountains and moorlands".*

This handbook addresses this failing and the Case Studies in it celebrate people and projects taking just those steps.

WOODLANDS AND GRAZING

finding a new balance in the 21st century

The design of land use systems that integrate stock (and indeed wild herbivores) with woodlands is a challenge that faces not just Scotland but, in a sense, the whole globe. It is at the heart of what this handbook is all about. The Highlands' historical struggle to balance the two is no different from that in many parts of the world. Much of upland policy right now in Scotland is precisely about negotiating a balance between competing land uses: between grazing animals (domestic and wild) and woodlands; between harvesting of protein and harvesting of cellulose; between extractive consumption (cropping) and fertilization; between sport shooting and sustainable land management for public benefits.

The FCS *Woodland Grazing Toolbox* is a useful guide to developing a woodland grazing plan.

The upland land use debate poses the question of where does the balance lie. Indeed can a balance be devised and what are the models we should be looking at? This section examines four broad management approaches or models that we can describe in a Scottish upland context (see figure below). They all attempt to find a balance of grazing and woodland management. And in a 21st century context, grazing means both of domestic and wild herbivores as both support rural industries and share the same ground. As defined in this handbook we can call these models of silvo-pastoralism and, as such, they can all be considered as types of agroforestry.

"Significant carbon and greenhouse gas emission savings can be made through silvo-pastoral agroforestry systems in which woodlands or forests are integrated with forage and livestock production systems" Can silvo-pastoral systems contribute to Scotland's emission reduction targets? Saunders et al. 2016

These systems are not mutually exclusive on a single unit of land, although two refer essentially to hill ground and two to low ground or in-bye. It is arguable that

while 'rotational fencing' and 'farm woodlands' are practiced widely in Scotland, the other two models are currently aspirational.

unfenced mosaic	rotational fencing	farm woodlands	Glensaugh model
hill ground	predominantly hill ground	predominantly low ground/in-bye	low ground/in-bye
extensive			intensive
free ranging sheep or cattle benefitting from shelter of woods & varied diet predominantly natural tree regeneration wild grazing animals heavily culled as economic crop many non-timber forest products (NTFP) woodland may or may not be harvested for timber but unlikely an important economic crop due to relatively poor access high species biodiversity though maybe full development of understorey and ground flora dependent on grazing levels & types soils building naturally without inputs high landscape value many ecosystem services inc. flood control & improvements to fisheries diverse employment domestic stock management & sales intensive deer culling + venison sales wildlife tourism & conservation wild harvesting other NTFP cropping education & hutting	mostly free ranging sheep or cattle but excluded from regeneration and newly planted woods benefitting from shelter of established woods and varied diet red deer culled to levels agreed with others in DMG some non-timber forest products (NTFP) other than venison woodland for firewood but woodland management could be light to negligible if poor access possible development of managed firewood cropping possible development of coppice woodlands many ecosystem services including flood control and improvements to fisheries high landscape and biodiversity value	enclosed sheep or cattle on improved and unimproved grassland more emphasis on stock than woodland but some economic timber harvest wild grazing animals shot sporadically for sport and home use high landscape value and potentially high biodiversity especially with mix of conifers and broadleaves some NTFP notably game in traditional model fenced woodlands promoting fuller development of woodland undergrowth and ground layer commercial fuelwood potential including short rotation forestry possible development of coppice woodlands for fuelwoods or specialist markets possible development of high value broadleaves and conifers	enclosed sheep or cattle on pasture only woodland and stock equally highly managed; timber crop as well as stock sales wild grazing component eliminated trees planted trees individually protected landscape value interesting! employment high – inputs high some natural fertilization effect if broadleaves water catchment management moderate – better than just grassland biodiversity moderate – better than just grassland no 'woodland' development in sense of ground flora and understorey

For comparison, refer to Annex 6.4 in Woodland Expansion Advisory Group report (2012) which presents a detailed comparison of several types of 'farm forestry' models including shelterbelts, hedgerows, SRC, SRF and the Glensaugh model.

The applicability of each will depend on several factors including (a) the landowner's particular priorities (b) the wild grazing pressure and willingness to manage this (c) availability of knowledge, skills and labour. Each will be tailored to the site conditions and other available resources.

It can be seen from the schematic that the four systems lie on a spectrum or gradient. They range from a relatively informal or extensive, low input, model at one end, which is most suitable for hill ground (LCA 5.1-7), to a very intense and formalized system, clearly more suited to low ground (LCA 4.2 or better), at the other.

Unfenced mosaics (an aspirational model)

At the extensive end of the spectrum lies an aspirational model for what may be termed hill land (mostly in LCA 6.1-7). It relies on woodland's natural ability to regenerate and often depends to some extent on grazing animals opening up the ground so that seeds can germinate. It therefore accepts the natural 'mobility' of woodlands over long time spans, where some woods may indeed degenerate and die out but others spring up elsewhere, perhaps alongside. It cannot work at current grazing densities and could only be brought about by radical deer control and more intensive stock management on the hill. It would be easier to achieve with cattle rather than sheep. Cows have lower mobility and are less harsh in grazing habit with respect to regenerating or shrubby tree growth. It works in some parts of Scandinavia and mountainous Europe where the scale and altitudinal range of the topography is greater. It also requires substantially more, and better distributed, seed sources than exist today in most areas of the Highlands. The prime

See section 13 for more on grazing in Scandinavian upland woods.

function of the woodland is in ecosystem nutrition, provision of biodiversity, and other ecosystem services including shelter to stock. It also supports extensive NTFP enterprises such as fruit and fungi.

Refer to section 8 'NTFPs'.

The model provides significant wildlife management related employment, mostly in culling deer to levels where natural tree regeneration can occur. The venison supply chain and associated economy would thus be supported but without the necessity of a sporting element – stalkers and gamekeepers becoming wildlife managers. The model also requires stricter domestic stock control than is currently typical, which might involve some temporary fencing. A combination of venison, beef, lamb and NTFPs, including a major element of wildlife tourism, would pay for the labour and what would be relatively low material inputs. All produce would enjoy the highest market values, earning organic and wild status with relative ease. The end objective is perhaps a 50/50 woodland/open ground mosaic but this would clearly vary greatly depending on amounts of bog and montane zone.

See sections 2 and 3 for more on the silviculture of natural regeneration .

Such a largely unfenced mosaic model based on what may be characterized as 'working with nature' could deliver better sheltered and drained grazings to stock farmers at the same time as other economic and social benefits sought by progressive stakeholders. Currently this model could work most readily for community, Government, or NGO-owned land units committed and able to reduce and maintain sufficiently low deer numbers. A deer licensing system, as proposed by a number of stakeholders, could operate on these types of land holding.

Refer to Getting deer numbers under control – a proposal for a new licensing system in Scotland. FPG online topic paper 2013

Rotational or 'spot' fencing (a feasible model already partly adopted)
In its most basic form and as commonly practiced today, this model involves deer (and stock) fencing areas of existing woodland (ideally along with adjacent bare ground) and newly planted woods. But the fences are not then usually maintained, with the expectation that stock and deer will progressively gain entry and that after 20 years the fence will be porous to most species. At this point the woodland becomes valuable to both stock and wild herbivores, as it provides enhanced grazing, browsing and shelter.

The 20 years period of fence maintenance here is based on the current FGS contract conditions.

Hopefully the benefits to stock and deer will be so clear as to encourage managers to immediately fence an adjacent area to expand the woodland. As new and protected woodlands flourish, confidence will grow and holdings under all types of management will adopt a more organised approach to rotational fencing. They will instigate a planned sequence of natural regeneration and restocking by planting, prioritising the most degenerate woodlands and setting up long-term targets and strategies. These may then evolve to include some permanent fencing and managed productive woodlands including coppice.

© John MacPherson/WTML

Natural regeneration by fencing.

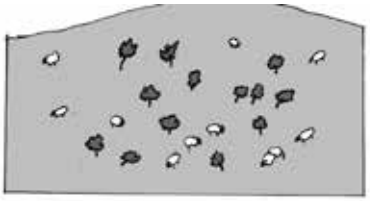
For many this is a model that assumes relatively high wild or domestic grazing densities or both. It allows for the maintenance

The CALL case study demonstrates planned woodland regeneration at landscape scale leading to many productive possibilities in the future.

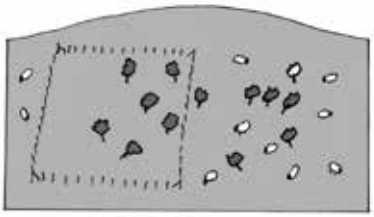
of sufficient populations of deer to support a commercial stalking enterprise, or a less intensively controlled domestic grazing regime. For others, the rotational fencing model may be viewed as the first stage of a journey towards deeper levels of integration of domestic with wild grazing and woodland management. This could include productive timber or fuelwood, or unfenced extensive mosaic, depending largely on the manner and the degree to which, grazing is controlled.

Just one very simple model of rotational fencing essentially only involving two stages of fencing.

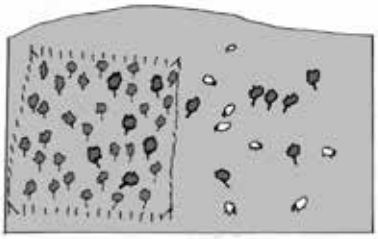
1. Remnant sparse woodland with no fencing and no regeneration.



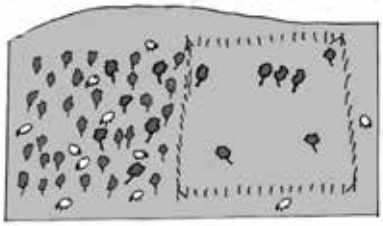
2. Fence 50% of the area plus an equivalent area around margins.



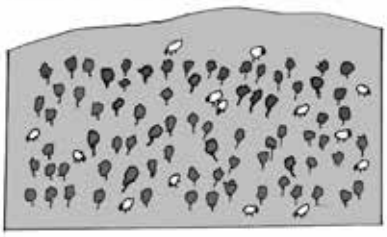
3. After 15-20 years tree regeneration is well established.



4. Allow grazing to return to regenerated woodland and fence the remaining 50% along with an equivalent area around margins.



5. After another 15-20 years the whole woodland is not only regenerated but doubled in size and grazing is benefitted by added shelter and vigorous growth of naturally drained and fertilized pasture.



Farm and croft woodlands (already adopted but with great potential for expansion)

This model is more applicable to the better land – not just the fertile or sheltered glens of the west mainland but also to those small and often scattered patches of 'good ground' that exist even on the less favoured crofts or common grazings.

At a certain scale, a matrix of fenced woodlands and shelterbelts with intensive stock management gives the potential for income streams for both. Where tractors, other equipment and labour can be used for forestry and farming this is ideal and already practiced throughout Scotland. Woodlands can be managed either as clearfell and restock and/or under various types of CCF. The promotion of more woodlands on farms is the main approach taken by the advisory and grant bodies. It is straightforward and whilst requiring investment, it is in tried and tested formulae and doesn't ask for any fundamental shift in methods. It does require an adjustment of ratios of woods to grazing and a shift both in attitude and grant incentives

See sections 2 and 3 for more on silviculture of woodlands for high value broadleaves and conifers.

towards greater support for productive broadleaves. This is especially the case for high quality timber, which has unexploited potential in many areas.

Even hardy breeds like Luing benefit from the shelter of trees.

Productive broadleaves on good farmland

Farm woodland models are well developed in places but inevitably more so where land is available and the climate and soils better, and thus where better quality, productive woodlands can contribute to the farm economy. In many areas they could be developed further and could also be introduced into the west, north, and islands. Here it is possible that sheep grazing may further decline and a wider variety of economic products and benefits will become desirable. The model is wholly appropriate to woodland crofting, to community land holdings wishing to retain some traditional stock yet diversify their economy, and to progressive estates looking beyond the limitations and the lifetime of the sporting model.

There is a lot of demand for a croft scale version of this model requiring careful and detailed design to maximise benefits to stock or horticulture as well as the human working environment. It may mean combinations of small and even micro woods, hedges and shelterbelts which, however, add up to create significant improvements to the micro-climate, drainage and fertilization environments of croft land.

In some places small stock-fenced exclosures have been used to introduce clumps of trees into grazed fields. Used in combination with tree tubes and in some cases an offset electric wire, these can deter deer where the pressure is relatively low. Such small scale but integrated woodland and grazing environments can also supply modest amounts of easily accessible firewood as well as fruit and pollinator habitat, as discussed in other sections of this handbook.

Glensaugh model (an aspirational model worthy of re-development)
This model refers to a long running (1988 -2001) trial carried out at Glensaugh Research Station in Aberdeenshire (Macaulay Institute with Forest Research). Summarized below it represents the only example in our region of an attempt to integrate sheep grazing and trees in an intimate mixture within a formalized system that gives an economic crop of both. Placing equal emphasis on both crops clearly requires expertise in both stock management and forestry and it requires ground capable of supporting reasonable pasture – LCA 5.3 or better.

The Glensaugh model would therefore only be likely to develop with appropriate support in the better quality land areas and it may be that other forms of agroforestry or diversification prove more popular. It is a relatively complex model and possibly unsuitable for the more exposed west. It would certainly represent a radical departure in landscape and cultural terms. It is not compatible with the relatively low input or part-time upland grazing models to which we have become accustomed.

A silvo-pastoral experiment at Glensaugh Research Station, formerly of Macaulay Institute (now James Hutton Institute)

In 1998 a whole system research trial was inaugurated comparing sycamore, larch and Scots pine in different planting densities, combined with pasture grazed by sheep. Trees were protected individually in staked net guards in straight lines and a regular square spacing of 5 metres.

At least up to the 12 year mark, when detailed analysis ceased, this showed that sheep stocking only decreased by about 12 % compared to the open pasture control. Sycamore actually grew better in the silvo-pasture than in the woodland control. There was no evidence of any reduction in sheep production per unit area with tree densities of between 100 and 400 stems/ha. The two conifers generally performed less well in the silvo-pasture than in the woodland control, although girth of larch was improved at 400 trees/ha, which was considered the most successful density overall.

In years with dry summers there was evidence of increases in both pasture production and sheep carrying capacity. By reducing local wind speed, sunlight and maximum temperatures, evapotranspiration of grass is reduced maintaining better levels of soil moisture for pasture growth.

The trial focused on the tree growth and stock performance but, from a wider environmental perspective, of as much interest was the fact that there were 14% more birds and up to 71% more species of arthropods in the best silvo-pastoral plot than in the agricultural (pasture only) control. There were 44% more earthworms in the best sycamore plot than in the agricultural (pasture only) control.

In such a system BOTH STOCK AND TREES ARE ECONOMICALLY PRODUCTIVE. Knowledge of silviculture and stock husbandry are both required. In the context of the need for farm diversification and carbon sequestration, the conclusion drawn by the researchers was that similar silvo-pastoral systems "must be seen as an attractive land use system and grants for establishment and management should follow".

SILVO-PASTORALISM – fundamental precepts

If some form (or combination of forms) of silvo-pastoralism represent the Holy Grail of upland ecosystem management, we need to understand very thoroughly the claims and pitfalls of the concept. We must weigh up the economic and environmental benefits, and the possible disadvantages of the above models. Here then are their precepts:

1. Shelter for stock and wild herbivores from rain, snow, wind, cold and heat: woodlands are warmer in winter and cooler in summer. Shelter improves lambing and calving percentages as well as weight gain in all types of stock and deer. It also reduces need for bought in fodder.
2. Trees fertilize ground layer vegetation with leaf litter, improving pasture. Where nitrogen fixing trees are used this should reduce or eliminate need for nitrogen fertilization of pasture.
3. Shelter from spring winds promotes grass growth for an 'early bite'.
4. Trees remove moisture, which generally, and in the west especially, improves pasture, though in the east it could do the opposite.
5. Tree roots increase soil infiltration rates, reducing run off and likelihood of flood events and soil erosion. Interception and retention of precipitation improves overall catchment management for everyone.
6. The woodland component of land increases bio-diversity markedly, providing niches for insects, epiphytes and birds. It increases populations of above ground insects useful for pollination, and below ground earthworms and arthropods that build and improve soils and improve feeding for birds.
7. Deciduous leaf litter feeds freshwater invertebrates that support fish, bird and mammalian wildlife populations, which can be human food resources.
8. Trees improve the landscape: people seem to value wood pasture as a landscape type but this is rather subjective.
9. The tree component increases GHG sequestration very significantly over simple grass or heathland.
10. The joint income from stock and timber should be more than from stock alone, provided the woodland component can be economically harvested.

11. Tree management – progressive thinning can produce a firewood crop before the final timber crop, which could provide heat and power to the farm or croft itself, or for sale.
12. Silvo-pastoral systems are likely to be increasingly subsidized in future as the heat turns up and agricultural emissions must come down.

This list of advantages or benefits might make you wonder why some form of silvo-pastoralism isn't the predominant land-use type throughout the whole region, but it isn't. However much we might like the idea of animals peacefully grazing and sheltering between woodlands and under trees in a sylvan idyll, it is not a prevalent model in the Highlands. There clearly are barriers or constraints to each of the above models, some more intractable than others. Some of these are examined in Section 12, Woodland Ecology. But, arguably, the biggest is examined immediately below.

Alders planted into dense rushes created this pasture in about 15 years in Wester Ross without any artificial fertilisers or drainage.

Wilson, S. M. (2011). *Approaches to the future expansion of tree cover on farmland and deer-range in Scotland:*
"Greater forestry activity and timber production on Scottish farms would help to develop and diversify individual farm businesses and the wider Scottish rural economy, creating employment and self-employment opportunities in woodland management, harvesting, woodfuel processing and small-scale sawmilling. Many of these opportunities could be available on a seasonal basis that would make them easy to integrate with existing farm work, reducing income vulnerability in rural areas. This would place the Scottish rural economy, especially in our remoter areas, on a comparable basis with that in parts of Scandinavia with established records of farm forestry".

DEER AND WOODLANDS – a summary

Refer to 'Woodland Ecology' section for more on the 'deer problem'.

Whilst sheep have taken their share of the blame for woodland destruction and accompanying nutrient and biodiversity loss over the last two hundred years, there has been a 40% reduction in sheep stocks across the Highlands & Islands since the early 1990's. However their declining grazing pressure has been more than compensated for by increasing red deer numbers which have grown from an estimated 150,000 in 1959 to 360,000-400,000 (2013). This has been encouraged, of course, by sport shooting interests that dominate the privately owned 'traditional' estates.

FCS results of native woodland survey
"The most widespread single factor inhibiting native woodland recovery is high levels of browsing and grazing impacts which inhibit woodland regeneration".

Deer, especially red deer, represent today the greatest impediment to woodland regeneration and expansion and the various industries and employment that could develop from it. In exploring ways of diversifying land use and better integrating grazing with woodlands, we cannot help but return over and over again to the theme of current large deer populations. The wide-ranging solutions to woodland regeneration and management that this handbook suggests try to take realistic account of how deer populations shape and limit the economic and biological potential of woodlands. At the same time the book looks forward to a future where more sustainable deer management will contribute better to the Government's carbon sequestration budgets, biodiversity policies and the integrated requirements of a wider variety of land users.

"Wild deer will be managed as a part of ecosystems, with their impacts on and role within water catchments, soil structure and habitats taken into consideration in management planning…The appropriate levels of grazing and trampling by deer (alongside livestock and other herbivores) will be identified as part of the management of Scotland's ecosystems. … Opportunities will be taken to enhance the positive effects of deer on biodiversity and, where they contribute to the loss of biodiversity, action will be taken to reduce their negative impacts". The Scottish Government: Scotland's wild deer – a national approach – review 2014.

"The overall mean density of red deer on open-hill range in the Highlands and Islands increased by approximately 55% from 6.8 deer per km^2 (95% confidence intervals (CI) 5.6 – 8.3 deer per km^2) in 1961, reaching a peak around 2001 of 10.6 deer per km^2 (95% CI 8.8 – 12.7 deer per km^2). Since the Millennium the density has remained more or less constant with an estimated 10.2 deer per km^2 (95% CI 8.7 – 12.4 deer per km^2)." Environment, Climate Change and Land Reform Committee: Report on Deer Management in Scotland: Report to the Scottish Government from Scottish Natural Heritage 2016, 5th Report.

See Section 13 for comparison with Norwegian red deer management.

Red and roe deer are naturally woodland animals. In countries with more woodland, that's where they choose to live for the most part. In Scotland they have had to adapt to life on the open hill and, as a result, they are smaller than their continental cousins and struggle to maintain condition throughout the year. By feeding and selective culling, their populations are maintained at artificially high levels, which, it is argued, are essential to attract hunters who provide the economic basis of many traditional estates. What is sub-optimal for deer condition and welfare suits the paying hunters who like to see lots of deer in open habitat for ease of shooting and recovery of quarry.

© John MacPherson/WTML

Keeping the vegetation low and simple over extensive areas does not square with either biodiversity or carbon sequestration policies.

Wilson, S. M. (2011). *Approaches to the future expansion of tree cover on farmland and deer-range in Scotland:*
"Red deer (Cervus elaphus) are naturally a forest-dwelling animal and the presence of woodland shelter on their range is likely to significantly improve their welfare, body weight, antler quality and reproductive fecundity. Deer are thought more susceptible to heat loss and hypothermic stress than either sheep or cattle. Access to woodland shelter is likely to reduce incidence of hill deer mortality during severe winter weather episodes".

Under current combined deer and sheep densities the majority of woods planted over the last 40 years will not self-regenerate either within their own bounds or on adjacent ground. When the fences degenerate after 15-20 years, herbivores

seeking shelter and the nutrition of a naturally fertilized herb layer under new woodland will once again prevent regeneration. The cycle of woodland decline will recommence. The new woods will contribute to aerial and water borne seed loads which may establish occasional new trees in protected gorges, river banks or cliffs, and they will sequester CO_2, fertilize the soil and also preserve gene pools. But on their own, the trees do not create woodland in its fullest sense and therefore do not provide the full range and extent of benefits and products.

The cycle of decline.

Being of one age class and with no recruits, the time will come when the wood resembles the state in which it was first fenced and the cycle will begin again. This model of fence, plant or regenerate, overgraze, destroy and re-fence is an expensive, wasteful and unsustainable one. It represents only a stop-gap form of management that doesn't address the fundamental problem. Sadly, it may be the best we can do for the next few years, in what might be described as an ecological and socio-political transition phase.

A collection of trees always in decline is not a woodland.

Planted trees within unmaintained fence, now heavily browsed and grazed so as to prevent development of ground flora or understorey.

Deer densities.

It is very hard to give precise deer densities that need to be maintained in order to allow woodland to regenerate naturally. This is because large herbivores do not usually distribute themselves evenly across the range available to them. Even at low overall densities, grazing pressures in woodland can be very much higher as it is their preferred habitat. It would also be unusual to be dealing with just one species of deer. There may well be three species, along with sheep and even rabbits, all interacting within a single woodland.

It is not surprising, therefore, that a scan of the literature on the subject of deer density required for natural woodland regeneration shows figures ranging from 2 to 10/km^2. One FCS (now Scottish Forestry) information note gives 4-7/km^2 for Scots pine regeneration in the Highlands. Another authority suggests a threshold of 4/km^2 in commercial forestry. These figures are in nearly all cases well below the current and target densities reported by the different regional deer management groups (DMGs) whose aims are primarily to manage the wild deer populations on their ground to generate stalking income. Deer densities of 20-40/km^2 have been quite normal until very recently.

But, as already noted, trees do not constitute the whole forest ecosystem and we need to think about grazing pressure in relation to plant diversity in general as another parameter of ecosystem health. At current deer/grazing densities, herbs and understorey are also declining. Indeed most woods have little or no developed understorey, shrub layer or regeneration. One authority suggests that plant

Where have all the flowers gone? by Kate Holl : https://www.wcmt.org.uk/fellows/reports/where-have-all-flowers-gone

The impasse?

diversity is reduced by deer densities of above 5/km^2 (Ratcliffe 1988) and some of the most heavily grazed may be seen not so much as woodland as groups of trees waiting for extinction in a sheltered heath.

The section on Woodland Ecology examines in more detail the serious challenges posed to the restoration of fertility, productivity and biodiversity of uplands by the deer stalking estates' priorities. The resolution of this will be central for some years to come in the upland land use debate. The 'deer problem' with which the uplands has wrestled so long was possibly first brought to the notice of Government and a wider public by Frank Fraser Darling in his seminal West Highland Survey of 1955. It may be summarized simply thus: the density of deer considered necessary by sporting estates to sustain their current economic stalking enterprises is considered by the majority of other stakeholders to damage the land and limit the potential for a diversity of other uses or services that it could, and should, be providing to the wider community.

100 years of conflict over the management of our uplands

"Only ignorance and the numbing effect of custom can excuse public apathy in regard to the state to which proprietors of deer forests and the army of shooting tenants and gamekeepers have reduced so large a proportion of Scotland… It is a burden so irksome and oppressive as to be altogether intolerable". James Scott in a minority response to a report by the Game and Heather Burning (Scotland) committee, 1921

CASE STUDY

STRATH HALLADALE CROFTS

by Sandy Murray

I have been crofting now for over 50 years: the first few along with my father until his passing in 1976. Since then I have made all the decisions myself, and have become an enthusiastic tree planter, especially after receiving a 'Scotland's Finest Woodland Award'! I have four crofts along the river in Strath Halladale, just in from the North Coast. When the Crofter Forestry bill was passed in the early 1990, I was employed part time as a Crofting Development Officer with Caithness and Sutherland Enterprise with a remit covering Crofter Forestry. I found myself interested in the idea and felt that the best way to find out all about it was to do some myself. That was the start.

Exotic conifer plantations form part of the croft woodland diversification undertaken over a period of 40 years.

WOODLANDS, STOCK & DIVERSIFICATION

Within the 360ha of my four crofts and six enclosed apportionments there are around 20ha arable and 20ha of hill reseed. I also have shares in two common grazings and currently run 14 beef cows and 300 North Country Cheviot ewes. To diversify our income we also run a 14 bed bunkhouse and do laser combat and clay pigeon shooting. To date I have planted around 95ha of woodland.

GRANTS

I have made use of grants by planting under many different schemes, putting in eight different areas of between 0.1 and 5 ha under CAGS and using two Woodland Grant Schemes, again in small, scattered areas, one for conifers and native woodland and the other for regeneration of native woodland.

More recently I obtained a grant through the SRDP for 11ha in 2 blocks, one on each side of the burn. Another grant under the CPS scheme made it possible to plant amenity trees along the river and around the ponds.

We also planted 2ha Christmas trees a year for 9 years, with no assistance except a small grant for marketing from CASE.

Stock fenced fragment of native gorge woodland with plenty of room to expand over time by natural regeneration.

Dense mixed broadleaved shelterbelt sheltering pasture. Well designed native woodland plantings in middle distance forming mosaic of woodland and pasture.

MORE DIVERSIFICATION

All these woodlands are doing well. For fourteen years we had an income from the sale of around 2,000 to 2,500 Christmas trees, and also from making and selling pine (and a few holly) wreaths for Christmas. Another enterprise was to produce rowan jelly from berries within the shelterbelts, where we also allow others to pick fruit.

SHELTER

From a crofting prospective I would say that the biggest benefit was the shelter the new woods gave us. We had to improve fencing, including deer fencing of 50ha, and this helped the management of the croft. Now there is firewood coming out as thinnings and from general woodland management, which offers another benefit. It is also important to mention the increased biodiversity and nature value it has brought to the Strath, all of which is good for the tourism side of the business.

www.achumore.co.uk

CASE STUDY

LYNBRECK CROFT, CAIRNGORMS

by Lynn Cassells and Sandra Baer

Lynbreck Croft in centre foreground includes fields with shelterbelts and hill land.

Lynbreck Croft is located in the Cairngorms National Park between Grantown on Spey and Tomintoul. At 150 acres it is substantially larger than most other crofts, but with a mixture of hill ground, woodland, grassland and bog, it resembles many other 'marginal land' small-holdings in Scotland.

We bought Lynbreck in March 2016 with a vision of living closer to the land and in harmony with our environment. We decided to develop a croft business model based on farming with nature. With no background in agriculture, we had a steep learning curve to try and make our vision fit with what we could realistically deliver on the ground.

For us, increasing the tree cover on the croft was always a priority project. We looked at our hill ground and noticed a small army of Scots Pine marching up through the heather. Taking this lead from nature, we added another 17,400 native broadleaf trees to create a new forest of the future. It will be a place where nature can thrive and where our animals can shelter beneath trees and forage on woodland flora and leaves. Our decision-making delivered for nature and for our croft business.

Luxuriant growth on young oak in weeded, fertile, grassy site.

CLIMATE CHANGE AND 'FUTURE-PROOFING'

In our short time here, we have become increasingly aware of how our climate is changing. Weather extremes are becoming the rule, rather than the exception. We have experienced acute periods of prolonged rain, snow and drought. We can no longer rely on seasonal averages and norms. We have to plan for the worst, and allow ourselves to enjoy the best when it comes. Incorporating more trees on our croft is the best way for us to 'future proof' our business.

We have planted 1km of new native hedging and are expanding our existing woodlands with more trees. Years of overgrazing and pressure from rabbits and deer have resulted in a real lack of young saplings establishing to take over from their elderly relatives. New planting, livestock exclusion, and deer and rabbit culling will provide a much needed young generation to give these existing woodlands a brighter future. For our agricultural business, these woods are 'living barns': possibly the most valuable resource we have on the croft.

Bracken areas are indicative of great ground for oak as long as you can keep the bracken cut or crushed as shown here.

Heather slopes planted with a mix of broadleaf species. A small patch of heather was cleared with a brushcutter and the trees were directly planted after a small hand screef with a planting spear.

TREES AS ANIMAL FODDER

We're also looking to use trees to provide feed for our animals. With annual hay cuts becoming increasingly difficult to plan and costlier to purchase, we're planting 5,000 trees as part of an agroforestry project which will enable us to feed freshly cut branches, and to dry others to make tree hay for the winter.

ROTATIONAL GRAZING

In the meantime, while our planting becomes established, we are using our animals to help restore and regenerate our croft in other ways. We believe in choosing the animals that are suited to our land, rather than trying to change the land to suit our choice of animal. We have a mixed herd of Highland Cattle and flock of Jacob Sheep, which we use to build soil and add diversity to our grasslands. We move them daily into new paddocks, mimicking their natural instinct to always be on the move, avoiding the danger of predators and on the search for fresh, tasty forage. We make sure they never take too much grass, never staying long enough in one place to overgraze, but always depositing the important natural fertiliser we need to keep our land healthy.

We use rare breed Oxford, Sandy and Black pigs to break up dense, tussocky vegetation and open up niches for other plants to seed and grow. With regular, weekly moves, they never stay in one place long enough to root up and expose large swathes of bare soil. We have hens that live in mobile houses in our field and forage in our hedgerows. Their job is to keep back weeds and scatter and clean up grubs in cow-pats. And then we have our native Scottish Black Bees, a flying squad of pollinators, hungry for nectar and spreading nature's goodness as they stop to feed.

We believe in happy, healthy animals that are able to express their natural behaviours. And we also offer high quality produce direct to the consumer. Our aspiration is to sell all of our goods to a local market. We work hard to engage with our community on social media and through the local newspaper and other channels.

Lynn and Sandra use their animals to undertake conservation grazing in their woodlands.

Pigs are often an important part of agroforestry eating up scraps and turning over ground as well as providing a useful source of income.

HAPPY ANIMALS MAKE TOP QUALITY PRODUCE

Through education, we want to empower people to make better-informed food buying choices: ones where cost is not the only factor, but the environmental and animal welfare impact is just as, if not more, important. At the end of the day cheap food delivers cheap health, which costs all of us more in the long term. To date, selling our produce has not been a problem. Our first meat boxes sold out in a handful of weeks. We sell eggs by the roadside and to local members of our Egg Club. This venture which asks for a monthly or annual subscription fee in return for a weekly box of fresh, free to range, organically fed hens eggs has proved very successful.

We're beginning to see that people like what we do, like how we farm and like what we produce. We want to make Lynbreck a bright shining light: a place where an ecologically intensive farming system benefits our business, our land and our community.

www.lynbreckcroft.co.uk

SECTION 7
WOODLAND AND FRESHWATER
Riparian and gorge woodlands

INTRODUCTION

The last forty years have seen increasing interest in the interactions between woodland, freshwater systems and fisheries throughout Scotland and indeed the UK. The connection between a lack of leaf litter entering river systems, resulting in lower invertebrate populations and consequent poorer feeding for fish was brought to greater attention by the efforts of the fisheries scientist Ron Greer and the Loch Garry Tree Group. In 1974 they started a tree planting initiative on the shores of Loch Garry, not far from the Drumochter Pass that represented a practical riparian woodland restoration project before the word 'riparian' had entered mainstream land management vocabulary in Scotland.

At about the same time, increasing concerns about acidification of all freshwater and land ecosystems from 'acid rain' focused attention on the effect of conifer afforestation, especially in the already acid soils of British uplands. In all that follows in this section, it is critical to distinguish between conifer and broadleaved woodlands, and between semi-natural and commercial conifer forestry plantations. All may be referred to as woodlands but their interactions and relationships with soils, with water, and with the riparian environment generally, are often completely different and sometimes precisely opposite in effect.

In general terms, conifer plantations are being progressively restructured in response to the EU Water Framework Directive to remove conifers from riparian zones and to create hold-backs in new schemes. At the same time, an understanding of the many potential improvements to the freshwater and wider riparian environment that broadleaved trees can bring has led to an encouragement to plant and maintain broadleaved trees along and near to water courses and standing water bodies in most (though not all) environments.

The EU Water Framework Directive provides the statutory basis for the protection and improvement of the freshwater environment and it is interpreted in the UK forestry standard 2017 http://www.confor.org.uk/resources/uk-forestry-standard-2017/

It is now well established that woodland management in upland catchments, including riparian woodlands, can play a major role in flood prevention by attenuation of precipitation and riverbank stabilization. Trees near rivers can also be used to improve fisheries and increase biodiversity across whole ecosystems. Before taking a look at some of these positive effects that can be gained by riparian woodland management, this section examines the history of this woodland type and more recent trends.

FROM DEEP HISTORY TO MORE RECENT TRENDS

It is likely that at 'peak forest' the floodplains of the Highlands and Island's rivers were largely wooded. However, with their natural fertility and access to water they were probably one of the first habitats to be cleared by early human settlers for enhancement of wild grazing, followed by agriculture. From the 1800s onwards, major drainage has been possible within floodplains. This, along with modification of water courses for navigation, log floating, mills and leats, access for fishing, impoundment for water supplies, and finally hydro-electricity, have all taken a huge toll on the naturalness of water courses and their associated riparian zones. In general, all this has contributed to woodland loss, as elsewhere.

Refer to section 12 'Woodland Ecology for more on post glacial woodland history.

A thin and often broken line of alders along one or both banks of Highland burns or rivers is not an uncommon sight. Indeed, in many areas, these fragile linear habitats have become so fragmented as to become a series of pathetically isolated trees in otherwise treeless upland landscapes. When one considers the many valuable uses that alder had, and still can be put to, this loss seems all the more poignant. Due to its resistance to rot, alder was once much valued in construction, clog making and as a source of charcoal.

Refer to section 10, 'Home-grown timber' for more on timber use.

A lone alder. In the background a highly fertile alluvial flat ideal for some planting of a wide range of species including oak and cherry.

In the 20th century commercial conifer afforestation was responsible for major encroachment of the riparian zone. This caused deep over-shading and frequently some serious siltation and hydrological disruption during both planting and harvesting operations. Coniferous needle litter further acidified watercourses already suffering from 'acid rain' deposition. Artificial fertilization of growing forest crops added yet another change to levels of nitrates and phosphates in particular.

Refer to section 12 'Woodland Ecology' section for more on acid rain and acidification.

By the 1980s these practices and trends, already widely condemned by environmental scientists and fishery interests, were finally acknowledged by industry and government. In 1988 this resulted in the Forest and Water Guidelines, which signalled a step change in policy and practice in regard to the riparian zone. In a short space of time the riparian zone and its woodlands became a major focus for the convergent interests of wildlife conservationists, the burgeoning reforestation movement, and the freshwater salmonid industry.

Acidification of freshwater by acid deposition from precipitation (acid rain) and agricultural run off is of ongoing concern as it has major implications for fish and indeed all freshwater life. Acidic rainfall and run off affect the land too, disrupting biotic soil processes, altering biochemistry and availability of plant nutrients and therefore the entire functioning of ecosystems. The subject of nutrient cycling and ecosystem nutrition is returned to in section 12 Woodland Ecology

The latter was undergoing a major resurgence and grew to be represented by 25 Fisheries Trusts and 41 District Salmon Fishery Boards in Scotland. This was probably in the nick of time as the evidence from fishing records suggests that stocks declined rapidly during the 20th century.

REVERSING DECLINES IN FISH AND FORESTS

Rod catches of salmon and sea trout fell to their lowest recorded levels during the late 1980s, 1990s and early 2000s in nearly all the rivers of Wester Ross, as well as in other west coast rivers of Scotland. It seems that the nadir of the once great Atlantic salmon and sea trout coincided with the nadir of the once Great Wood of

Caledon with which their fate had always been so completely entwined. The future of this group of fish, the enormous potential for them to once more both feed and delight human communities, is now under such a deluge of threats from salmon farming to oceanic acidification, that we cannot be certain that it will be saved. However, one critical lifeline is offered by the major improvement to its breeding grounds that woodland restoration can offer in the Highlands and Islands.

Fishery managers have focused for some years now on stabilising riverbanks, improving shelter around watercourses, and specifically in increasing deciduous leaf litter fall into burns, rivers and lochs by new woodland establishment. Livestock and deer have been fenced out of some areas to allow woodland to re-establish, even if only a very narrow strip. Conifer plantations have been removed in proximity to watercourses in some places.

The increased deciduous litter entering the water system (allochthonous input) is a major source of nutrition for freshwater invertebrates such as larvae of caddis, mayfly and stonefly. These in turn are fed on by young salmonids, raising productivity and survival rates both in freshwater and in the sea.

Plant growth within burns is also important in providing habitat and feeding for invertebrates (autochthonous production) and too much shading tends to reduce this. A mix of open banks and deciduous riparian tree growth is therefore most likely to provide balance between shade and leaf litter for fisheries.

Whilst the main contribution to new riparian woodland habitat since the 1980s has been an incidental part of native woodland establishment in general, a number of riparian woodland projects have been undertaken with the specific aim of improving salmonid fisheries.

"The relationship between land use and fisheries is so intimate that the overgrazing and consequent reduction in vegetation, especially of trees, has dire consequences upon fish populations". Findhorn District Salmon Fishery Board report

SALMON AND WOODLAND NUTRITION

Salmon and other anadromous fish (those that migrate up freshwater from the sea) transport significant amounts of marine nutrients into the freshwater and terrestrial environments. Or rather they did when they were plentiful, up to about a century ago. The decline has been ongoing since then, with drastic reductions even in the last 20-30 years. This pathway of land fertilization has therefore been considerably reduced.

Fish death fertilizes trees

About 90-95% of salmon die after spawning and whilst most corpses contribute to feeding fry and parr and other life in the river itself, some of the nutrients are transferred to the land by way of predation. This is primarily by birds and otters (and mink in a few places). Birds taking salmon from freshwater in the Highlands and Islands include white-tailed eagle, osprey, cormorant, divers, heron, merganser and goosander. Indirectly, the nutrients return to the land through bird predation on the myriad of invertebrates that feed on the decomposing flesh of salmon. Birds feeding on these invertebrates typically include dipper, common sandpiper, greenshank and other wading birds visiting freshwater loch shorelines.

Carcasses of salmon are also washed up on the banks of rivers and lochs where they are scavenged by an even wider range of insects, birds, rodents and other mammals and their nutrients therefore scattered into the terrestrial ecosystem far and wide in faeces and ultimately in the corpses of those animals. Some of these nutrients, such as nitrogen and phosphorus, will find their way into plants and trees.

Salmon production on two nearby rivers with contrasting catchment vegetation

(All the pictures and text in this box are reproduced from the Skye and Wester Ross Fisheries Trust Review February 2018 with permission.)

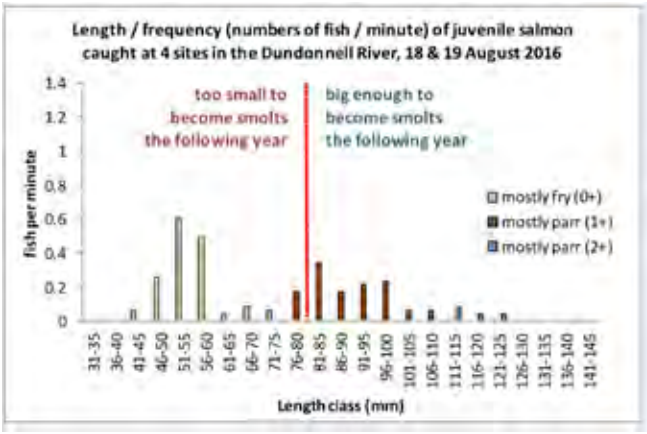
The Dundonnell and Gruinard rivers in Wester Ross provide contrasting conditions for juvenile salmon. The accessible part of the Dundonnell River flows through a well-vegetated corridor with riparian trees for most of the way from the gorge to the sea. Riparian trees provide leaf litter and insects in late summer and autumn. The river also receives run-off from farmland and from several houses within the catchment area. Parts of the river have been unstable in recent years with bank erosion and movement of streambed sediment; it is likely that washout events have reduced egg survival and recruitment of fry in some years.

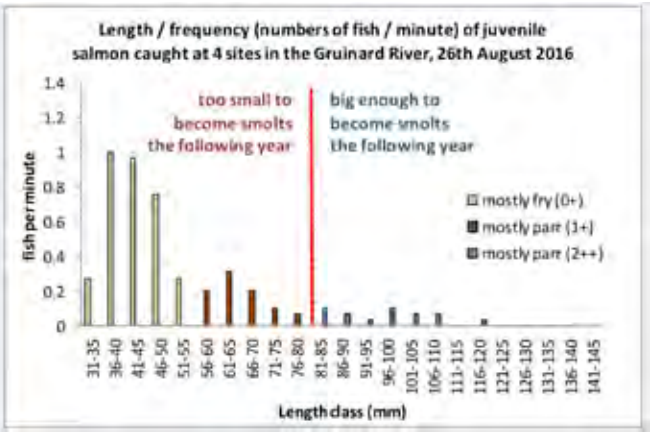
By contrast, the Gruinard River flows through an 'open' valley grazed by red deer. However, below Loch na Sealga, the stream bed is very stable providing some of the best spawning and nursery habitat for salmon of any river within the Wester Ross area, in terms of physical characteristics. There is no human habitation within the catchment area and healthy riparian woodland is scarce. The streambed and riparian areas provide a limited supply of food, perhaps especially during the latter part of the summer and autumn.

The graphs below contrast length vs frequency of juvenile salmon recorded in a 2016 survey. The original report supplies data also for a 2008 survey which displays similar trends.

Fewer juvenile salmon were recorded in the Dundonnell River than in the Gruinard River per unit effort (fishing time). However in the Dundonnell River, the average size of fry and parr was consistently larger than in the Gruinard River. A higher proportion of fish were of 'pre-smolt' size in the Dundonnell River, which may therefore have produced more smolts per unit area of river habitat per year than the Gruinard River.

Juvenile salmon grow slowly in the Gruinard River. Only a small proportion of those that were caught during juvenile fish surveys were big enough to become smolts the following year. Most of the energy is going into juvenile salmon that will need at least one more year in the river before they are big enough to go to sea.





(above) The Gruinard River. Lots of hungry wee fry, few of which will survive for long enough to smoltify.
(below) The Dundonnell River. This salmon parr (right) was somewhat larger than average.

On the Pacific coast of Canada and the USA the transfer of nutrients from salmon to the land has been well studied. One study in Alaska showed that up to 17.8% of the nitrogen in trees within 500 metres of two burns was marine derived. Another study showed that growth rates of Sitka spruce were more than three times greater adjacent to salmon spawning sites compared with non-spawning sites.

Admittedly the numbers of Atlantic salmon in the generally smaller Scottish rivers may always have been at a smaller scale, and the numbers of predators somewhat lower, but Highland upland freshwater and terrestrial ecosystems are both exceedingly short of nutrients so that even small inputs are important. Historically, as in the Pacific coast forests of today, the Highlands had bears, which are a major predator of salmon and must have been responsible for significant fertilization of riparian woods. Brown bear activity has been closely correlated with marine-derived nitrogen in Alaskan vegetation and it has been shown that a female brown bear deposits about 37kg of nitrogen per year into the terrestrial environment.

The unhappy conclusion is that the near loss of salmon from our rivers represents a significant loss of nutrient inputs to our nutrient limited upland environments affecting invertebrate, bird and fish life. This leads in turn to loss of fertility of soils for tree and plant growth. Lower productivity of vegetation means less allochthonous material enters freshwater systems to sustain invertebrates. Thus a feedback loop of declining productivity in all ecosystems, marine, freshwater, and terrestrial is soon established.

IMPROVING RIPARIAN WILDLIFE HABITATS

Riparian woodlands are critical to a number of bird species whose range and abundance is limited in the Highlands and Islands by its paucity. Goosanders and goldeneyes like to nest in holes in trees by rivers and lochs and are more vulnerable to predation when forced to nest on the ground. Species such as the dipper, sandpiper, swallow, sand and house martins, grey and pied wagtails, like to feed on littoral invertebrates and those that fall into the water. Overhanging trees increase both.

Mixed deciduous riparian woodland at Spinningdale.

Riparian woods are of value to beavers, which use felled branches and stems to make their dams. These create local pools and floods that can be exploited by many species including snipe, kingfisher, heron, ducks and some fish such as brown trout, perch, roach and eels. Trout and salmon are often able to ascend beaver dams, however the spawning habitat can be reduced.

The oligotrophic nature of our freshwater lochs is often cited as natural and a feature of interest in the Highlands. Although the acidic rocks of many areas combined with acidic litter of many heathland plants does indeed lead to relatively acidic water and low productivity, the fact is that a great many lochs would be far less oligotrophic than they currently are if their banks and those of the burns flowing into them were wooded. With much increased deciduous litter we could expect far greater numbers of invertebrates supporting higher populations of fish and therefore fish-eating mammals and birds, especially waterfowl and divers.

REDUCING FLOODING AND GROUND SATURATION

It is becoming widely acknowledged that woodlands and trees can play a crucial role in flood prevention by intercepting rainfall and storing large amounts in the soil beneath them. Indeed it is considered that the soil qualities under the woodland are more important than the above ground parts in terms of storage potential. The leaves of the trees intercept precipitation, evaporating some of it before it even reaches the ground. The root structure opens the ground to infiltration whereby the roots take up large volumes of water to feed the tree, which then transpires water from its leaves as part of respiration.

"...root systems create a complex interconnected drainage system, partitioning and transporting water resources within catchments. Increasing rainfall infiltration into the soil profile through tree planting is in many ways a natural 'drainage system' analogous to that of engineered drainage". N. Archer et al (2015)

In upper catchments where rainfall is especially high and soil permeability is often badly impaired by muirburn and over grazing, woodland regeneration can be expected to be particularly effective in attenuating water movement.

One study in upland Wales, involving planting of a mix of broadleaved trees in rolling grassland grazed by sheep and cattle, found that soil infiltration rates were 67 times faster and surface run-off volumes were reduced by 78 percent under trees compared with the grassland. These results were obtained early on from small trial plots of young trees. It can be deduced that mature woodland will achieve even more impressive results.

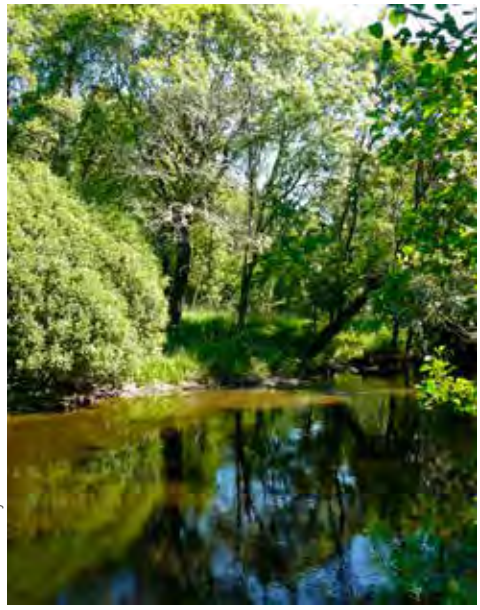
In our context of the use of lower fields for grazing and horticulture, we are often very concerned with general downslope movement of water at all times of year. By simple observation, the quantity of flowing surface water and soil saturation in our typical hill land is unlike anywhere else in Europe or Scandinavia despite reasonable gradients. We can identify large areas of the hill (typified by abundant bog asphodel and bog cotton) which seem to remain more or less permanently saturated or impermeable to water. The cumulative effect downslope is hardly surprising with consequent saturated in-bye and dense rush growth in fields. As noted elsewhere in this handbook, woodland on the slopes of the hill will soak up significant quantities of water to the benefit of downslope grazings.

Refer to section 9 for more on the 'natural drainage' provided by shelterbelts and hedges.

PROTECTION OF REMNANTS

As with all types of semi-natural woodland described elsewhere in this handbook, protecting our few remaining riparian woodlands has to be a priority. Land managers should assess the possibilities of this wherever existing fragments remain. On wider floodplains of rivers in the region some quite extensive remnants of alder carr can be found. Many of these are currently grazed due to the relatively rich grazings they offer. The nitrogen fixing alder will have maintained the nutrient status of the soils over the centuries and helped to provide natural drainage whilst being able to survive temporary inundation. Many of these alders have little or no

natural regeneration and rotational fencing will be required in the short term to ensure their survival.



Alder carr with willows.

Typical unfenced fragment of gorge native woodland in otherwise treeless landscape.

Whilst a few wet woodlands which exist on flat and relatively expansive floodplains should be a high priority for protection and regeneration, the significance of relatively small gorge woodlands can hardly be over-emphasised in our heavily grazed and burnt upland landscapes. These often represent the only refuges from tooth and fire for remnant populations of native tree and shrub species as well as woodland plants, including many ferns, bryophytes and lichens. To get a flavour of the woodland potential in any given area, visit a gorge woodland and you will be amazed by what you find clinging to wet cliffs, often in deep shade. These are the places to find holly, aspen, juniper, Scots pine of ancient local origin, along with woodland understorey of blaeberry, cowberry and woodrush, all of which may be completely absent from the surrounding grazed landscape.

These fragments are like oases in a desert. They can act as nuclei for regeneration by natural seeding if the surrounding land can just be fenced from grazing animals. They are also critical refuges for bird and insect populations providing pollen, nectar, berries and shelter.

Watercourses and gorges can present difficulties for fencing and linear protection tends towards the uneconomical. It is best therefore, if at all possible, to design exclosures to include a good area of adjacent land to either side for planting, natural regeneration or both.

Fragment of ancient Scots pine gorge woodland in Wester Ross, deer fenced to include a much wider area for potential natural regeneration.

PLANTING NEW RIPARIAN WOODS

General principles

Whether for flood alleviation, improving water quality, fisheries management or for general river restoration and biodiversity improvements, riparian woodland planting and regeneration is supported by a range of grants. There are strict guidelines to follow in order to prevent damage and pollution to watercourses. Minimum working distances from watercourses can be found in the UK Forestry Standard 2017, which apply to all mechanical equipment as well as pesticides and fertilizers.

See box at the end of this section "Keep your distance" for minimum working distances from watercourses.

The need to observe these rules does not preclude planting trees right up to the edge of watercourses. It just means that these areas will have to be planted using manual means of screefing, without fertilizers or chemical weed control. It is recommended that deciduous trees should be planted in the immediate riparian zone, although a percentage of native Scots pine in mixture should not cause any problems if grant conditions allow.

Refer to section 3 'Woodland Establishment' for more on weed control.

In nearly all riparian situations, new fences will be required to exclude deer and domestic stock during the establishment phase. Many sites may be surprisingly fertile on alluvial deposits and growth can be rapid. This includes the growth of grass sward, once grazing is excluded. This may result in strong competition for nutrients and light, so there will be a need for careful early maintenance of newly planted trees and bushes.

Mini floodplains abound in Highland catchments: those fertile areas of grass by meandering burns where the deer and sheep, not surprisingly, like to graze. Even oak will come away at altitudes as high as 500 metres or more on such good soils. To nurse it along in the earlier stages, oak could be combined with alder, which could be later coppiced for firewood to allow the oak to reach its full potential.

Typical fertile mini-floodplain at 350m capable of supporting rich woodland on alluvial soil. A site like this is ideal for use of small tree enclosures (see below).

Floodplains of any size offer a special opportunity for establishment of the larger broadleaved woodland tree species for possible future timber production where access would allow. The inherent fertility and frequent depth of soil may, however, be compromised by frequent waterlogging. Great care should be taken in identifying the different soil conditions over the course of a whole year in what may well be a patchwork of wet and drier ground. The immediate river banks and the wetter

areas of the floodplain will be most suitable for alder and a variety of willows (perhaps to coppice) whilst the slightly drier sites could grow oak, ash, wych elm, cherries or sycamore. Silver birch should also be considered as a quality timber tree in its natural range, eg central and eastern Highlands and Argyll.

Refer section 3 'Woodland Establishment' for more on timber-quality broadleaves.

Small tree enclosures

It can be very difficult to design riparian woodlands for a whole variety of reasons including their long linear shapes, the risks of flooding and needs for river bank access, be it for leisure, fishing or deer control. Long fencelines along rivers can also give rise to landscape issues and create wildlife hazards. Water gates are expensive and often very difficult to maintain.

One answer to these problems is to create small tree enclosures scattered along riparian corridors that respond sensitively to local topography, access and other needs. The 'Pearls in Peril' project in the Deeside catchment (not quite in our bioregion but with many similar characteristics) has been experimenting since 2012 with this approach.

The Pearls in Peril project was set up by a multi- agency and Fishery Trust partnership with EU LIFE funding.

The primary objectives of the project are to (a) help stabilise the riverbanks, reduce erosion and amounts of silt entering the river (b) introduce leaf litter and therefore nutrients into the freshwater system (c) ameliorate water temperatures. All these things are to the benefit of both salmonids and freshwater mussels. Of course, general improvements to wildlife habitat and landscapes are gained as well as local shelter for stock and deer along the riverbanks.

Climate change is leading to increasing water temperatures in the east of the country, which can adversely affect fish and freshwater mussels by a number of mechanisms. Increasing cloud cover on the west may counteract this tendency to some degree.

Experience shows that a good size of enclosure is 4 x 4 m accommodating about 20 trees, or 4 x 6 m with 30 trees. The method involves only a standard stock fence of 1.2 metres height with all trees individually guarded by 1.2 m shelters. The combination of dense shelters and fence should be enough to deter deer from jumping in and this has worked on the Deeside project. In areas of high deer density, such as in the west, deer fencing might be required. However, the method avoids full strainers at each corner by using stayed and tied back corner posts.

The project has installed around 1000 such enclosures and embarked on detailed monitoring of river water temperatures and fish numbers, which will quantify the effects in the longer term.

4 x 4m exclosure with tubed alders establishing well in the riparian zone of a River Dee tributary.


Keep Your Distance
Minimum working distances from watercourses, including connected ditches and drains
Width up to 1m
5m
No harvesting, brash tracking, ground preparation machinery
No application of inorganic fertiliser
No pesticide preparation, application, storage or cleaning of sprayers
Width 1 - 2m
10m
No ground preparation
No storage or application of fertiliser
No pesticide preparation, application, storage or cleaning of sprayers
Width > 2m
20m
No ground preparation
No fertiliser storage
No application of inorganic fertilisers
No pesticide application
Drinking water supply
50m
No fertiliser storage
No pesticide application or drift
No pesticide storage
Fuels and Oils
No refuelling within 10m of any watercourse
No storage or handling of fuels and oils within buffer areas
Always follow the UK Forestry Standard Forests and Water Guidelines
In the event of a pollution incident, contact the SEPA Pollution Helpline on
0800 80 70 60
For more information on diffuse pollution and how to reduce the risks from forestry activities see www.forestrywaterscotland.com
SEPA
Confor
FCA
dpmag

SECTION 8
AGROFORESTRY & NON-TIMBER FOREST PRODUCTS (NTFP)
wild harvesting, food forests, forest gardens, edible landscapes

Definition of terms

Agroforestry (AF) refers to any system that includes elements of managed agricultural or horticultural production integrated with tree or woodland management on the same unit at the same time.
Non-Timber Forest Products (NTFP) is the term most used in Scotland for all the biological harvests as well as the products made from them that can be derived from woodlands and plantations of any sort including the margins and clearings within. Coppice products, although woody by nature, are often included in NTFP. In Europe NTFP tend to be called *Non-Wood Forest Product*s (NWFP) or even *Wild Forest Products* (WFP) but this does not adequately describe the diversity of woodland types or co-products encouraged by timber management or designed multi-functional woodlands as described in this section.

Silvo-pastoralism (a type of agroforestry) is examined in section 6.

CLIMATE CHANGE, FARMING AND FOOD

Should some of the ideas and aspirations in this handbook appear overly ambitious or optimistic, they might best be viewed in the context of the Scottish Government's recent policies for agriculture and for food and drink production and consumption.

These include placing Scotland as 'a world leader in green farming', making us a 'Good Food Nation', enacting 'a refreshed action plan for organic farming', 'halting the loss of farmland biodiversity' and encouraging a 'new focus on soil health'. Part of achieving these goals will be that … 'farmers (will) combine food production with other land uses including woodlands, renewable energy, natural flood risk management, tourism and recreation… The Government recognizes that great innovation and effort will be required to bring about these things referring to a "step change in agriculture" as we move towards a 'low carbon agriculture'.

This handbook suggests ways in which many of these ambitious aims and policies can be addressed in the context of the upland environments and resources of the Highlands and Islands. The integration of agriculture with forestry and woodlands, common throughout Europe, Scandinavia, and indeed many other parts of the world, could be central to these aims. Crofting and estate management in our region would be well advised to pay attention to the 'green' rhetoric of government because policy, albeit with a time lag, and the incentives that support it, will inevitably follow. There are not an infinite number of ways that the low carbon agenda can be pursued in our uplands and woodland management is almost certainly the most feasible and effective. As this handbook sets out to show, it can add resilience to crofting, sheep, and cattle farming if tackled in the integrated ways which the term agroforestry implies.

It is worth noting a 'requirement' within the Community Empowerment Act (part 9) for local authorities to develop 'a food-growing strategy for their area,

Scot Gov Land Use Strategy Policy 8: *"We will develop and implement a package of measures to facilitate the step change to climate friendly farming and crofting. This will promote carbon efficient agriculture, environmental benefits and increasingly integrated land use."*

including identifying … 'areas of land that could be used by a community for the cultivation of vegetables, fruit, herbs or flowers'. Inaccessibility of land continues to constrain the Government's green farming agenda but community woodland acquisition offers exciting possibilities for the development of agroforestry projects including forest gardening and other potential crops and harvests examined in this section.

INTRODUCTION

Definitions of agroforestry and silvo-pastoralism are given at the start of Section 6, which examines the latter.

The term agroforestry covers a host of land use systems that integrate woodland, forests and trees with agriculture and horticulture. At their most simple these include forest farms throughout Europe, including Scotland and Scandinavia, where both stock and woodland are managed to give two income streams and equipment is often shared. At their most complex are the forest gardens of the Amazon and Indonesia where the forest is modified to create a more productive food and timber resource, often supplying all the needs of the local community. Between these two extremes lie a wealth of models from which we can draw inspiration and practical ideas to diversify our own land use systems. We have the potential to add new employment opportunities, and new local value, especially in improving diets and quality of life for ourselves and for our many visitors. Some of the ideas that follow are innovative and quite complex, others very simple. Many require new knowledge and training. All would contribute to the 'step change' in agriculture that the Scottish Government seeks and should therefore be eligible for support, if not now, in the near future.

"In Scotland, interest in NTFPs has been increasing over the last 10 years or so. There is now a wide range of businesses generating significant economic activity… policy relevant to the sustainability of personal use is as important as regulation of commercial harvesting" from Scottish Government's policy on NTFP.

Work funded by Forestry Commission Scotland and Scottish Enterprise and carried out by Reforesting Scotland, helped found the Scottish Wild Harvests Association. There is a UK body, the Association of Foragers which has several Scottish members.

The closer integration of forestry and woodlands with all types of farming and horticulture has been a recurring theme of the last 30 years or more in progressive land use forums. A great start to embracing agroforestry in Scotland has been the achievement of a burgeoning NTFP movement. What might have been seen as a fringe interest a few years back has now become a serious focus of interest for NGOs, Governments and progressive land managers throughout Europe as some of the examples below illustrate.

It is useful to distinguish between four main types of agroforestry in addition to the silvo-pastoralism (itself embracing several sub-types) examined in Section 6.

- Combinations of more or less 'conventional' agricultural, horticultural and silvicultural practices on the same unit where each contributes to productivity and there is a sharing of resources of labour, equipment and/or infrastructure and mutual biological or ergonomic benefits, eg farm woodlands, silvo-pastoralism, horticulture and trees.
- Harvesting of wild or 'as found' produce from existing environments whether on commercial or own use basis. In this handbook that only pertains to woods, to their protected margins, and to hedgerows – in other words, NTFPs which can be food or a variety of other products.
- Designed and predominantly planted forest gardens, edible landscapes and food forests managed continuously but not necessarily exclusively for food crops (this will include 'edible edges' of shelterbelts and woods).
- Modification and enrichment of existing woodlands, whether plantations or planted semi-natural woodland, to increase and expand productive capability and economy. This is currently most relevant to fruit and nut species but could embrace plants such as wild garlic and the management of animals such as wild boar or fowl in the future.

It is important to see agroforestry systems and NTFPs as offering enhancement or additional economic crops/harvests and not necessarily as substitutes or alternatives to existing or traditional land uses. The range of agroforestry systems is wide: they can be based on existing woodlands and plantations of all types or can be created from bare ground. They can be deeply rural, involving huge areas of land, or highly intensive in urban or peri-urban locations. They can be artificial, wholly designed landscapes or relatively lightly modified or semi-natural ones.

The definition of NTFP embraces the collection of craft materials, mosses and fibres and is sometimes extended to include educational, recreational and spiritual activities taking place within a forest. Some of these we look at briefly in a section 10 'Home-grown Timber sub-section 'Huts and Hutting'. But in this section we focus on food crops, which is in line with the stricter definition of agroforestry.

HORTICULTURE

The development of horticulture in its many forms represents a massive opportunity for the Highlands and Islands and can be greatly enhanced when integrated with trees and woods. We have plentiful clean water supplies, clean air, and large areas of (potentially!) available land, combined with a high dependence (as everywhere) on imported food. Rising food prices, increasing visitor traffic and changing subsidies all indicate improving economic viability for the supply of fresh, local fruit and vegetables. This can be at a variety of scales of enterprise, as large as wild fruit orchards, or as small as a kitchen garden for home needs. There are excellent opportunities to combine horticulture with self-catering and B&B visitor accommodation.

The Scottish Crofting Federation's Horticulture: a Handbook for Crofters is a deeply inspiring and informative contribution as well as a call to arms delivering an important message to policy makers and funding bodies. A "step change" is possible with well targeted and considerably more flexible and forward looking support.

These opportunities are being recognized widely in the region and a number of successful enterprises already exist from Shetland and the Western Isles to Skye. These are not just individual units but groups forming production and marketing co-operatives as found throughout Europe and Scandinavia. Local markets from Lochgilphead to Ullapool and from Stornoway to Dingwall are thriving. Producers find they can sell whatever they grow to the general public as well as to hotels and restaurants, which are always delighted to buy fresh salads in particular.

But all horticulture and fruit growing requires shelter and many parts of the more inhabited Highlands and Islands are particularly windy, with salt as an additional hazard. Rapidly changing temperatures, heavy wind-driven rain, sleet and snow are all common hazards. Well-planned shelterbelts, hedges and woodlands make a massive contribution to lowering local wind speeds and ameliorating extremes of temperature. Nearly all successful enterprises use these means along with carefully sited and constructed poly-tunnels which benefit from some shelter themselves.

Refer to Section 9 for more on shelterbelts and hedges.

As section 9 Shelterbelts and Hedges describes, woodlands, shelterbelts and hedges can do more than give shelter to crops, stock, tunnels and workers. They can also be used to drain the land and their leaf litter can be collected as part of composting mixes. Chipped wood from coppiced broadleaves will make paths between beds and mulches for certain crops. Earthworms, which are more likely to be found under deciduous woodland, can be transferred to production beds and composts. Coppiced broadleaves will yield essential poles of many diameters for informal windbreaks, for bean-poles and other crop supports, animal barriers and the numerous small fabrications that a horticultural enterprise requires.

Poly-tunnel growing herbs and vegetables on croft at Corrary, Glenelg.

Surrounding trees help to feed and shelter the pollinating bees and many other insects essential to successful fruit and some vegetable growing. Willows are great as fast-growing shelters and their catkins provide an important early source of

pollen and nectar for bees and other insects. Small-leaved lime is also good for bees and grows well in more sheltered places, although it rarely comes into flower without a warm summer. In all these ways woodlands and horticulture integrate well together even on small units of land such as crofts.

WILD HARVESTS

Prolifically fruiting native elder on west mainland coast. A much under-represented woodland edge species in plantings.

As elsewhere in Scotland we may recognize ten main groups of (non timber) wild harvests from woodlands in the Highlands and Islands: (1) berries and other fruit (2) nuts (3) seeds (4) fungi (5) tree sap (6) greens, herbs, tubers and flowers (7) dyes (8) lichens and mosses (9) poles, rods and bark (10) animals such as woodpigeons, pheasants, rabbits, roe deer. This is not an exclusive list but covers the main biological components harvested mostly, but not entirely, on an informal basis for the home economy. This section only covers the most common of these. There are so many more associated with fully functioning upland ecosystems but this is a book about woodlands so the information here is confined to these. Within a woodland mosaic, with grazed meadows and controlled grazing densities, there would be several more major potential food sources.

Guidelines for Wild Harvesting

Whilst Scottish Access legislation allows individuals to gather most plants, fungi, and mosses for their own use (even on Scottish Forestry land), people must obtain the permission of the landowner to dig up roots or transplant any plant. Gathering for commercial purposes is specifically excluded from the right of access. No one is allowed to pick plants from nature reserves, SSSIs, the property of the National Trust, or on MOD land. Certain rare plants cannot be gathered anywhere. There are three SNH codes for gathering fungi, mosses, and bulbs, which describe the specific conservation considerations for these classes. Gatherers should restrict quantities taken from individual or groups of plants, with a proper regard for their future, although the most commonly gathered species such as nettles and wild garlic tend to be resilient where they occur. Berries can likewise be abundant and resilient but gatherers should remember that they provide a very significant food source for birds and mammals. The shooting of birds and animals can only be carried out by licensed individuals and with landowners' permissions. For codes, see http://www.forestharvest.org.uk/Sustainable.htm

A. FOREST BERRIES AND OTHER FRUIT

The biggest NTFP industries in Europe, Scandinavia and Russia are based on wild berries that are mostly associated with woodland. In Sweden and Finland, for instance, the main species are blaeberry, cowberry (lingonberry) and cloudberry, all of which species grow wild in the Highlands and Islands.

The following excerpt serves to illustrate current interest in diversifying fruit growing in our region.
Great caution should be exercised in introducing the exotic species mentioned below into anything other than controlled horticultural environments as some are highly invasive!

Agronomy Institute of UHI report 2015-16
"Several northern berry crops have the potential for supplying high-value extracts for the nutraceuticals / health food supplements sector as well as products for the food and drink industry. Species being grown by the AI include cranberry *(Vaccinium macrocarpon)*, sea buckthorn *(Hippophae rhamnoides)*, aronia *(Aronia melanocarpa)*, Saskatoon *(Amelanchier alnifolia)*, low-bush blueberries *(Vaccinium angustifolium*), salal *(Gaultheria shallon)* and elder *(Sambucus nigra)*. Orkney Wine Company (OWC) produces a range of fruit wines and liqueurs using non-grape ingredients. Since 2012 the AI has been helping the company source unusual, locally grown ingredients to produce unique wines with a high content of local fruit. Several of the species being used have been in Institute research trials since 2004. The James Hutton Institute has helped the company establish its own fruit garden so that it can increase the production of wines made from local fruit. Commercial products which have resulted from this collaboration include the wines Orkney White and Orkney Rosé and the liqueur *Kvasir*. These products include fruits of cranberry, aronia, elder and salal and flowers of elder, all supplied by the Institute".

In the Highlands and Islands the main forest berries picked, mostly informally but in some cases with commercial applications, are bramble, blaeberry, cowberry, juniper, sloe, elderberry and rose hip. Native crab apple, bird and wild cherries are occasionally picked for home consumption, most of them requiring plenty of sugar.

Blaeberry and cowberry

Blaeberry and cowberry are common characteristic dwarf shrubs of our region. The potential for the restoration of these fruits as a wild or lightly managed harvest in commercial quantity is contingent on the reduction of grazing densities. They are especially compatible with silvo-pastoral models A and B (see section 6 Grazing Animals and Woodland). Their spread and fruiting will be greatly encouraged by the simple act of fencing existing woodland. Management in other countries extends to cutting the foliage back, which is said to encourage fruiting. This clearly should not happen in the growing or fruiting seasons, although it is performed then by herbivores in Scotland, who love the berries as much as the fresh green foliage in the spring. They are prime candidates for enrichment plantings and food forests (see below).

A note on names:

Blaeberry *(Vaccinium myrtillus)* in Scots and *Fraochan* in Gaelic is called blueberry in English or lowbush blueberry to distinguish it from high bush blueberry which refers to wild and cultivated species mostly from USA. Cowberry *(Vaccinium vitis-idaea)* is the commonest name in Scotland for what may also be referred to by many different names including lingonberry in England and Scandinavia.

Refer to section 12 ''Woodland Ecology' section on ecoclines and edge effects

Berries of the woodland edge occupy niches that combine shelter, fertility and just the right amount of light. Woodland management that creates clearings, rides and tracks encourages their growth and will favour insects and many bird species. Species of this habitat include elderberry, bramble, wild raspberry, blackthorn (sloe), roses and hawthorn. All these plants make excellent components of hedges and shelterbelts and can turn simple windbreaks into productive 'edible landscape' features. All these berries, hips and haws are used to make jams, preserves, cordials and wines in our region both commercially and for the home economy.

Blaeberry re-invading heather and flowering in full sunlight where grazing has ceased.

Juniper berries are used to flavour gin, and are added to a variety of dishes, especially to venison in our region. Juniper was once a very common shrub. It still grows quite prolifically in the Scots pine dominated woodlands of central and eastern Highlands. It is also a native component of western birch woodland and would naturally form significant understorey throughout our region, as well as being a major component in the montane scrub zone. Sadly, throughout much of the north and west Highlands & Islands it has been driven to near extinction by grazing and

burning. It hangs on in gorges and on cliffs, on small islands and in the montane zone. It is very susceptible to muirburn, being evergreen and with high resin content, but its tough root system often survives the fire to re-grow. It can be found in extremely prostrate forms on sea cliffs and to the very tops of our highest hills. But juniper will grow into a sizeable and productive bush, even on poor acid soils, as long as it is protected from herbivores. It seems adaptable to both full sunlight and high exposure but also to side shading in woodland clearings and under the dappled shade of a light canopy. It was one of the first pioneers of the colonizing post-glacial Great Wood and could again become a major component of upland woodland mosaics in a context of modified grazing management. Its absence is a major loss to the whole ecology and economy of our region, as it can provide food (including winter foliage and berries) to many species in the widest possible range of altitudes, soil types and habitats.

Juniper *(Juniperus communis L.)* is a priority species in the UK Biodiversity Action Plan as it is declining in many areas. The pathogen *Phytophthora austrocedri* which causes dieback and eventually death has now been recorded as far north as SE Sutherland. It is a notifiable disease in nurseries but consult SF literature for precautions you can take to mitigate further spread : https://www.forestresearch.gov.uk/tools-and-resources/pest-and-disease-resources/phythopthora-austrocedri/

Juniper is a slow growing plant and though it seeds prolifically, the berries germinate at anything between 15 months to 5 years. Variability in germination time is considered to be an ecological adaptation, increasing chances of establishment in unpredictable habitats. This makes it an expensive species to grow in nurseries, which explains, along with its very slow growth, its low use in planting schemes. Nursery propagation by cuttings appears the way forward, as two-year old plants can be successfully planted out. However it is a major candidate for enhancement planting of native woods and could be especially important in food forests and all kinds of designed future forest types (see below).

Juniper fruiting prolifically on an ungrazed island off the Wester Ross coast.

From FC: Growing juniper: propagation and establishment practices. Info Note 2003
'Plants grown from seed of local origin should be used when establishing areas of juniper or when introducing juniper to a new site. Care should be taken to source material from sites with similar ecological conditions to the site to be planted and which occur within the same seed zone. When expanding an existing population, it is advisable not to mix material from different populations that are more than about 1 km apart (unless there is evidence from genetic studies to sample more widely). This option could be considered when establishing a new population. Seed should be collected from a minimum of 20 bushes that show the full range of growth forms. If the objective is to expand juniper on a site where there are a considerable number of bushes and establishment time is limited, then propagating plants from cuttings taken from as many bushes as possible (at least 30) is an option'.

HIGHLAND SPECIALITIES

BLAEBERRY AND COWBERRY

BLAEBERRY *(Vaccinium myrtillus)*

Blaeberry is a very common component of our upland vegetation and is naturally most at home in the relatively lightly shaded woodland formed by birch and Scots pine. It also grows out in the open amongst other shrubby heathland plants but the best growths are often found in gorges and on cliffs out of the reach of grazing animals and muirburn where scattered light is prevalent and a little extra warmth and shelter can be found.

Given the wide distribution of the plant from low to quite high altitudes and its prolific fruiting throughout a range from the dry east to the wettest west coast locations, it suggests an ideal candidate for commercial exploitation. Unfortunately the green stems, leaves and sweet fruit are highly favoured by deer and sheep and are eaten in preference to the other dwarf shrubs so that the potential of the plant to spread and fruit is currently severely restricted in nearly all areas except fenced woodlands. It is interesting to reflect on the potential value of this berry crop alone to the Highlands and Islands if uncontrolled grazing and muirburn were to magically cease.

Blaeberry in fruit in west Highland birchwood.

Sweden averages an annual wild harvest of 485 million kg of wild berries (including blaeberries, lingonberries, and cloudberries) and Finland averages 450 million kg, with up to 730 million kg in a good year (Sinclair 2000). Most of the berries are harvested and individually quick frozen (IQF) for substantial jam, preserve and cordial industries.

Both HC and HIE have been involved over the last 20 years in projects to determine if certain berry crops could be established and grown intensively in the Highlands. A three-year blaeberry crop trial was established at 14 sites. The official report on these trials was very brief and contained little hard data, concluding that blaeberries would take at least five years to establish as a crop. Studies in North America have found that adding bee-hives to the fields, reducing weed competition, and developing appropriate fertilising methods greatly increased wild blueberry yield. Some commercial operations mow on a two-year cycle.

In the context of enriching Scottish woodlands with native blaeberry, the crop will be greatly increased by exclusion of (most) grazing. Light levels under dense canopy might need to be optimized in some cases by a light thinning. The most appropriate native species to provide suitable lighting levels may be birch and pine mixes but several other species such as aspen and rowan do not cast deep shade either.

Mycorrhizal associations are almost certain to be critical to the plant's nutrition and health and Scots pine and birches form close natural associations so it is wise to work with these. It is also logical to manage blaeberry and cowberry together as they co-exist in the wild. Intercropping of these two species in field-grown commercial operations in Scandinavia has been observed.

COWBERRY *(Vaccinium vitis-idaea)*

Cowberry shares almost identical requirements of some shade and damp acid soil with blaeberry.
It forms mycorrhizal relationships with a number of fungi, including Rhizoscyphus ericae and has been grown commercially as a field crop in Denmark and Norway. As for blaeberry, its berries are harvested and individually quick frozen (IQF) for jam, preserve and cordial industries.

Cloudberry amongst crowberry.

CLOUDBERRY or AVERIN or EVRON in Scots *(Rubus chamaemorus)*

Cloudberry has an almost magical status in Scandinavia where it fruits prolifically on bogs in the tundra and montane zones. In Scotland too, it is a sacred plant, but as it so seldom fruits here, a find of berries is a rare occurrence even for trained eyes. In Gaelic place names it only occurs twice in the whole country. The name of the hill 'Beinn nan Oighreag' in Breadalbane means 'Hill of the Cloudberries' in Gaelic.

Cloudberry is not a woodland plant but would thrive with lower grazing pressures and without muirburn in the sort of extensive upland woodland and montane scrub mosaics envisaged in this handbook. It is a favourite flower and berry of grouse yet current muirburn destroys it. It takes 7 years for a new plant to become sexually mature and, as it doesn't set seed in the Highlands, it can only propagate vegetatively.

B. HAZEL NUTS

Hazel nuts ripening. Once a mainstay of the Highland diet.

The only nut producing species native to the Highlands & Islands is the hazel. It has a very special place in our woodland history, not only as a major component of past diets but also managed for its valuable multi-purpose coppice products. It is thought that its nuts were so important to early human populations that they encouraged its growth possibly in Mesolithic, and certainly in Neolithic times. The husks have been found from Shetland to the Western Isles in many archaeological excavations and the pollen record bears out its importance as a component in all woodlands especially those of the islands and western seaboard.

Today it is found in neglected coppice woods throughout the region and scattered throughout upland birch-dominated woodland. Its nuts are harvested by a few for the home economy. The resource is now nowhere near large enough to sustain commercial picking for food, although some are collected for native tree nurseries. It is being planted in native woodland regeneration schemes but soil deterioration and peat formation limit the scope for its immediate planting. It would be a major choice for planted food forests and forest gardens where nut production can be enhanced by arboricultural techniques similar to some fruit growing practices. It does not thrive in tree shelters, so needs proper stock fencing.

Knockfarrel Croft in Ross-shire has enriched planted native woodland with hazel for commercial purposes (see case study)

C. SEEDS

The seeds and fruits of all native tree and shrub species are picked for provision of native tree nurseries supporting a small seasonal economy, which includes some specialist climbing collectors. As woodland regeneration projects increase, the employment opportunities will increase and if woodland planting could be expanded to include plants of the shrub and ground flora then it could support still more.

D. BIRCH SAP

Birch sap has probably been collected for millennia and can be drunk fresh from the tree in small quantities or fermented to make wine. It can be collected by drilling 2-3cm into a healthy trunk between February and bud break. However, it can be difficult to plug the drilled hole and stop the flow, so a preferred harvesting method is to cut a branch the diameter of a broomstick, or slightly greater, and attach a collecting vessel to its end. There are commercial operations in Scotland and a home economy.

E. FUNGI

Despite a wide variety of edible species found in all woodland types from conifer plantations to semi-natural woods, the resource is not big enough to support large-scale commercial operations. Experienced collectors currently sell small amounts to hotels and specialist suppliers. Chanterelles and ceps are the most highly valued but other edible species including hedgehog mushrooms are collected. It goes without saying that great care is needed in identification, as some species are extremely toxic. It is also important not to over-pick vulnerable and rare species and the Scottish Mushroom Code should always be followed. The increasing area of planted and regenerated native woodland can only increase the size of the resource, which could be part of the economy of a woodland croft for instance.

Refer to Scottish Wild Mushroom Code http://www.forestharvest.org.uk/Images/ScottishWildMushroomCode_2010.jpg

The feasibility of growing shiitake on inoculated birch logs in our region was investigated in depth by Highland Birchwoods in the 1990s but, with their demise, the information has been deleted from the web. However you can find useful information at scottishforestgarden.wordpress.com

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PIGS, CHICKENS AND OTHER FOWL

Pigs and fowl of many varieties do well in woodlands, benefitting from the shelter, ground flora and fauna. However it is usually necessary to confine them to enclosures within woodland, if only for their own safety from predators. This can lead all too easily and quickly to ground becoming totally bare and poached, which will damage soil structure and tree roots. Temporary fencing and easily moveable feeding and accommodation devices are essential to ensure that this is not the outcome. Thus a reasonable size of woodland is required for these combinations to be sustainably viable.

The FCS Woodland Grazing Toolbox is a useful guide to this subject.

Trials of both wild boar and domestic pigs in the Highlands have been carried out over the last 20 years. For instance wild boar were introduced into a native woodland by Trees for Life to see if natural regeneration or general biodiversity was enhanced. FCS ran both wild boar and domestic pigs in conifer plantations as part of agroforestry trials in Moray. None of these trials was very conclusive, whilst all contributed some understanding to the gradual evolution of viable agroforestry for our region. It certainly appears that the stocking density of wild boar required to achieve a positive rather than a negative result is much lower than expected. In that respect the issue reflects the general observations in this handbook concerning naturally sustainable balance of woodland and herbivore populations.

Woodland grazing and pigs (FCS Woodland Grazing Toolbox)

"Pigs and wild boar are omnivorous. Roots and rhizomes are their favoured food but they will eat leaves, berries, nuts and invertebrates.

Their rooting behaviour can be used as a conservation tool in woodland, especially to reduce bracken cover and to provide niches for tree seedling germination. The impact of their rooting can be unpredictable, depending on the breed of pig, stocking density and the size of the woodland enclosure. If stocking levels are low, their rooting action can be beneficial, reducing rank vegetation and encouraging seedling germination. At high stocking levels, their impact can result in a complete removal of ground cover, including tree seedlings and seasonal flora such as bluebell and pignut, and even severe damage to mature trees.

Because of the potential for long-term damage to the woodland structure, the use of pigs in woodland should be undertaken with caution. There needs to be a clear idea of what they are there to achieve and their impact on the woodland must be carefully monitored".

There are opportunities for invention with mobile devices to allow regeneration of the fauna and flora that the hens rapidly deplete. Well managed mobile runs in fenced hedgerows and shelterbelts have been successful for keeping trees weeded and hens happy.

Maintaining that balance between fowl and woodland has to be a lot easier! Being descended from woodland creatures, hens love foraging in and around the edges of woodland, both coniferous and deciduous. They benefit from the enhanced micro-climate and, having a natural fear of wide open spaces, can be much encouraged to range freely under dispersed tree and shrub cover. Ironically, in our region their main dangers are from the woodland predators, fox, badger and pine marten. Great care needs to be taken to provide secure housing, and even daytime protection, by electric and or rabbit fencing. Where pine martens are present, overhead netting may be required.

Whether mature trees benefit in any way from the chickens is debatable. Where possible, enclosures should be moved around woodland to prevent complete ground vegetation loss and depletion of the invertebrates that fowl feed off. The fertilisation from droppings will certainly benefit rapid regrowth of ground vegetation once the chickens are moved on. Chickens, ducks and a variety of fowl will be an obvious and economic component of any woodland croft.

Free range hens in a Sitka spruce plantation on a woodland croft in Ross-shire.

BEES

The importance of bees of all types, including bumblebees as pollinators, cannot be overstressed both for commercial crops and wild species of plant. It has been noted how all insect species across Europe are in serious decline and wild bees are no exception. We can choose species of trees, shrubs and other plants in agroforestry systems to specifically benefit bees and therefore assist pollination of crop plants and other plants that are part of the whole fully functioning ecosystem.

Honey bees are just one species of over 200 in the UK and are ideal components of managed food forests, forest gardens and agroforestry enterprises such as woodland crofts. They need shelter to thrive and their hives must maintain a consistent temperature of between 20-30 degrees Celsius. Sunlight is therefore essential to provide this warmth so that hives are often sited in clearings in woodland that receive a good combination of shelter and sunlight.

Hives in woodland are best sited on stands off the ground to deter investigation by badgers and other animals. It also keeps them above ground frost and damp.

Honey bees will forage up to about three miles for food sources but a designed environment should include a variety of plants, trees and shrubs that provide a sequence of flowers from early spring into the late summer. The early flowering willows are particularly relevant in our region, as they provide essential early nectar and pollen to emerging bees, including the bumblebees. The kind of mosaic of grasslands and woods that this handbook promotes make good habitats for bees. But in the Highlands and Islands these can be greatly improved by enrichment plantings of specific flowering plants, as discussed below.

Native Scottish black honey bees at Lynbreck Croft (see case study).

Rhododendron nectar is toxic to honey bees and the resulting honey is unsafe for humans to eat although the bees are more likely to die than produce toxic honey. This may be important to note in areas of the Highlands and Islands where woodlands are infested with this invasive plant although there is evidence that honey bees avoid *R. ponticum*. Other species of bee including the tree bumblebee seem adapted to feed on it safely.

DESIGNED FOREST ECOSYSTEMS AND FOREST GARDENS

Forest gardens are probably the world's oldest form of land use and most resilient agroforestry system. They originated in prehistoric times, evolving from progressively modified existing forest environments and incorporating fruit and nut trees, shrubs, herbs, vines and perennial vegetables. But they have never been a feature of northern temperate zones, mostly because of early extensive deforestation accompanied by predominance of domestic cattle, sheep and goats. In the context of shifting social and ecological priorities there is increasing demand and need for more locally produced food in more economically self-reliant and low-carbon communities. Designed ecosystems may become more common in temperate zones including Europe even as the last ancient tropical ones are wiped out by (largely Western) demands for vegetable oils, coffee, exotic fruits and other luxuries.

For now, there are probably no examples of designed food forests in the Highlands and Islands, although there are a small handful of forest gardens carved out of semi-natural woodland. However in the vanguard of designed forest ecosystems in Europe are the so-called Dutch 'food forests', offering examples that display diversity in organizational structure, productive components and indeed in their driving principles. Some of these 50 or so food forests have been created out of existing woodland but the high degree of management and cropping of animal as well as plant harvests places them in the category of designed forest ecosystems. There are several relevant ideas from these Dutch projects that could be adapted to our Highland environments so they are explored in more detail in the box below.

DUTCH FOOD FORESTS

(Edited and reproduced from RS Journal 56, with permission of Reforesting Scotland)

"At present around 50 food forests have been established in the Netherlands with a total area of a little over 100 ha. Many of these food forests are located in peri-urbanised areas rather than in traditional forested areas. The rewilding of forest foods does not just reflect new interests in natural rather than domesticated food products but also new ways of living with nature that transcend the historical dichotomy between rural people as agricultural producers and urban people as enjoyers of the amenity values of nature.

The various food forests in the Netherlands were either developed by creative innovators searching for new production systems at the interface between agriculture and forestry or by local community groups. In addition to the development of food forests by civil society organisations and private entrepreneurs, the growing interest in wild food products has also resulted in the development of new forest management practices by commercial forestry and conservation organizations.

In some forests the forest vegetation is enhanced by native fruit or nut-producing species as well as by traditional cultivars of local fruit species.

Professional forestry and conservation organizations are attempting to introduce new systems of lightly managed or natural grazing in traditional forest and nature conservation areas. The introduction of both 'wild' and ancient forest grazers involves the integration of ecological and agricultural aims as well as cultural heritage values. It has led to the development of specialised markets for the meat of culled animals. These meats are branded as 'nature or wilderness meat' and marketed as niche products, often through marketing co-operatives of conservation organisations or to their members".

MODIFICATION AND ENRICHMENT OF EXISTING WOODLANDS

Many native woods have been planted throughout the Highlands & Islands in the last 30-40 years. Some are as small as 0.1 ha and some as large as 300 ha but, of whatever size, it will not prove very difficult to modify some of these woodlands in the coming years. Indeed the whole question of how or indeed if these woodlands are to be managed will almost certainly become increasingly voiced. The management aims of enrichment (by which we mean artificial addition or promotion of species) are diverse. They range from increasing wild harvests for informal or non-commercial aims to increasing wild harvests for commercial aims, such as hazel nuts or fruits to support or create specific industries. Other aims might include increasing biodiversity in general or encouraging specific species or groups for conservation, or making woods more interesting to visitors as part of commercial recreational ventures.

Intensities of herbivore grazing will, as usual, act as a constraint to enrichment. If this is not to limit, or indeed determine, the future productive potential and biodiversity of nearly all our woodlands, then active management will be required as establishment era fencing becomes porous. Assuming that deer (all species) are seriously controlled and domestic grazing too, then, in practical terms, what form might enrichment take and what are its economic possibilities?

Mixed hedgerow fruits including crab apples.

Wild fruits weighed and ready for jelly making.

It has been noted elsewhere in this handbook how conservative in terms of the species planted are the majority of native woodland planting schemes. Those established by natural regeneration are little better as they inevitably tend to regenerate only species already present. In the majority of cases this has led to woods dominated by combinations of birch (downy and silver), Scots pine, alder and willow. It is understandable that low risk strategies are often adopted when establishing new woods. But 15-20 years down the line, when shelter has been established, the ground is substantially drier, the ground flora already modified, pH and earthworms on the rise, then the environment in many cases is conducive to a substantially wider range of tree and shrub species.

Re-stucturing of existing woods by enrichment with higher value timber species is dealt with in section 3 Woodland Management

Where seed sources are abundant and ground is relatively fertile, extraordinary transformations can occur of their own accord under new woodland, so long as grazing is excluded long-term or kept to low levels. The heavier seeds (such as holly and rowan), transported in the guts of birds (where they have been naturally stratified), fall to the woodland floor and germinate. Jays and rodents may bring in acorns where there are adjacent oak woods. Therefore some diversification or enrichment can be promoted by the relatively simple action of maintaining fences and culling deer beyond the establishment phase.

In the best locations impressive understorey growth of bramble, blaeberry, cowberry, juniper and elder might just occur through maintenance of fencing. But in many locations, probably the

Dense blaeberry in birch woodland fenced from stock and red deer, Wester Ross.

majority in the less fertile north and west, especially where woods have been planted on ground long bare of woodland, and on peaty and heathy sites, diversification may be very slow indeed. There is therefore great potential to enrich woodland artificially, increasing overall biodiversity and potential for wild harvesting by introducing new tree and shrub species. Choice of site and species will take account of the shade provided by the canopy and the degree of shelter to winds as well as all the usual site factors.

Protection of enrichment plantings.

Protection of new plantings from grazing and browsing will be paramount unless perimeter fences are repaired and maintained to a high standard. Where they are not, then all enrichment plantings within woods will require their own special protection. This could be individual double-staked tree shelters or, perhaps more economically, small fenced exclosures protecting a few trees and shrubs. This is likely to prove a relatively expensive option compared to that fundamental maintenance of perimeter fences, which will allow a much more substantial enrichment process aimed at providing long-term, potentially economic production of NTFPs.

Enrichment plantings can be native and non-native BUT EXERCISE GREAT CAUTION WITH POTENTIALLY INVASIVE SPECIES!

Enrichment planting will often focus on edges where sunlight is maximized and fruit ripening is enhanced. Appropriate species include bramble, wild raspberry, juniper, sloe, hawthorn, elder, roses, bird cherry and crab apple as well as hazel for nut production. But these are only the natives. There is scope too for introduction of some cultivated fruit trees and bushes, depending on the overall objectives.

Enrichment plantings for wildlife conservation and biodiversity

The discussion above focuses on food production, but where wildlife management is a priority, species enrichment will also include oak, ash, wych elm, holly, aspen and other under-represented native species. Although not native, small-leaved lime could be introduced to feed bees either as pollinators or for honey production. And other non-native species such as buddleia can be planted for butterflies. Privet (probably introduced to our region) is a food plant of several butterflies including speckled wood, comma, red admiral and peacock, all of which occur in our region.

Clearly, blaeberry and cowberry will be welcome additions. If they are present at all, they should spread naturally. Honeysuckle, a natural component of our woodlands from Shetland to the Borders, is good for many insects and is a prime candidate for enrichment plantings. For butterflies we need to match plants to specific species that are found in our region – not forgetting that the flowers to feed the butterflies are mostly different from the plant species to feed the caterpillars. Nettles are the food plant of the caterpillars of small tortoiseshell, peacock, red admiral, comma and painted lady, all of which occur in our region.

There is growing interest in the restoration of all plant communities in our woodlands. The concept of enrichment for productive economic and/or informal wild harvesting is in its infancy. Yet it seems likely that economics, combined with a diversity of long-term management goals, will determine the extent and types of enrichment, some of which could be ongoing and pay for themselves.

The most likely groups to embrace the concept are perhaps community woodland owners and NGOs with interests in conservation, education and general enrichment. But some could evolve long-term economic production strategies for specific crops or groups of crops. The potential to transform the food production of a woodland by adding harvestable quantities of fruits and nuts adds an intriguing dimension to woodland management. It could have very positive environmental, and modest commercial, outcomes as well as contributing to local food and health strategies. It is precisely the sort of innovation that is worthy of Government support in its drive for a low carbon food economy and ‘Good Food Nation’.

CASE STUDY

HEBRIDEAN BASKETS, GREAT BERNERA

by Dawn Susan

I live and work from home in Crothair, Isle of Great Bernera on the Western Isles. I have a 27acre croft and grow willow for my basketmaking and teaching which I do there. The willow coppice area is only around half an acre but I grow about 65 different varieties and make part of my living from selling cuttings. These include basketry willow, windbreak varieties and willow for winter colour.

Willow varieties vary a lot in how they grow and even within a species the varieties can be very different. Some of them grow thick and tall, whilst some are very fine and don't have a lot of withies on the coppiced stools. The type and depth of soil also have a big effect on growth. For instance the variety Flanders Red will grow to 2m in a deep soil area but in another area only to about half that.

Woven gourd-shaped sculptures, which include a variety of natural materials such as birch and alder twigs and the use of pussy willow. The work is inspired by the pods of Lise Bech amongst others.

My favourite for basketmaking is *Salix purpurea*. I really enjoy using the different bark colours in my work but the most colourful, such as varieties of *Salix daphnoides* are not always right for basketry. I can use these in platters and as side weavers on baskets, plus in my frame baskets, fish and stars if I use them half green. Half green is the term basketmakers use for willow that has been cut and allowed to dry for a few weeks so that it is still flexible enough to weave with but has lost much of its moisture.

Salix purpurea. Excellent for larger projects such as baskets for peats or creels.

Salix 'Vitellina' grows like a flame with yellow near the base flowing into orange and then red at the tips.

My favourite willow for use as a windbreak is *Salix hookeriana*. This is native to the west coast of the Americas and has evolved to deal with cold salt laden winds. Its hairy leaves and bark do not suffer at all in the fierce winds that come straight off the sea from the north here on the croft. It is the fastest growing and one of the most beautiful willows I have found. The wind here is the reason that my willows do not grow to the height they might attain in sheltered mainland areas. After about 14 years from planting some do get to 2m+ but not many of them. Willow coppice is reputed to last around 25 years. I planted my first cuttings in 2001 and continued planting until about 4 years ago. My cuttings go all over the UK, to basket makers and gardeners alike. I find that people living on the island are more interested in buying the windbreak varieties.

Small basket using birch twigs as well as woven willow.

Willow creels were an important part of crofting life. Used for carrying virtually everything... peats, seaweed, potatoes, manure... Many crofters made their own creels in the winter from carefully protected willow trees.

OTHER PLANTING

I have planted up most of the croft with native trees and use my own downy birch twigs and branches in my basketry work as well as willow. The other trees include alder, aspen, ash, Scots pine, oak, goat and grey willow. There is an area around the house which has non-native trees including five monkey puzzles, some lodge-pole pine, mugo pine, beech, and five apple trees, which give lots of apples even though there have only been in five years. There are also two cobnut trees, which don't yet nut, and a Victoria plum, which occasionally fruits low down. The croft is primarily 'unimproved' and has a lot of heather on it. I have used heather in my work both in rope making and sculptural pieces. The croft also has hair moss and purple moor grass that I have harvested to use in twine making workshops, so it yields a great variety of useful materials.

www.hebrideanbaskets.co.uk

CASE STUDY

BALEVEOLAN CROFT, LISMORE

by Iona Hyde, Clare Haworth and Mike Hyatt

INNOVATIVE DIVERSIFICATION OF CROFT

When Mike Hyatt and Clare Haworth bought Baleveolan Croft on the Isle of Lismore in 2011, the croft house and outbuildings were derelict and the croft had not been actively managed for many years. Six years on, not only does the 16ha croft support a thriving bunkhouse business, but Clare and Mike have created a modern, diversified crofting enterprise that supports a productive tea plantation, an abundant organic garden, a poultry business, an orchard, and about 5000 new trees, all planted since 2012.

THE ALL-IMPORTANT SHELTERBELTS

After taking on the croft, one of the first things Mike and Clare did was to start planting shelterbelts of mainly native species. The trees were intended to provide shelter, fruit and firewood but also to improve the biodiversity and amenity value of the croft. A wide variety of species was planted including willows, hazel, rowan, oak, hawthorn, guelder rose, dog rose, elder, birch, alder, blackthorn, ash, cherries and a few spruce.

There are few deer on Lismore, so once the stock had been excluded from the planting sites, the only protection necessary was vole guards. These shelterbelts are well established, with trees now up to 3m in height. Further planting followed in subsequent years and, to date, over 5000 trees have been planted on the in-bye land on the eastern side of the croft. All species are doing well, although alder, willow and birch are showing particularly good growth rates, as might be expected in this location. The crofters are now introducing woodland plants into the field layer and have already established some native bluebells.

Guelder rose providing flowers and berries for birds and insects.

Shelterbelt of mixed native species five years after planting.

During the winter of 2018/19, a further 3ha of land will be planted, with assistance from the Woodland Trust's MOREwoods scheme. This planting will be mostly in the more exposed western side of the croft and so more protection will be given to the trees for the first few years with 0.6m tubes and shrub guards. The intention is to create bands of woodland running across the croft to provide shelter for stock, which are to be re-introduced at some stage in the future. The western boundary of the croft is a steep coastal cliff that supports an important area of ancient semi-natural cliff woodland. Among other species, the nationally scarce rock whitebeam *(Sorbus rupicola)* grows there. An area of former rough grazing contiguous with the ancient woodland was fenced off in 2015 in an attempt to expand the existing woodland on to the croft. Naturally regenerating birch, hazel, blackthorn and rowan are already well established within it.

BUNKHOUSE

Underpinning the economic sustainability of the croft enterprise is the bunkhouse, which was completed in 2017. Accommodating up to 12 people, the bunkhouse is built to 'passivhaus' standards. It provides much needed affordable accommodation on the island and attracts visitors from all around the world. The original croft house is currently being renovated and when finished will provide a permanent home for Mike and Clare. Although staying true to the original vernacular, the finished croft house will be renovated to high environmental standards, with diathonite cork plaster insulating the external walls and an air source heat pump system providing heating through under floor pipes.

Apples ripening well in the forest garden.

FRUIT TREES AND BERRY BUSHES

As well as woodland and shelterbelts, the crofters have planted approximately 60 heritage fruit trees on the croft. Fifteen different traditional Scottish varieties of apples, plums and cherries are already producing abundant fruit. Within the areas of established woodland, a forest garden system is being developed. A variety of berry-bearing species have been added as understorey: raspberries, loganberries, tayberries and blackberries are all already producing fruit. The intention is to further diversify the range of produce from the croft by introducing an intercropping system into the remaining areas of in-bye in the eastern part of the croft, initially using a heritage barley variety planted with beans and peas.

HENS AND BEES

Baleveolan is also home to a flock of about 60 rescue hens. They roam the croft during the day, including the woodland areas where they help with weed control and fertilise the trees. They produce a plentiful supply of free-range, organic eggs that are sold to neighbours and the Island Heritage Centre café. A range of different bee-friendly plants such as borage are grown around the vegetable gardens to encourage native bees as well as to provide an established pollen source for more bees, which are to be brought on to the croft next year.

Hens help to keep the weeds down and provide eggs for the home economy and also for sale.

SCOTTISH TEA

In 2016, lazy beds were created and planted with potatoes to break up the soil. The following year, the beds were fertilised with organic manure and a plantation of approximately 500 Camelia *sinensis var. sinensis* tea plants was created. The tea plants are grown in alternate rows between rows of edible shrubs, which provide shelter from the wind. These include mahonia, sea buckthorn, currants, lingonberry, fuchsia, gorse, berberis and dog rose. Vole damage has been the greatest hindrance to establishment. Although several plants were lost to voles, their replacements have thrived and cuttings taken from the damaged plants have rooted and been used as replacements. The tea has already produced one harvest. Geotextile mulch matting lies permanently over the roots of the tea plants to protect them.

Tea plants planted through permanent geotextile cloth mulch.

Tea plants in alternate rows with edible shrubs.

OTHER CROPS

A wide variety of vegetables and herbs that can tolerate the wind and salt as well as the slightly alkaline soil are grown on the croft in raised beds and cold frames. Varieties of beetroot, kale, broad beans, broccoli, carrots, potatoes, chard, spinach, cucumber, lettuce, rocket, squashes and parsnip all produce good crops.

www.facebook.com/thelismorebunkhouse/

CASE STUDY

LAGANDORAIN CROFT, IONA

by Iona Hyde and John MacLean

When John MacLean bought Lagandorain Croft at the north end of Iona in 2000, the only trees in sight were those beyond the reach of sheep on the crags of Dun I. The 35ha croft is species and habitat rich and recognised in particular for its spectacular flower meadows. It is also stunningly beautiful. Like most crofts, however, it has been heavily grazed over a prolonged period. Wanting to improve both the biodiversity and amenity of the croft, John started to plant trees in 2003 and has now established almost 3ha of mixed native woodland. The woodland surrounds a series of rocky knolls in some former in-bye parks and provides the backdrop to the award-winning Iona Hostel, which John built in 2001.

The hostel and other croft buildings benefitting from the growing shelter of the trees.

The trees have been planted in an effort to mimic natural growth. This is both for aesthetic reasons and to create the dense growth broken by open spaces, the preferred habitat of corncrakes, which annually return to Lagandorain. Corncrake numbers have decreased overall on Iona in recent years but the Lagandorain population appears to be stable.

Following stock fencing of the site and exclusion of sheep (there are no deer on Iona), planting started with mainly willows (goat, grey and osier) downy birch, rowan, alder, sessile oak and hazel. As this has established, other species have been introduced, including ash, hawthorn, blackthorn, dog rose, yew and hornbeam. Forester Colin Blyth has been involved in the planting and has advised throughout.

Osier (S.viminalis) *providing shelter for crofters as well as stock.*

SHELTER, TUBES AND MULCH MATS

Progress was slow at first but John was surprised and pleased at the high survival rate of the trees planted. The initial heavy planting of willow to create shelter has played an important part in this. Over the years supplementary planting has been

undertaken and additional areas planted to extend the woodland. In winter 2017/18, a further 500 mixed native were planted with the financial and advisory support of Woodlands Trust's Croft Woodland Project. The excellent weather conditions following planting over the summer of 2018 allowed for rapid establishment and growth of the new trees.

Shrub shelterguards protecting hawthorn and blackthorn.

A wide variety of different tubes and guards have been tried and tested over the years and 0.6m shelter-guards (with a polythene lining) have been found to be the most effective, although in the most exposed parts of the croft, the widest ones sometimes require double-staking. Mulch mats are used and discarded silage wrap dug in around the bases of saplings has been a very effective use of what would otherwise be waste.

The exotic shrubs, fuchsia, ramanas rose and common osier proving their hardiness.

The original plantings are now well established and coppicing of the willow was introduced in 2015, producing the first firewood on Iona for many years. Willow rods are also cut from the osier and planted elsewhere on the site to further extend the woodland. Growth rates of osier are so high that it is being coppiced every two to three years. There has been a noticeable increase in wildlife on the croft since the woodland was planted, with woodland bird species now nesting in the trees. The ground flora is also recovering and as well as a wide range of flowering plants, creeping willow is establishing on the knolls. The trees provide much needed shelter for the surrounding pasture, grazed by John's flock of black Hebridean sheep. Beehives have recently been introduced to the woodland area with a view to increasing pollination and producing honey.

WET GROUND

The next phase will see more alder planted in wet ground on the southern part of the site and some prostrate juniper will be introduced to the south facing slopes of the rocky knolls, a characteristic feature of knolls on the adjacent Ross of Mull. Efforts have been made to improve the drainage on the site with a series of deep ditches dug throughout. The ditching and draining has had a positive effect on the trees, which responded well to the improved conditions. Paths are being created through the woodland to allow pedestrian access and maintenance of the trees.

A CARBON NEUTRAL BUSINESS

Iona Hostel has held a Green Tourism Business Scheme 'Gold Award' for 14 years and has twice been voted Scotland's best eco-hostel. The calculations have yet to

be done, but almost certainly, and thanks to the woodland, Iona Hostel is the first carbon neutral business on Iona.

Willows beginning to shelter and provide natural drainage to pasture.

Volunteers at Iona Hostel have always been an essential part of the planting and management of the woodland and this took a significant step forward with the arrival in the hostel of Marc Broatch-Stevens in 2012. Marc's background is in woodland management (he's a graduate from Newton Rigg School of Forestry), so Lagandorain's woodland has provided an ideal opportunity for him to practise his skills. The wood today is testimony to Marc's hard work and good advice. In John's words…*'he loves the place as I do and so quite rightly it's also known as Marc's Wood'.*

http://www.ionahostel.co.uk/

SECTION 9
SHELTERBELTS AND HEDGES

INTRODUCTION

Scotland is one of the windiest countries in the world. The wind causes many problems to all forms of land use, especially in our Western and Northern Isles and the coastal areas of the Highland mainland. It lowers the productivity of livestock, it lowers the yield of pasture, it affects the welfare of all animals and directly causes mortality and ill health, especially in lambs and calves. Added to that is the fact that wind chill affects humans and their buildings and makes life uncomfortable, sometimes making it difficult to work.

This section examines how trees, hedges and woodlands can be established and managed in specific ways to create shelter from the wind and improve the environment for livestock, horticulture, wildlife and humans. Section 6, Grazing Animals and Woodlands, in this handbook also deals with the sheltering effects of trees but here we focus mostly on the concept of the windbreak.

A RANGE OF FUNCTIONS AND BENEFITS

A good windbreak or shelterbelt, as it is often called, performs several functions at once. It takes up space on any land unit and this can be particularly significant on small in-bye fields or parks, so it needs to pay back in a variety of ways. It will easily do this if properly designed and managed.

A single windbreak, or best of all a network of windbreaks and hedges, can be designed to give shelter to:

(a) the whole living and working environment including houses and other buildings, roads, paths, gardens and play spaces
(b) crops, pasture and livestock including fowl
(c) horticultural activities and poly-tunnels
(d) bee hives

Shelterbelts and 'paraweb' protecting poly-tunnels on Lewis.

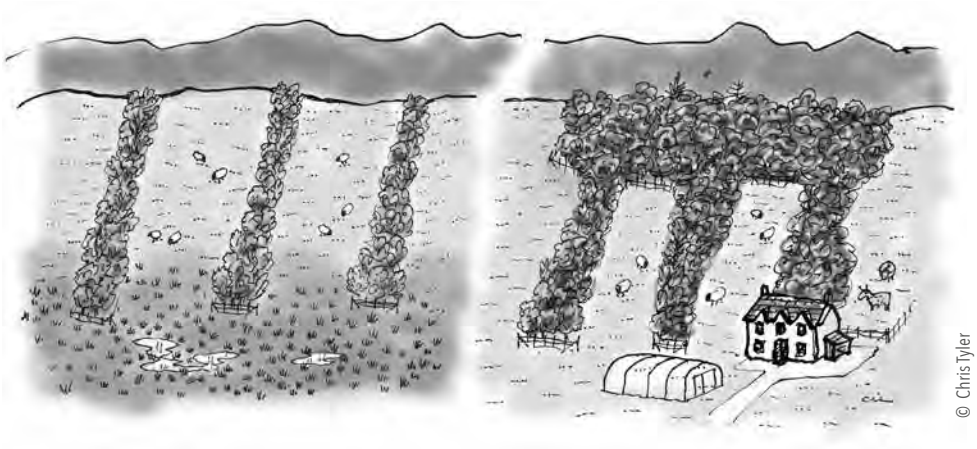
At the same time as providing shelter, shelterbelts and hedgerows provide:

1. wildlife corridors that can connect with woodlands and gardens
2. bird nest sites and migrating bird stop-overs
3. flower 'refuges'
4. shelter and food for essential pollinators
5. fruit for informal picking or as intrinsic part of productive design

THE ADDITIONAL BENEFITS OF DRAINAGE AND WARMTH

Refer to section 7, 'Woodlands & Freshwater Systems' for much more on trees and rainfall.

In the shelterbelt literature you may find reference to the adverse drying effects of trees on immediately adjacent crops and pasture. This simply reflects the wildly different concerns of lowland and eastern farmers to those in the west and north. Throughout much of the Highlands, woodlands and well-placed shelterbelts and hedgerows can play a useful role in reducing run-off and saturation of downslope fields. Rushes are a major problem, substantially reducing areas of grazings, especially in the western crofting areas as sheep numbers and available labour decline.



© Chris Tyler

(left) Under-performing shelterbelts where design fails to intercept water running off the hill. (right) Well designed shelterbelt system reducing run-off throughout the croft, therefore reducing rush growth and facilitating horticultural use below.

Many studies have substantiated the drying effect of trees on land. It occurs through a combination of the interception of precipitation and its evaporation and transpiration from vegetation. Finally there is significantly increased infiltration through the soil which has been opened up by tree roots. A detailed study has shown that surface run-off, even under young trees, is reduced by an impressive 78% compared with adjacent grassland.

It is quite clear that well-designed arrangements of shelterbelts and hedges can dramatically improve not just local wind regimes but also the frequent water-logging and cold temperatures which bring about loss of grass and animal productivity. They should be designed so that at least one arm runs across the top or upslope side of the area to be improved. Clearly strips of trees running with the slope will not be so effective. However, environmental and operational factors will determine design and compromises are inevitable.

From *The Crofting Forestry Handbook* 1993 SCU

"The accumulation of warmth in the lee of hedgerows, walls and plantations gives rise to the 'early bite' that is welcomed by shepherds. Taking the results of a large number of experiments across Europe for a variety of crops and pasture types indicates that, in tree-sheltered fields, the average increases in yields are about four and a half times as great as any losses due to the space occupied by the shelterbelt plus edge effects of competition with the crop or pasture. And shelter not only affects bulk yield but also the quality of the crop or grass. In one scientific comparison of tree-sheltered with unsheltered pasture, the former showed total weight of grass up by 9%, dry weight up by 68%, Vitamin C content up by 108%, digestible protein up by 144% and starch up by 85%".

© John MacPherson/WTML

Sheltered grazing at the edge of Balmacaan Wood, Drumnadrochit.

HEDGES

In the windiest environments, where space is strictly limited, or possibly as part of a bigger overall improvement scheme, hedges can provide a useful degree of shelter. They share many of the benefits of their larger shelterbelt cousins but with less investment in land – though more in cost per square metre, due to high density of trees and shrubs and high ratio of fencing to enclosed ground.

Some useful hedgerow species are given in a table at the end of this section. It goes without saying that these species need to be well adapted to high winds and even to salt spray in some locations. Another useful characteristic of many of the deciduous species in the table is that they can be repeatedly coppiced or pruned and will reshoot from their bases or cut branches.

The benefits of a hedgerow can be considerably enhanced if some trees are left to grow above the cut hedge height, even to full maturity. This can add another whole dimension to the windbreak with the possibility of introducing fruit above the reach of grazing animals. Indeed, in better environments they could one day even provide timber.

Many of the species that are ideal in hedges such as hawthorn, blackthorn, elder, holly and roses are all berry producing and many are edible. Early blossom of thorns is a visual delight and gives important feeding for insects.

Refer Section 8 Non-Timber Forest Products section for more on fruit.

© Anon

Blackthorn forming edge of shelterbelt giving nectar for insects, fruit for people and nest sites for birds.

© Nick Rodway

Native dog rose is an excellent choice for the edges of shelterbelts providing dense shelter, flowers for pollinators and nesting habitat for birds.

In places with rabbits or large numbers of voles, hedges will need to be established using individual tree shelters/guards unless fences of rabbit netting can be provided to either side. Even these will not protect against voles that will home in on the coarse grass that will quickly grow up in the protected strip.

Establishment in extreme environments is sometimes assisted by use of artificial windbreak material, which is often attached to fences. But beware how increased loads can pull them over so those fences need stays. All manner of temporary devices have been used at a small scale from pallets to fishing net!

Refer to Establishment section for more on tubes and fences.

A degree of weed protection during the establishment phase will greatly increase survival rates and enhance early growth. This can be achieved with mulch mats or screefing at time of planting, or hand weeding for the first couple of years. An excellent weed-free start to the life of a hedge can be given using a single/double plough furrow, or by lifting and inverting a strip of turf. Hens can be used for weed control once plants are above a certain height though some damage is inevitable.

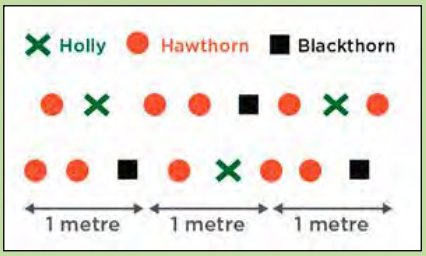
Refer to Establishment section for more on weed control.

Hens should be moved around rotationally to avoid ground damage and allow regrowth of ground flora.

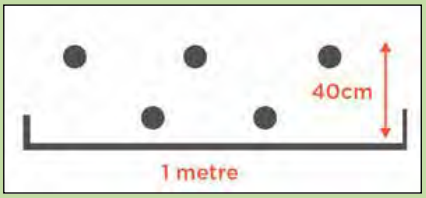
When and how frequently to trim hedges is so dependent on site and species that there can be no specific rules but for nearly all deciduous species cutting is usually undertaken over winter. Always avoid the bird nesting season (i.e. March – September) when cutting hedges! The ancient craft of hedge-laying is outside the scope of this handbook but is practiced in parts of Scotland. It is a great way of reinvigorating and thickening up ageing hedges to make them stockproof once more.

Refer to table at end of this section and Appendix 1 for many more species suggestions.

Example of an arrangement of three common hedging species in mixed double row.



Staggered double row: can be 40 to 60 cm apart



Standard mix supplied by Woodland Trust MOREwoods scheme in our region.

Hedge species	%
Hawthorn	70
Blackthorn	10
Hazel	10
Crab Apple	2.5
Dog rose	2.5
Elder	2.5
Holly	2.5

THE PRINCIPLES OF SHELTERBELT DESIGN

GENERAL POINTS

Shelterbelt designs on the hill or in-bye should utilize existing fences, woods and existing groups of trees where possible. This economizes on materials and helps to landscape new plantings. Try to avoid isolated blocks 'hanging' on hillsides and try to relate the edge of new plantings to local landform by curving around knolls and planting up hollows and gullies. New shelterbelts should be designed to help stock management.

Whilst hard lines of trees are not generally pleasing to the eye, within the restricted bounds of a shelterbelt it will be hard to avoid them and impossible where single furrows have been ploughed. Inverted mounding will be preferable to any type of ploughing.

Inside corners of shelterbelts can be cut across to increase the width of the wood slightly, avoid poaching of the ground in the corner of the field and helping to soften harsh angles in the landscape.

Exclusion of all grazing, domestic and wild, will be necessary at least during the establishment phase and should be achieved by fencing, tubes or a combination.

To maximize longevity, drainage and wildlife advantages of the shelterbelt, this exclusion will need to be maintained. It is particularly important that the understorey and lower branching is maintained as wind will accelerate under a 'hollowed out', browsed shelterbelt. Grazing animals within a shelterbelt will also damage tree stems and roots and cause serious impaction, reducing infiltration rates and eliminating the advantages of drainage that the trees will otherwise afford. Beware of rabbits and voles and protect new plantings as for hedges!

Willows forming a fast dense shelterbelt on Shetland.

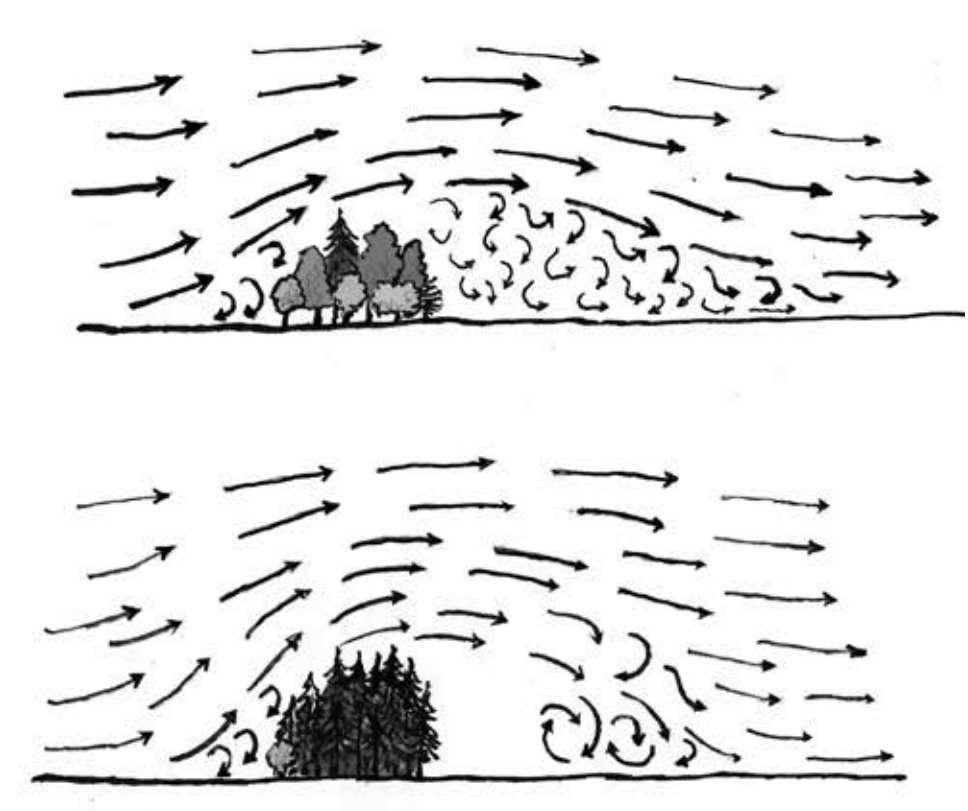
HEIGHT

The diagrams (below) illustrate the airflow patterns over two types of shelterbelt. The distance that shelter is provided relates to the top height of the shelterbelt with the best designs of the more permeable type affording some protection as far as 30 times the height of the trees to leeward. Note that some shelter is afforded even to windward of a shelterbelt (up to ten times the height of the trees). The maximum shelter is afforded between two and five 'shelterbelt heights' to leeward in the case of permeable type. This should amount to at least a 20% reduction in wind speed.

POROSITY

To create the maximum distance of leeward protection, a shelterbelt should not present a solid, impermeable barrier to the wind. It is important that the shelterbelt lets through a percentage of the airflow (ideally between 40 and 50%) so that eddies do not occur either to windward or leeward. The wind deflected over the top descends and meets the wind that has passed through the shelterbelt, which is now travelling at a slower rate. This limits heavy turbulence and strong winds are lifted above crop and stock level providing a less harsh microclimate.

A more solid shelterbelt can provide a greater reduction in wind-speed close up to the leeward edge and can therefore be good for a small lambing park, poly-tunnels or a horticultural plot. However it will provide a shorter total distance of measurable shelter and can give rise to pronounced eddying with sharp, local increases in wind velocity.



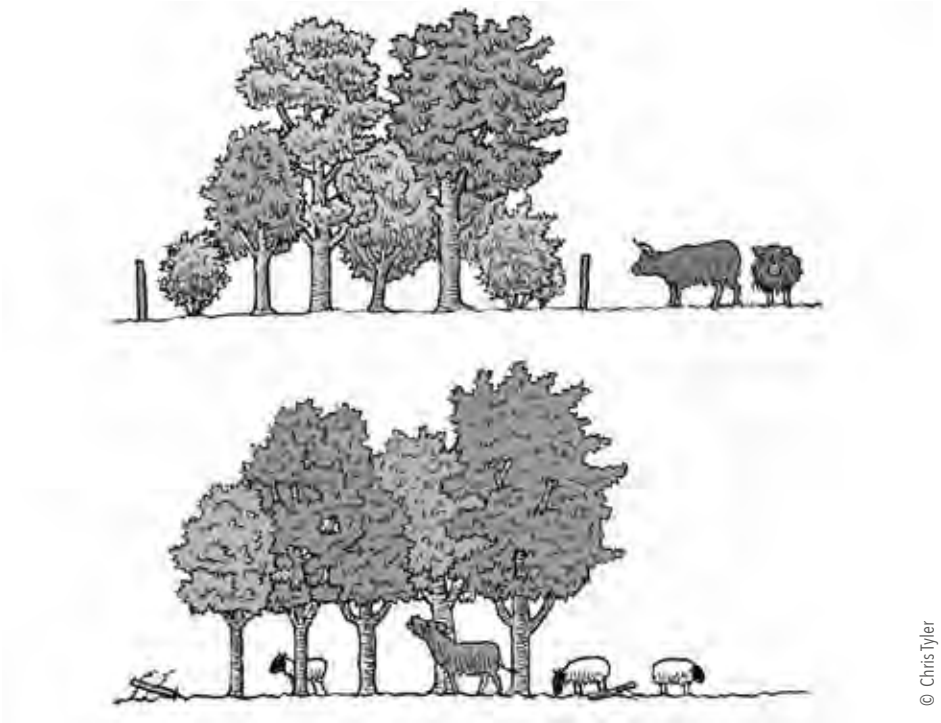
Classic wind flow diagram over two types of shelterbelt. The permeable type (top) lets some wind through but with long protected leeward distance and relatively little eddying. The more impermeable type (bottom) provides a shorter but better sheltered zone with stronger eddies.

It is useless to have a shelterbelt with nothing but clear stems from ground level to head height, as can happen with the wrong species mix and stock incursions.

Dense mixed species shelterbelts either side of a narrow croft on Lewis sheltering grazing for cattle.

WIDTH

Greater shelterbelt width does not of itself lead to more shelter. Indeed, if a wide shelterbelt has a smooth or evenly flat 'top', by the time the wind reaches the lee side of the belt, it may have accelerated back to its original speed on hitting the front of the belt. Uneven tops are therefore better at slowing the wind and they are achieved with species mixes.



Grazing and browsing animals can seriously damage a shelterbelt by removing all the understorey. This causes the wind to accelerate under the trees. Hens and fruit growing are better ways to get more value from a shelterbelt.

LENGTH AND ORIENTATION

Ideally the shelterbelt will have its long axis positioned at right angles to the prevailing wind direction. However, existing arrangements of fields and other factors may lead to compromise positions. A single shelterbelt is most unlikely to achieve satisfactory shelter from all quarters over the whole of one holding and a system of shelterbelts is often the ideal.

At the very least an L or T shape should be incorporated in the design, if at all possible, to account for different wind directions.

SHAPE

It is generally agreed that a relatively vertical edge to a shelterbelt is preferable to a gently sloping one though, in Highland Scotland, high exposure will almost always lead to a 'wind shear' effect on leading edges. Deliberately designed 'pitched roof' profiles are, however, incorrect as such shapes are too aerodynamic to obstruct the wind in the desired fashion.

OPENINGS

Wind accelerates through any gap in the shelterbelt, so position gates carefully where choices exist.

Willie Beattie and Sandy Murray admiring dense shelterbelt at Strath Halladale.

SPECIES CHOICES AND MIXES

It will be clear from the above that a good shelterbelt comprises a wide mix of species and that these will often include both deciduous and evergreen species, both broadleaves and conifers.

A wide variety of species and heights of trees and shrubs including bramble at edge for fruit.

There are a great many sad looking, narrow bands of Sitka spruce or lodgepole pine in the Highlands and Islands and small groups around houses, many of which have recently wind thrown. It will be sensible not to repeat this type of planting. Any of the native deciduous trees will be better along with sycamore or larch. In highly exposed situations use alder, willow, birch, hawthorn, blackthorn, sycamore and possibly coastal provenance lodgepole pine, but steer clear of Scots pine which is not tolerant of either high winds or salt spray.

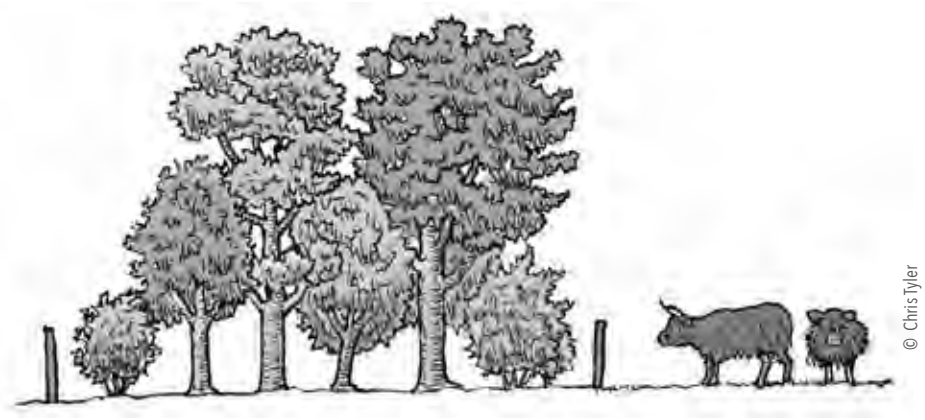
Conifer only shelterbelts are not recommended. When they mature, wind whistles through the bottom, which can even increase wind speed where no understorey vegetation survives, as is often the case.

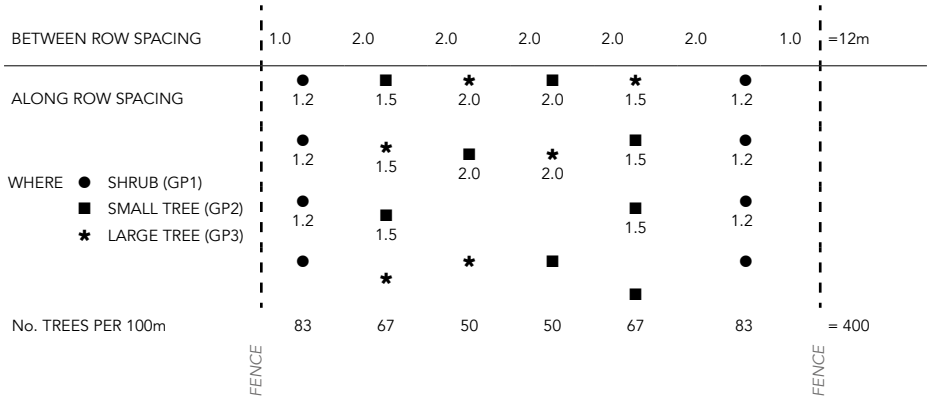
Suitable species for shelterbelts and hedges in the Highlands and Islands are shown in a table at the end of this section in three groups:

Group 1
Low-growing and densely-branching bushes at the edge of the shelterbelt which form the low-level windbreak that persists throughout its whole life. They are exceedingly wind-hardy and windfirm and may be either deciduous or evergreen.

Group 2
Small trees providing intermediate height branching and alternating in each row with Group 3 trees. These are almost certain to be deciduous trees (with the exception of holly).

Group 3
The tallest trees determining the length of sheltered ground achieved. These may include both conifers and tall growing deciduous trees.





EXAMPLE SCHEME (establishment and design)

Widths

The diagram illustrates an ideal shelterbelt design for a high exposure site where space is relatively limited. It is just 12 metres wide. In reasonably favourable Highland conditions, the shelterbelt might be expected to reach a top height of between 15 and 20 metres having effect over between 450 and 600 metres to leeward. If located in a windier coastal environment and the tallest trees only reached 10 metres in height, the shelterbelt would still provide some shelter for 300 metres!

It can be seen that the shelterbelt comprises three groups or tiers of vegetation each performing their own role in the design and combining to achieve the uniformity of branching and foliage required from top to bottom.

A wider shelterbelt clearly gives scope for more complex arrangements of low, intermediate and high cover and will give a better chance of trees in the centre reaching greater heights than the 12 metre design. Greater width may also give

more opportunities for useful timber production but does not, in itself, confer more shelter than a narrower belt.

Planting a double row hedge prior to fencing.

Once the shelterbelt reaches more than about four to five lines of trees, great care is required with the deployment of the Group 2 species, some of which are not tolerant of the degree of shade that will now exist in the central part of the wood. It is therefore advisable to confine these to the outer rows of the belt though always mixed with Group 3 trees to avoid creating a 'pitched roof' profile.

Spacings

As the diagram illustrates, closer spacings are employed at the edges where bushes may be planted as close as 0.3 metre as in a hedge but 1 metre from the edge to avoid browsing. Trees in the inner rows will typically be planted at about 2.0 metre spacing, though often tighter at windward edges in the most exposed environments.

These spacings refer to distances between plants on a given line. The spacing between the lines is usually fixed for ease of planting and subsequent maintenance. It is usually about 2.0 metres, as in the diagram. If a double outer row of shrubs is used then the spacing between those particular lines will be much less.

The width of a shelterbelt will be determined partly by the amount of ground available. On croft land, particularly the in-bye, amounts of space are often very restricted. Shelterbelts of as little as five metres in width may be required and can be effective. But, remember that it is the height of the shelterbelt that is important, and height cannot be achieved in exposed environments without a reasonable width of belt.

If even five metres seems too much, then a staggered double row of the bushiest species can be planted to create an 'informal hedge' requiring little if any maintenance, once established (see above under hedges). It will not fall over, as a single line of larger trees (particularly conifers) is likely to, at a later stage. It can be encouraged to stay bushy at all levels by trimming or even coppicing – if appropriate species (such as willows) are chosen.

Refer to section 4, 'Coppice'.

MAINTENANCE, REPLANTING OR REGENERATION

The primary objective of shelterbelt management will be to provide continuity of shelter. A wood that demands to be felled in one go at some stage is not therefore a good shelterbelt.

To avoid this, it has been suggested that a shelterbelt should comprise two adjacent belts of trees of different ages. When one is mature and has to be felled and replanted, the other steps in. This presupposes a large amount of available land and that trees need to be felled all at one time.

For small units of land, such as on much croft in-bye, this is clearly not a practical suggestion and the use of deciduous trees avoids the clear-felling in any case. Incorporation of several different species will ensure longevity and many deciduous species can be readily coppiced to rejuvenate ageing or falling trees.

When trees do eventually show signs of regression they can be individually removed and replanted if they have left a significant gap. Unlike conifers, deciduous trees are most unlikely to windthrow but, if they do, may be given the chance to sprout from the cut stool or even the (uncut) fallen stem – in the case of willows for instance. Trees in the central lines of the shelterbelt can be thinned after good establishment is achieved. This may not be advisable in high exposure or where the belt is very narrow in the first place.

Other management of shelterbelts will depend on the subsidiary objectives. They should not generally be opened to stock at any stage as this would lead to the destruction of the crucial shrubby layer. Fences need to be maintained as a permanency therefore.

It is almost always possible to remove some firewood from a predominantly deciduous shelterbelt without damage to its integrity. But do not remove the understorey as this will compromise the effectiveness of the wind break! The easiest way will be to coppice a proportion of those trees which respond best to this treatment. This will, at the same time, help to maintain the low and intermediate level cover in the wood. Thinning of larger stems from the central core of the belt for firewood could also be considered, replanting where necessary.

SPECIES SUGGESTIONS FOR SHELTERBELTS & HEDGES

BUT SEE ALSO APPENDIX 1 FOR MORE EXTENSIVE LIST WITH SITE REQUIREMENTS, USES AND LATIN NAMES.

see above under 'species choices and mixes' for the three group descriptions

Group 1	Group 2	Group 3	HEDGES
NATIVE SPECIES – plant in preference			
roses – native	whitebeams	alders	hawthorn
elder	rowan	ash	blackthorn
crab apple	birches	aspen	beech
blackthorn	holly	birches	willows
hawthorn	bird cherry	gean (wild cherry)	elder
broom	hazel	wych elm	honeysuckle
whin (gorse)	willows – many species	oaks	roses – native
sea buckthorn	crab apple	beech	whin (gorse)
native willows – grey, goat and eared	alders	Norway maple	
honeysuckle	aspen	sycamore	
juniper		Scots pine	
EXOTIC SPECIES – reserve for more extreme environments in terms of exposure or acidity (see bottom of appendix 1 table)			
roses – non native		alders – non-native	Escallonia – several species
exotic willows – many species		larches including Siberian	New Zealand holly
dwarf conifers eg mountain pine		Sitka spruce	roses – non native
Fuschia		lodgepole pine	
New Zealand holly			
Escallonia – several species			

CASE STUDY

WOODLANDS IN SHETLAND

by James Mackenzie

About ten years ago I wrote a short account of a shelterbelt planted on our croft in Shetland for Managing Small Woodlands in the Highlands and Islands, published by the Scottish Crofting Federation. The accompanying photograph illustrated the belt and garden around our house (figure 1). A decade later, much has changed, as you can see (figure 2), mostly thanks to one of the last Forestry Commission Woodland Grant Scheme (WGS) grants administered in Shetland.

SHELTER AND FIREWOOD

The small 3ha croft now has approximately half of its area planted with trees, and logs from thinnings and coppicing have almost supplanted the traditional (and more labour intensive!) peat as a means of warming the house. Our Shetland sheep benefit from the shelter provided, of course, and in garden and open ground areas temperatures three or four degrees Celsius higher than outside are common, in both summer and winter. The microclimate is instantly sensed, and demonstrates that in Shetland it is wind-chill that is a prominent feature of the weather.

You may notice that the overhead power line, to which I referred in the article, has partially disappeared. A few years ago, of their own accord and at their expense, Scottish Hydro-Electric engineers re-routed the cable underground, clear of the shelterbelt, in case tree growth impeded it in the future. This was something I had not really expected, at least not in my lifetime!

Aerial of James Mackenzie's croft in 2007

Aerial of James Mackenzie's croft in 2008

SMALL AREAS ESTABLISHED WITH GRANTS

I am happy to say that there are many other relatively young and thriving woodland areas in Shetland. Though small – generally not exceeding 2 hectares – they were mostly planted on in-bye croft land, in and around school grounds, and of course in gardens, both public and private. A good number of these were established under the Forestry Commission Scottish Forestry Grant Scheme (SFGS), which awarded a Locational Premium for Woodland Creation in the Northern and Western Isles, and which ran from 2003 to 2006. Shetland Amenity Trust (SAT) spearheaded a local advisory and assessment team and produced an information note on selecting sites and tree and shrub species suitable for this scheme.

EXPOSURE-TOLERANT SPECIES

SAT has, since 1989, been at the forefront of tree-planting initiatives in Shetland, and has been responsible for introducing exposure-tolerant species not available on the UK tree market, and which were seen to thrive in the harsh climates of the Faroe Islands, Iceland, and the west coast of Norway. These provide quick-growing shelter behind or among which a diverse variety, native or exotic or both, can be successfully established. Its tree nursery continues to propagate species of suitable origin, from locally collected seed and cuttings, and to supply these to the horticultural trade and to community and school woodland projects. The most successful of these hardy shelterbelt plants are *Alnus sinuata* (Sitka alder), *Populus trichocarpa* (black cottonwood), *Salix alaxensis* (Alaskan felt leaf willow), *S.hookeriana* (Hooker's willow), all from S.E. Alaska, via Faroe and Iceland, and *Betula pubescens ssp. tortuosa* (Arctic downy birch) from Iceland. We also use common alder from Sutherland.

Shetland Amenity Trusts's tree nursery providing local provenance stock.

NEW PROJECTS

Lately the Woodland Trust has contracted SAT to administer applications and supply trees for its new Croft Woodlands Project grant scheme in Shetland. To date three projects are up and running, three are being assessed, and there are a further five serious expressions of interest.

SAT's Woodlands Team was also contracted to plant 3,000 trees at the new Anderson High School at Clickimin in Lerwick in 2016. A 'green corridor', open to pedestrians and cyclists, and incorporating sustainable drainage ponds is being created in this urban area, where more housing is planned.

IMPOVING BIODIVERSITY

The benefits for biodiversity afforded by well-designed and managed woodlands are considerable. The number of breeding birds has increased; for example, redwings and long-eared owls have both bred recently, and fungi new to the islands, such as the wonderfully named Lycoperdon perlatum (common puffball), have been recorded in Shetland woodlands, which are also rich in mosses and lichens.

There is no doubt that the woodlands are popular with the public, with some being recognised for their public access potential and others designated as Local Nature Conservation Sites, by Shetland Islands Council. On the West Mainland alone, Michaelswood in Aith, Gairdins at Sand, and Lea Gardens in Tresta, boast large visitor numbers throughout the year. Community woodlands near Voe and in Brae, planted as part of the Millennium Forest for Scotland initiative, and both featuring well-constructed footpaths, are great assets to the people living nearby.

HISTORY OF WOODS IN SHETLAND

A word should be added about the history of woodland in Shetland. It is now believed that much of Shetland was covered in scrub (mostly birch) woodland from after the last Ice Age until about 5,000 years ago, when there was a fairly rapid decline, coinciding with early settlement in the islands. It is remarkable that the fungus Boletus edulis or Ceps, commonly found in deciduous woodland, fruits on the summit of Shetland's highest hill, Ronas Hill (450m asl), and is a mycorrhizal associate of the minute alpine *Salix herbacea* (dwarf willow). Perhaps it is a relict of earlier woodland. A few relict trees also exist in ravines, on sea-cliffs and holms (small islands) in lochs. Among these are downy birch, aspen, rowan, hazel and several species and hybrids of willows, along with dog-rose and honeysuckle.

It was in the eighteenth and nineteenth centuries that the first plantations began to appear, usually on estates or in large gardens owned by lairds and wealthy merchants. Mature sycamore, ash and elm are to be found in these.
The largest group of plantations in Shetland, at Kergord in the Central Mainland, was begun in the early twentieth century, and extends in all to about 11 hectares. These contain the tallest trees in Shetland – Sitka spruce reaching 20 metres – and have fine stands of sycamore, elm and Japanese larch.

Weisdale.

In the nineteen fifties and sixties, the Forestry Commission was responsible for several experimental coniferous plantations in the form of shelterbelts. These have now been thinned or cleared of wind-blow, and replanted with a more mixed variety of trees.

When I first moved to Shetland in 1976, I often heard the expression: "Trees can't grow in Shetland." Provided that appropriate land, species of good provenance, and good management are supplied, nothing could be further from the truth!

www.shetlandamenity.org

CASE STUDY

ORKNEY – AN OVERVIEW

by Jenny Taylor

The name Orkney conjures up many different images – standing stones, windswept cliffs, lush farmland, abundant wildlife and whisky... but perhaps 'woodlands' comes pretty far down this list. Nevertheless, there are, in reality, many small woodlands on the islands and a great interest and enthusiasm for planting and caring for trees.

ORKNEY WOODLAND PROJECT

For the past 20 years, free local advice on woodland creation has been available in Orkney from a local advisor funded from a variety of sources, and in recent years by the Woodland Trust. The aim of the Orkney Woodland Project (OWP) has been to advise anybody within the community on all aspects of tree planting and management, encouraging and promoting the creation, use and appreciation of woods throughout Orkney.

Remnant native aspen survives in a number of locations in Hoy and Mainland Orkney.

The combination of available advice and grants from the Forestry Commission (now Forestry Scotland) and the Woodland Trust has resulted in the biggest phase of tree planting in the islands since the beginning of the twentieth century, when wealthy landowners planted the policy woodlands around their large houses. Even in the wind-blasted northern isles, people seem to have a deep-rooted instinct to plant trees. Their reasons for this are varied and include shelter for people and livestock, screening and privacy and attracting wildlife. Significant economic benefits are rarely assumed here, although there are definite opportunities for small-scale sustainable use of wood for fuel and craftwork.

© Jenny Taylor

Plastic mulch mats and porous mesh type tree shelters in East Mainland

SMALL SITES FOR A CHALLENGING CLIMATE

Most of Orkney's new woodlands are planted on private land by farmers and other landowners, community groups, schoolchildren and even monks! Sites are generally small, often 0.5ha or less. Because of Orkney's challenging climatic conditions, it is important that people do not take on bigger projects than they can plant and maintain in the limited time they may have available. There seems to be little desire in the islands to plant huge woodlands and this is understandable, given the love for the beautiful open landscape shared by most residents, indigenous or not. So the project has never promoted large-scale afforestation, but instead has concentrated on encouraging appropriate species on appropriate sites.

LOCAL PROVENANCE

Ideally, all planting stock would be grown locally and there are a few, very small-scale growers on the islands. However, to obtain the quantities required, a good range of species and a keen price, we regularly send local seed to a north-of-Scotland nursery, so that genetically native stock can be returned to the islands.

© Eleanor Garty/WTML

The young, urban-fringe woodland at Muddisdale, Kirkwall, where the sheltered pathways are now well used by walkers, runners and dog-walkers.

WHAT WORKS FOR ORKNEY

Feedback from the owners of the young woodlands has always been very welcome, helping us to refine and develop future advice. After twenty years of new planting, the following seem to be the essentials for successful tree establishment in Orkney:

- a high density of planting to give mutual shelter against the winds
- vigilant and thorough weed control, by chemical or mechanical means, to prevent competition from grasses and encourage quick establishment
- the use of good plants of appropriate species and of local or northern (coastal) provenance
- a high level of grant, without which most people cannot afford to take on a project
- huge quantities of hard work and enthusiasm

A strong emphasis has also been put on advising where not to plant, both from a silvicultural point of view, but also in order to avoid conflicts with valued and sensitive flora, fauna, archaeology and landscape; the support and advice of Orkney Woodland Group on these issues has helped develop a robust system for ruling out inappropriate sites.

In the exposed, maritime conditions of Orkney there is just no leeway for cutting corners, so the amount of time and money put into schemes is proportionally higher than in more sheltered places. On the plus side, Orkney has rich, fertile soils. It appears that good ground conditions go some way towards mitigating the adverse affects of our idiosyncratic climate, with its salt-laden gales, short, cool growing season and large variation in day length between the seasons.

However, the most important factor of all is the people involved. Their passion and commitment for planting and caring for their young woods is inspirational. During the past twenty years, approximately 250 new young woodlands, amounting to about 140 ha, have been planted (almost all by individuals, not contractors). This is a tiny amount compared to mainland Scotland schemes. However, these many small schemes have proved largely achievable, successful and appropriate to Orkney's environment, landscape and culture. The project has advised many hundreds of people so that a very high proportion of the population has been involved in some aspects of tree care and planting. As a result, there is now a confidence and belief in the community that there are ways to make trees thrive here. Skills are developing and being passed on from neighbour to neighbour, from generation to generation. People rarely now say 'Trees won't grow in Orkney'.

Ann Chapman, justifiably proud of her wonderful young woodland on Rousay

Jenny Taylor has advised on woodland creation and management in Orkney for over twenty years and has recently handed over the day to day work of the OWP to Jane Rawle. The OWP is overseen by the Orkney Woodland Group (OWG) which consists of representatives of the local Council, SNH, RSPB, the Orkney Field Club, SGRPID and the County Archaeologist. See the OWP website at:
www.orkneycommunities.co.uk/woodland/index.asp

SECTION 10
HOME-GROWN TIMBER – MARKETS AND USES

CLIMATE CHANGE AND TIMBER

"Increase the use of Scottish wood products in construction from the current annual level of 2.2 million cubic metres to 2.6 million cubic metres by 2021/22; 2.8 million cubic metres by 2026/27 and 3.0 million cubic metres by 2031/32".

Scottish Government target: from Scottish Forestry Strategy 2019-2029

Scottish-grown timber is a low carbon, renewable resource and can make a particularly significant contribution to reducing our carbon emissions when processed and utilised locally. Substituting Scottish timber for foreign imports helps to minimise carbon emissions. The more efficient the processing and the shorter the distance the wood is transported from woodland to end use, the greater the carbon saving. Timber can substitute for products with higher energy and CO_2 emissions associated with manufacture, such as steel and plastic. Furthermore it is non-toxic (unless treated), non polluting, and recyclable.

All timber fixes carbon in its fabric for the long term until that product is finally burnt or rots into the ground. The better the product is made, the longer the product lasts and the greater that effect. Carbon fixation in buildings is therefore now a major goal of Scottish Government timber development.

Home-grown conifers (eg Scots pine, lodgepole pine and Sitka spruce) from un-thinned plantations in the north and west Highlands is relatively fast grown and of poorer form than Scandinavian or central European species. It is therefore mostly chipped to make MDF, chipboard and OSB composite boards. OSB is a major structural component of timber-framed buildings in Scotland. Some is made into pellets for stoves in a process that also generates electricity for the grid.

The better grade home-grown softwoods are sawn at five major sawmills in our area into a wide range of products including for construction framing, garden and agricultural requirements. A handful of small sawmills mill high value larch and Douglas fir, mostly for fencing and structural applications.

Making the best possible use of locally-grown timber of all types creates local employment and can stimulate management of existing woodlands and the planting of new ones. Value is added by local processing and manufacturing which is often a three-stage process supporting many skilled jobs. Primary processing is saw-milling and is sometimes carried out by mobile sawmills in the Highlands and Islands.

Secondary processing involves re-sawing, planing and dimensioning. Final use may involve building anything from a house to a hut or making anything from a toy to a staircase. When all these things start to happen in an integrated way at local or regional scale and are properly supported, we can claim to see Rural Development Forestry (RDF) in action. Woodlands then start to play a central role in the economy of local communities. This is a Scottish Government strategy.

Highland timber processing companies have recently benefitted from Scottish Government development funding as part of this strategy. This support has also been used to help the Association of Scottish Hardwood Sawmillers (ASHS), which supports a growing number of furniture makers and other timber artisans in Scotland, in recognition of the part they can all play in reducing carbon emissions.

The use of timber in household items could be a part of reducing the plastic pollution problem. We should seek every opportunity to support an increasing production of such items. Everything from wooden spoons to breadboards, from worktops to furniture, can be made from wood. The substitution of wood and cellulose products for high energy and non-biodegradable plastics is of increasing importance environmentally. It presents useful business opportunities for Highland-based artisans and manufacturing enterprises. It is not that long ago that the majority of household items were made from local woods.

The rapidly growing hutting movement is supported by new planning policy and revised building standards. It aims to re-establish a Scottish cultural tradition, whilst stimulating use of local timber and small scale processing and building enterprises. Greater availability and appreciation of the value and uses of local timber will spread knowledge and increase demand over time. This should reduce carbon emissions and contribute to the whole woodland revival that Scotland has begun to see over the last 40 years. Reforestation in its widest sense may finally start to fulfil both its economic and ecological potential.

INTRODUCTION

The use of floating piers make it possible to manage larger scale operations economically where they can be installed eg as at Pennygael (Mull) and Ardcastle (Lochgair).

Softwood plantations of all sizes, comprising a variety of mostly exotic species, have been established all around the Highlands since the end of the Second World War. A number of the small, state-owned ones have been sold off as being uneconomic to fell and restock. Private owners of more remote plantations still standing will struggle to make economic sense from felling these, as the costs of harvesting may not even pay for the transport costs to remote mills. The steeper the ground, the poorer the access, and the further from mills, the more uneconomic harvesting becomes. Added to this are the increasing costs and difficulty of excluding large populations of red and roe deer. Altogether the prospect of restocking with the same exotic conifer species, aimed at the same distant markets, is not attractive.

Nevertheless larger scale conifer plantations will be commercially viable in favoured locations, with good access and good site conditions, within shorter road distances to the main mills in the Highlands at Fort William, Boat of Garten and clustered around Inverness. Establishing and managing this type of woodland is largely outwith the scope of this handbook although Section 11 covers the main planning and consultation processes which are common to all but the smallest woodland operations.

Instead, this section looks at the species, processing options and end uses that offer opportunities for economic activity at a smaller and more local scale. In general terms, this means growing tree species with higher log values. Ideally, these will be processed locally into high value products that may be exported from the region or used locally.

PRIMARY PROCESSING (SAW-MILLING AND AIR DRYING) OF LOCAL TIMBER

For owners of smaller woodlands, perhaps felling only a few trees at a time or selecting trees in a continuous cover management system (CCF), it may make sense to add value by processing on site before sale. Even better may be to use the produce on the croft, farm or estate itself. Milling on site allows retention of all the produce and immediate separation of the quality cants or boards from the fire-wood.

Refer to section 3 'Woodland Management and Harvesting' section for more on CCF.

Modern chainsaw mills are more sophisticated than they were 10-20 years ago and can be purchased at modest sums. These tools really can be used effectively by anyone with some chainsaw experience and the time and energy to move logs and heavy produce manually. They are exceptionally portable and can be walked into the woods to save extracting small numbers of logs. The quality of the cut is high but the kerf is relatively wide and they are best used for larger sections of timber or cutting into cants for easier transportation and re-sawing on more efficient machinery.

Logosol chainsaw mill: simple, inexpensive and effective giving high quality cut and plenty of exercise.

Lucas mills can be set up over felled or fallen logs where they lie and can be used even for the very largest diameter hardwoods or softwoods. They are swivel-headed circular saws that can make vertical or horizontal cuts as they travel down the length of the log.

Lucas mill walked into and working in the forest.

Mobile bandsaw mills such as the Wood-Mizer, Logosol and Norwood are in a different league and are best hired in with professional operators. Having your logs well prepared, and organising some log handling equipment or plenty of strong labour for removal and stacking of the produce is enough work in itself. To be cost effective you will need to get sufficient logs on to an accessible landing or open

space big enough to set up the mill, marshal logs and stack produce as it comes off the mill at high speed.

Wood-Mizer towed into forest with produce loaded straight off mill onto trailer.

Milling hardwoods can be profitable, as high quality hardwood should sell for four to ten times the price of spruce and two to five times the price of Douglas fir and larch. The problem with milling hardwoods is that you never know the quality of the sawn timber until the log is opened up. It is always a bit of a gamble and one or two poor stems will not even pay back the cost of a hired mobile mill. On the other hand, a single high quality log of a good size could produce a cubic metre of kiln-dried timber worth over £1k at today's prices.

High quality, wide boards of oak, ash and sycamore fetch around £1200/m^3 with the highest value elm reaching £3000/m^3. To grow such timber requires on-going management but is not impossible on the best mainland Highland sites.

Sawn sycamore and beech can stain quickly after milling and the sapwood of Scots pine (as well as some other softwoods) can be infected by blue stain within days. This substantially reduces their value. Felling in winter helps a little to avoid these hazards but, whatever the season, immediate careful stacking and drying will be necessary. Detailed drying regimes for different timbers are beyond the scope of this handbook but kiln manufacturers provide schedules for different timbers as part of their specific operating instructions.

SECONDARY PROCESSING

Secondary processing of timber involves significant investment along with covered and secure space and is therefore only likely to be undertaken as a full-time business venture. However, this is a natural progression from saw-milling experience and can add significant value, provided markets are understood and there is considerable use for finished timber within the local economy.

See below for more on strength grading.

Once produce from a mill has been air dried, it can be re-sawn (if necessary) and kilned and/or dressed (planed), profiled and sanded for use in fabrications, furniture or construction. Most local joinery businesses will have a planer or thicknesser and some have profiling machines. However, not all sawmills have kilns and very few offer strength grading, as the majority of locally sawn timber is used in external and non-structural applications such as fencing.

Relatively small secondary processing equipment for smaller workshop enterprises is increasingly sophisticated and affordable. And a very wide range of power tools is available, making furniture and craft work more economic at small scales. Some

of the bandsaw systems now take planing and moulding devices that run on the same carriage rails as the saw, enabling dressed timber to be produced highly efficiently with reduced handling and space requirements.

Larger ripsaws, panel saws, four-sided planers, profilers and bench sanders of a scale to undertake production joinery items remain the preserve of professional workshops with dust extraction and handling facilities.

Small solar kilns can be set up or dehumidifier units purchased but the cost of handling equipment and subsequent dry storage space should not be underestimated.

The high level of skills required for timber processing and fabrication does not change through the ages and there is no substitute for a good apprenticeship. However there are several Highland-based timber specialists in business today who started with little more than a shed, a chainsaw and a mobile sawmill.

Medium scale 4-sided planer-thicknesser processing home-grown larch into structural posts and beams in a Highland workshop.

USE OF LOCAL TIMBER IN CONSTRUCTION

The uses that local timber can be put to in construction depend greatly on

(a) the species of timber available

(b) the dimensions, straightness and other qualities of that timber

(c) the processing and grading resources available locally

(d) the skills and experience available in design and building with home-grown timber.

Whilst it is entirely possible to build houses, byres, huts and other structures with home-grown and locally processed timber, it is easy for the inexperienced to underestimate the equipment, facilities and knowledge needed to do so economically, legally and effectively. There is a world of difference between an insulated house that meets building standards and a simple, single-skinned hut that is exempt from building warrant. Nonetheless they both have to meet Scottish structural Building Standards and provide safe and appropriate durability and functionality for their users.

A building made entirely out of Highland-grown European larch: post and beam frame, cladding and decking.

The sapwood of all conifers is non durable and should always be separated from the heartwood at milling. Sapwood can then be used for internal applications or firewood.

Only a few estates, larger farms and community groups are likely to have access to larch, oak and Douglas fir. These timbers will often be well worth processing locally as part of fabricating or building projects. They are expensive to buy from merchants and mills so the effort and expense of hiring mobile processing equipment, or using suitably equipped local workshop facilities, will be worthwhile. Larch and oak have natural durability, which means that they can be used in external applications without treatment. Larch is particularly good for fencing, cladding, steps, decking and indeed a myriad of external uses on a croft or estate, provided the heartwood is used and the sapwood graded out. (This can be used for internal applications or firewood.) Nearly all hardwoods will be worth milling locally for making furniture and artefacts – again assuming you have the drying and processing facilities locally.

However, the fact is that kiln-dried, regularised, treated and strength-graded softwoods for framing (KD PAR whitewood in the trade) available from merchants throughout Scotland cannot be matched on price by small-scale local operations. If you are building a conventional stud-framed house and want to use Scottish timber for the frame, you can buy this readily from the main merchants (though you will need to specify Scottish).

Acoustic strength grading of milled, home-grown Scots pine.

The most likely timbers you will have from a local Highland plantation will be Sitka spruce, Scots or lodgepole pine. None of these has natural durability. They cannot be used externally therefore without some form of treatment except for temporary works. However, there are ways of using these timbers for cladding if you know what you're doing and understand the limitations (see 'cladding' below).

The use you can make of other timbers will depend on the four conditions a-d above. Access to a kiln and other secondary processing equipment can open up the possibility of making everything from flooring to furniture, depending also on the available skills and labour (see sections below).

To summarize: whilst home-grown pines and spruces can produce reasonable timber, to be used or sold as structural, it will need to be fully dried (preferably kiln dried) and strength graded. Most often it will also need to be planed all round (PAR). Unless you have a local sawmill or secondary processor with kiln, strength grading and planing facilities, your output for these species will be limited to non-structural and internal applications and possibly to cladding, with the qualifications given below. Larch, Douglas fir and oak, with their natural durability, offer wider and higher value opportunities as we will see below.

BUILDING STANDARDS, STRUCTURAL ENGINEERING AND STRENGTH GRADING

Before embarking on any construction project it is essential to have some understanding of statutory Building Regulations and wide-ranging British and European Standards. Most structures – certainly all public buildings and dwellings – require building warrant and structural engineering certification. This effectively means that the design will be professionally executed and that the structural (and some other) timbers must be specified by an engineer. As a general rule, all structural timber should be both well dried (to around 12% moisture or lower) and strength graded by a qualified individual or by machine (as used in larger sawmills). Timber can be dried by kiln or by air-drying if it is to be used for single-skinned, unheated buildings.

In some cases, sheds, agricultural and forestry buildings, as well as a variety of unheated, unserviced structures, can be built under Permitted Development Order and, on occasions, without Building Warrant. But it is essential to check this out

thoroughly with the Local Authority. This small 'exempt' category which now includes 'huts' (see below) lends itself particularly well to self-build and the use of local timber.

Visual strength grading of softwoods and hardwoods requires separate qualifications and rather few people have these. Some, but not all, local and mobile sawmillers can offer the service. Timber cannot be used in any structural application unless it has been strength-graded, either visually or by machine. This applies to huts as much as to houses. Acoustic strength graders are slowly being introduced and will become more common in the coming years. At the moment they are prohibitively expensive for small operations but hired services will become more common. These should significantly facilitate the use of home-grown timber.

The system for visual strength grading timber is relatively complicated and beyond the scope of this handbook. You will need to refer to the British Standard BS 4978:2007+A1:2011 for visual strength grading of softwood and the explanatory notes from TRADA who run courses to gain the qualification required. Visual grading of temperate hardwood will be to BS 5756:2007 and the standard should be consulted directly.

In a nutshell, home-grown pine may be strength graded to C14 and C22 ; spruce to C14 and C18 ; Douglas fir to C14 and C18; larch to C16 or C24. Note that the grades for European and American grown timber of the same species are different! British grown Douglas fir with both cross sectional dimensions 100 mm or more and the total cross sectional area exceeding 20,000 mm^2 may be graded to C24. This is very useful in post and beam construction (see next section). Strength grading of timber to be used in the round for pole frame building (ie as structure) presents some challenges. You are advised to use the services of a qualified structural engineer in nearly all instances when designing timber structures. (see next section).

POST AND BEAM STRUCTURES (including oak and softwood pole framing)

Where local timbers can really come into their own is in post and beam structures. These can be used for houses, agricultural and forestry buildings, huts and many other structures where a heavy, and preferably visible, frame is appropriate or simply desirable for its inherent beauty. Perhaps the ultimate post and beam structures are made of oak (occasionally other hardwoods) in traditional ways, with traditional tools and joints. This tradition stretches back a very long way in Scotland and is upheld by a small number of craftsmen businesses which you can count on one hand. Clearly Argyll has the resources to maintain such industry and there can be no finer use for the material than a locally hand-crafted oak frame that will keep carbon fixed for centuries!

© Alba Green Oak Frames

A home-grown oak frame under construction

An arguably slightly less highly skilled version is the bolted post and beam frame. These can in theory be made out of any hardwood or softwood but in Scotland they are most often executed in larch or Douglas fir. A well executed bolted frame in high quality locally grown and processed Douglas fir can be a work of art too: one likely to endure for centuries. Douglas fir is valued for the dryness of its heartwood, its stability, its workability, its colour and finish. Larch likewise, but it is much less stable and inclined to warp and move subsequently, which can lead to

problems. If it is kiln dried before use and some wastage anticipated, these problems may be overcome.

A less highly finished or crafted post and beam frame made from local Sitka spruce may be entirely appropriate for a hut. A design for such appears in the Reforesting Scotland *Good Practice Guide to Hut Building*. Generally speaking, post and beam frames utilise large sections of timber, which are ideal for milling on small-scale machinery such as chainsaw mills because the number of cuts is small. Even a small hut will require timbers of 150x150 or more for its posts. These are expensive to buy from a sawmill but can be competitively milled on site by mobile equipment. Post and beam construction benefits from a range of sophisticated power tools from large auger drills to chain mortisers and beam planers. However, it can also be accomplished by hand tools.

A home-grown Douglas fir house frame under construction in Wester Ross by Alba Green Oak Frames.

Post and beam construction offers a reason for growing large diameter trees on longer rotations which ties in with low impact silvicultural systems (LISS) and continuous cover models of woodland management. A post and beam industry such as exists in the USA and Japan could therefore play a role in the more diverse Scottish forest economy to which public policy aspires by providing a counter-balance to the prevailing short rotations of the industrial forestry model.

See section 3,'Woodland Management' for more on LISS.

Log building and pole framing, which both utilize timber in the round, are attractive options for people with access to woodland and the necessary time and skills. Log building does not have a long-standing tradition in Scotland, unlike many other northern temperate and boreal zones. There are several reasons for this:

(a) major deforestation early in human occupation

(b) open-grown Scots pine in grazed woodlands would not have provided straight stems

(c) the pattern of land ownership denied rural tenants access to good straight timber

(d) the sapwood of Scots pine, the main available long length timber, rots quickly in relatively warmer and wetter climates, at least of the western part of the country.

However there are a number of log builders in Scotland and highly skilled log scribing techniques are kept alive by a small group of professionals and enthusiasts. Due to availability and climate, species choice will be different from other parts of the world. Here in Scotland the outside of a log wall is ideally protected by a (sacrificial if necessary) layer of cladding or rain-screen to keep it dry but aerated. Scottish Building Standards in relation to both spread of flame and insulation contrive to make it difficult, though certainly not impossible, to build log homes.

The home of modern pole framing is the west coast of USA. California in particular has some very fine pole frame buildings on steep slopes. It involves using un-sawn, peeled logs in the round to create a post and beam structural frame, which can be exposed internally for greatest effect. It is most often jointed with steel bolts but can use metal flitch plates, metal connections or traditional mortise and tenon. One of the most successful agricultural building suppliers in Scotland uses transmission poles frequently but very few people indeed have attempted a full-blown pole frame for an insulated building. A new generation of hut builders in Scotland must surely be destined to change this! (see below)

Untreated sapwood of all species rots in the external environment and this understanding is the starting point for all log and pole framing design! Creosote treatment is illegal for anything other than transmission poles. Vacuum impregnation with chemical preservatives may be an option but negates the value and practicality of the technique for most people.

FLOORING, LININGS AND INTERNAL JOINERY

Home-grown timbers may be considered in many non-structural internal situations, but good dimensional stability is essential and materials should therefore be kiln dried if at all possible. At the very least, before installation, they need to be conditioned to the conditions they will experience in use. Skirtings, interior sills, architraves and ingos can all be made in either hardwood or softwood. Floorings and linings have been made from home-grown timber and good examples include the visitor centre at Glencoe with its Scottish oak floor and birch ceilings.

There are local mills in Scotland producing flooring and linings from both local larch and Douglas fir and these make attractive, medium wearing floors. A smaller number will make home-grown hardwood floors to special order. It is the kiln drying that is necessary to manufacture these items that is most likely to prove the stumbling block to using your own timber. Some mills will contract dry for you if you are determined to process your own. Transport distance to the kiln may then become the issue.

Less highly finished linings for huts and cabins can be made from off-saw timber provided that designs allow for some shrinkage and warping and timber is given a period of air drying and conditioning. Internal timber linings were traditional in both large estate and croft houses in Scotland before the days of Building Standards and plasterboard. Now that the latter is classified as toxic waste and we have an urgent agenda for local timber and carbon fixation, these applications look increasingly relevant to revive. Modern intumescent (flame resisting) coatings make it possible to meet Building Standards for internal timber linings.

Scots pine is still traditional as the principle species for internal joinery in Scotland. However nearly all this is imported from Scandinavia and has been for over a century and a half. This may seem strange considering its place in our culture and it partly reflects the common perception of the inferior quality of Scottish timber. In fact, good quality Scots pine can be grown on the right sites in the Highlands

and we could make far more use of this timber for joinery in the future. However, a genuine difficulty is presented by the rapidity with which blue stain (caused by several different fungi) spreads into the sapwood after milling and this happens faster at higher humidities as found in the west. Immediate stacking and kiln drying is the best way of circumventing this problem – something that small scale or remote operations can struggle with. If the problem can be solved, Scots pine is an ideal timber for flooring, linings and most interior joinery tasks.

Scottish-grown birch ceiling and oak flooring in Glencoe visitor centre designed by Gaia Architects.

TIMBER CLADDING

Timber cladding has become increasingly popular, particularly in domestic scale rural projects over the last 25 years, and has been made mostly out of larch. The difference between European and hybrid larch may have been overstated in the past. It is now known that speed of growth and the position of the timber within the log play a larger part in durability. It is essential that cladding boards are carefully graded. Good specification will allow a maximum of 5% sapwood, which should only appear on the back face of the board, with no wane used untreated. With treatment or coating this specification could be lowered.

Refer to sections 2 and 3 for more on growing productive hardwoods and 'alternative' softwoods.

Whilst Scottish larch is a good, sustainably sourced material, *Phytophthera ramorum* may spread north into Highland larch plantations. This will inevitably reduce the supply of larch sawlogs, possibly permanently, after a period of increased availability. The use of other timber species for cladding may therefore become more common. Home-grown Scots pine can make a good alternative if properly graded and pressure treated. There are plenty of options to consider before resorting to plundering the last old growth forests on the planet, be they of Siberian larch or Canadian Pacific cedar.

Other than in Argyll, available oak in any harvestable quantities is largely absent from the Highlands and Islands. Oak makes excellent durable cladding and shingles, and elm has been used traditionally in waney-edged agricultural cladding as far north as Sutherland. The highly durable sweet chestnut is experiencing a minor resurgence in southern England as a cladding material. It is not inconceivable that the warming climate will open the possibility of this species being planted

commercially in Scotland in the future. It would be a welcome addition to our currently very short list of durable species.

Highland-grown European larch cladding.

Trials by Napier University have shown that home-grown Sitka spruce can be used for cladding if surface treated and detailed very carefully. Detailed information on the use of all species of timber cladding in the Scottish environment is available in both *External Timber Cladding: Design, Installation and Performance* (Davies and Wood, 2008) and in the *Reforesting Scotland Good Practice Guide to Hut Building*. An appreciation of the complexity of the subject can be gained from these publications as it is not within the scope of this handbook.

HUTTING AND HUT BUILDING

Refer to http://www.thousandhuts.org/wp-content/uploads/2011/05/180327-GOOD-PRACTICE-GUIDE-first-version-for-website.pdf

Under a new Building Standard in Scotland, single storey huts of less than 30 sqm internal floor area can now be built without Building Warrant under exemption 23A (of Schedule 3 of Regulation 5 of the Building (Scotland) Regulations 2004). However, they still need full planning permission and to meet the domestic standards on structure and on solid fuel stoves, amongst other aspects. Full details of this new legislation are explained in Reforesting Scotland's *Good Practice Guide to Hut Building*. The services of a structural engineer are strongly advised in order to ensure compliance and safety.

Hutting is a Scottish cultural tradition with its roots in post World War 1 'villages' of small timber huts for returning soldiers and their families, designed to get them out of the cities and into the countryside for recreation. Reforesting Scotland's 'Thousand Huts Campaign' has revived the concept with the support of the Scottish Government. The first new developments were established during 2018 on both private and Forestry Commission land. The concept is widely accepted as having multiple benefits to society, broadly under the umbrella term of 'nature re-connection'. In terms of meeting existing SG policies and strategies, hutting can provide mental health improvement, green tourism and socially equitable engagement with the land.

It is also hoped that it will stimulate the use of local timber, small-scale processing and timber building enterprises. It could be an excellent forum for knowledge and

skills exchange and the regrowth of the whole timber/woodland culture that reforestation and rural development forestry implies. There is evidence that, combined with an undoubted upsurge in micro-house building worldwide, it is already stimulating new business activity in the Highlands. Woodlands of all types, including conifer plantations, are excellent places for hutting developments, which can be readily absorbed into such landscapes. The woods often supply suitable building materials and the new hutting activity could promote intensive sustainable woodland management that would have positive environmental outcomes. Planning Departments and existing policy may be challenged by this view of woodlands. But if environmental and social benefits are to be reaped, policy needs to adapt to the whole notion of *inhabited* woodlands and the practical requirements of continuous cover forestry.

A 30 sqm hut clad in painted Sitka spruce in a Highland conifer plantation. Designed and built by North Woods.

FURNITURE MAKING AND CRAFTS

There has been some expansion in the market for hand-made timber furniture and artefacts in the last few years in Scotland. This is reflected in the increasing membership of the Association of Scottish Hardwood Sawmillers (ASHS), a co-operative organization of small and medium sized businesses that supply Scottish hardwood and premium softwood timber products. It is involved in education, training and market development, helping people to both buy and sell the more specialist high value home-grown timbers.

The Scottish Working Woods (SWW) label is a guarantee for customers that the timber or product they are buying is produced by a small Scottish producer in Scotland, and that the raw material (timber etc) is grown in Scotland. The raw materials are, as far as possible, sourced locally to the producer and are produced in an environmentally friendly way. Members of ASHS, Scottish Furniture Makers Association (SFMA) or Scottish Wild Harvests Association (SWHA) can apply to SWW for a licence to use the label to market their products, which must contain at least 90% Scottish raw materials.

The long-term development of these markets and label should be a source of inspiration and encouragement to any woodland grower in the Highlands and

Islands who is considering establishing and managing some high-quality broadleaved woodland. As discussed elsewhere in this handbook, in sheltered glens and on reasonably fertile, wind-firm soils, there is a good case for considering sycamore, oak, gean, elm, beech, ash and birch for modest lengths of furniture grade timber. Holly, hawthorn or even yew can be used for smaller diameter craft wood. Planting these species represents long-term investment but that is exactly what sustainable land use and woodlands involve.

© Lise Bratton

Scottish-grown elm table and chairs by Graeme Murray.

KEY POINTS

- USING LOCAL TIMBER (1) promotes woodland management and the establishment of new productive woodlands (2) substitutes for foreign timber that may be from unsustainable sources and has higher associated transport GHG emissions (3) substitutes for other materials with higher GHG emissions like steel and plastics (4) fixes carbon long term – buildings and furniture the best of all.
- It is evident that RURAL DEVELOPMENT FORESTRY works for local communities when they are supported to establish and manage woodlands, process timber and manufacture products all at the same time. The aim of policy should be to grow woodlands and grow markets for local timber simultaneously.

Argyll Small Woods Co-operative co-ordinates woodland management including sales of timber as well as giving advice, organising events and training. This could be a model for other areas to follow in the future where sufficient numbers of small owners become established.

- CURRENT AVAILABILITY of good local timber constrains the growth of small timber processing and fabricating enterprises in Scotland. Only by planting a great deal more woodland of a variety of productive timber species will this chicken and egg situation be overcome.
- Poor access to and within woods, long distances between sites and processors and a fragile rural road network are also major constraints.
- There is a strong case for developing networks of timber growers, suppliers, processors and end-users with the necessary skills, tools and markets for end products on a regional basis.
- When planning woodlands in the Highlands and Islands, however small, think about what timber they could produce and what might be made from it. If site conditions are suitable, plant larch (if and when disease restrictions are lifted) or oak as by far the most durable timbers in the external environment. They will always be useful on croft or estate, with minimal processing.
- Douglas fir is one of the best timbers for visible structural applications in buildings. It is also amongst the most valuable to mill for croft/estate use. On good sites it grows as fast and straight as Sitka spruce.

- Most hardwoods can be utilized to make a wide variety of products and their high value makes local processing economic. They are not as slow growing as you may think. First thinnings of ash (see elsewhere for current planting restrictions) and sycamore may be useful at 40 years. Oak is a gift for your grandchildren.
- A timber processing and making economy will grow around an available timber resource. Have faith and plant the trees now, while selecting the species realistically in relation to your available site conditions.

QUALITIES AND USES OF HIGHLAND GROWN TIMBER

Species	Qualities of Highland grown trees	Durability and treatment	Uses	Structural grades for visual grading
		SOFTWOODS		
Scots pine *(Pinus sylvestris)*	Strongly differentiated pinkish heartwood and cream sapwood. Knots relatively small but many. Takes longer to air dry than spruces. Stable and easy to work. Medium structural strength to weight ratio for a softwood. Sapwood infected with 'blue stain' very quickly after felling in the wet west so needs milling and drying as soon as possible after felling.	Non-durable. Avoid external use untreated. Takes vacuum treatment well. In this condition can be used for cladding and other external uses including fencing.	Traditionally used for internal finishing and linings, low to medium wear flooring. Can be used for framing if it's what you have but if you have spruce then reserve the pine for finer work.	Home-grown grades C14 (GS) or C22 (SS) European/ Scandinavian : C16 (GS) or C24 (SS)
Sitka spruce *(Sitka sitchensis)*	Almost no differentiation between heartwood and sapwood. Fast growing and often therefore wide grained and hard to get a good finish on small equipment. Medium structural strength to weight ratio for a softwood.	Non-durable. Vacuum treated for framing and fencing but long grain does not take treatment particularly well.	The main home-grown timber for hidden structural framing. Can be used untreated for cladding with very careful detailing, full ventilation and a surface coating.	Home-grown grades C14 (GS) or C18 (SS)
Lodgepole pine *(Pinus contorta)*	Less differentiation between heartwood and sapwood than Scots pine. Highly variable form dependent on growing conditions and provenance. Other qualities similar to Scots pine.	Non-durable. Avoid external use untreated.	Can be used for framing if its straight enough to get the lengths required.	Home-grown grades C14 (GS) or C22 (SS)
Douglas fir *(Pseudotsuga Menziesii)*	Strongly differentiated pinkish heartwood and cream sapwood. High structural strength to weight ratio for a softwood. Often straight and large stemmed.	Medium-durable heartwood.	Can be used untreated for cladding with very careful detailing, full ventilation and a surface coating. Medium-wear flooring. Arguably the top choice for post and beam framing due to strength, workability and character. Used extensively internally wherever a strong figure and rich colour desirable.	Home-grown grades C14 (GS) or C18 (SS) or C24 if sections over 20,000mm2 and a minimum of 100 x 100mm in section Canadian/USA grades: C16 (GS) or C24 (SS)
Larches *(Larix spp.)*	Strongly differentiated pinkish heartwood and cream sapwood. High structural strength but prone to 'springing' off the saw and warping during drying.	Durable. Can be used externally without treatment.	Boatbuilding, exterior cladding, decking and structure. Also used for flooring and post and beam.	C16 (GS) or C24 (SS)
Norway spruce *(Picea abies)*	Creamy white, very little visible differentiation of sapwood and heartwood, straight grained.	Home-grown material should be used externally only with treatment and careful detailing. Can be used for internal framing.	The traditional cladding material of northern Scandinavia and imported to Shetland for this use. Homegrown material is faster grown and not so good.	Home-grown grades C14 (GS) or C18 (SS) European/ Scandinavian: C16 (GS) or C24 (SS)
Western hemlock *(Tsuga heterophylla)*	Light reddish brown, very little visible differentiation of sapwood and heartwood, fairly straight grained.	Non-durable and resists treatment.	Stable so used in doors, joinery and furniture.	Canadian/USA grades: C16 (GS) or C24 (SS)
Western red cedar *(Thuja plicata)*	Natural high durability though home-grown timber not as durable as imported material.	Treatment not required for wall cladding but is required for use on roofs.	Only usually available in small quantities. External applications, structural but mostly for cladding. (The traditional cladding and roofing timber for shakes/shingles on Pacific coast of USA and Canada).	
Lawson cypress *(Chamaecyparis lawsoniana)*	Pale yellow brown, similar strength to spruce.	Heartwood slightly durable.	Seldom used in Scotland but can be used for joinery.	

Species	Qualities of Highland grown trees	Durability and treatment	Uses	Structural grades for visual grading
HARDWOODS				
Oak	Very hard, light to medium brown, flecked if quarter-sawn.	Durable. Can be used externally without treatment.	Boatbuilding, excellent flooring and furniture, also fencing and cladding, and shingles. Post and beam frames.	*Visual grading of temperate hardwood will be to BS 5756:2007* There are both appearance and structural grading systems for hardwoods, which require qualified graders to use.
Birch	Silver birch can be straight and useful but downy birch is usually of too poor form for anything other than firewood.	Non-durable. Avoid external use.	Excellent flooring and furniture. occasionally spalted.	
Wild cherry/ gean	Attractive pinkish timber.	Moderately durable.	Highly sought after for furniture, crafts	
Aspen	Light but strong.	Non-durable. Avoid external use.	Not used in Scotland, historically arrow shafts and clogs.	
Sycamore	Hard, very pale cream sometimes with a wavy grain giving some areas a shine.	Non-durable. Avoid external use. Stains rapidly after milling, store boards upright.	Excellent flooring and furniture.	
Ash	Fine, strong timber with highly variable colouring and grain pattern. Often combines creamy brown clean areas with dark olive grey zones.	Non-durable. Avoid external use.	Excellent flooring and furniture, sports equipment, tool handles.	
Beech	Very hard and fine grained, cream with pinkish tinge, and tiny flecking	Non-durable. Avoid external use.	Excellent flooring and furniture.	
Elm	Heartwood is strong and reddish brown, often highly figured and forming complex grained burrs.	Slightly durable but requires surface coating in external applications.	Wide boards used in cladding occasionally. Furniture especially with highly figured burrs. Structural post and beam.	
Alder	Featureless but strong. Grows very fast but rots from the heart at a young age and logs large enough to mill seldom without some rot in the Highlands. Softish timber.	Rated as non-durable and yet used traditionally in wet applications so durability may possibly depend on complete immersion.	Turnery. Traditionally for lock gates, clogs etc.	
Holly	Very slow growing, hard, uniform pale cream without visible grain.	Non-durable. Avoid external use.	Highly valued for turnery and craft.	
Yew	Deep orangey brown heartwood, often highly figured.	Non-durable. Avoid external use.	Furniture and turnery.	

SECTION 11
WOODLAND DESIGN, PLANNING & GRANT APPLICATIONS

INTRODUCTION

Woodland and plantation design, for whatever objectives, by its nature requires long term planning and a little imagination. Harvesting a timber crop can seem almost unimaginable when planting a tree that fits in the palm of your hand. Yet you will probably be surprised how, after what sometimes seems like a painfully slow start, your trees start to close canopy and an extraordinary transformation to woodland begins. The alders and willows frequently surprise even the pessimist.

Sections 2 and 3 of this handbook titled Woodland Establishment and Woodland Management and Harvesting largely deal with silviculture and the practicalities of smaller scale operations likely to be carried out by crofters, farmers, estates and community groups with their own labour or perhaps with help from contractors. This section looks at planning of larger schemes, undertaking the right level of consultation and getting appropriate advice for any type of woodland development.

The importance of a structured and comprehensive approach to woodland planning can hardly be overstated and this applies at all scales. The planning exercise integrates consultation with neighbours, specialists and statutory agencies; setting and prioritising of objectives; surveying and mapping; grant applications and financial management; employing contractors; and meeting all legal requirements.

Most larger schemes will be eligible for grant assistance through SF. For any establishment scheme over just a few hectares and where grant aid is being sought, it is almost certainly necessary to take professional advice from a woodland consultant. For any tree felling you will need a felling permission and restocking specification so, unless experienced in the matter, it will be best to seek advice of a consultant.

This section is intended to help you engage with consultants at an informed level that will facilitate you in assessing the constraints and opportunities relating to your site, defining your objectives and optimising the benefits of your woodland scheme to both yourself and the wider community.

FORESTRY CONSULTANTS / AGENTS

There are many businesses offering woodland advisory services in the Highlands and Islands and it is especially important to choose one with experience of your locality and understanding of the type of woodland you are looking to create, manage or re-structure. There is a lot of difference between a conventional conifer plantation designed and managed for pulp timber and a mixed woodland integrated with stock or crofting activities with a variety of intended produce and benefits. Along with solid local experience and interest in native trees, you may be looking for particular skills in community consultation, coppice management or local timber processing. Take care in choosing your consultant and ensure they are sympathetic to your objectives. You are as likely to find what you need in a one person business as in a larger business.

The Institute of Chartered Foresters has an online directory of consultants https://www.charteredforesters.org/about-us/hire-a-consultant/

A forestry consultant (often termed a 'forestry agent') can help you with all scales of tasks from a single woodland establishment scheme to a 10-50 year plan for a whole estate, grazings committee or community group. They can help you ensure right from the beginning that plans are realistic in terms of site suitability and, equally importantly, that contractor skills are available locally and at affordable costs.

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Willie Beattie, former Croft Woodlands adviser, discussing planting proposals with crofter Sandy Murray (see case study – Strath Halladale crofts)

SITE CONSTRAINTS & SITE SURVEYS

Refer to SF Land Information Search website: https://map.environment.gov.scot/LIS_Agri/Agri.html

When considering woodland establishment you should always consult the SF Land Information Search website at an early stage. This will alert you to any designations and other major constraints that apply to your potential woodland establishment areas. These will influence your initial plans and ideas on locations for new trees and woodlands and ensure they do not immediately conflict with influences beyond your control. Many of these constraints will also affect woodland management works. A consultant can undertake this assessment on your behalf, perhaps sub-contracting out some specialist survey work.

The UK Forestry Standard (UKFS) is the reference standard for sustainable forest management in the UK. https://www.confor.org.uk/resources/uk-forestry-standard-2017/

A number of site constraints are regulated by law. Other constraints are considered in the context of industry good-practice, as set out in the UK Forestry Standard. Many, if not all, of these will need to be addressed in any application for grant funding.

A checklist:

Suitability for species/woodland type

For more on matching trees to site, see Section 2, Woodland Establishment.

A combination of factors will influence the type of woodland or individual tree species that will thrive on a given site, and therefore the objectives that the site is capable of delivering. For example a sheltered site with well-drained mineral soil could produce high quality timber, while an exposed site with shallow peaty soils may deliver biodiversity or stock management benefits, and supply a modest amount of firewood.

ESC-DSS is a computer based system that uses a range of spatial data to predict the suitability of species or woodland type for a given site http://www.forestdss.org.uk/geoforestdss/esc4.jsp

An agent may use the ESC-DSS tool in combination with site and soil investigations to help determine the type of woodland a location is capable of. One feature of the tool is the ability to generate standardized scores for windiness (DAMS score).

Different species tolerate different levels of exposure, but it should be noted that DAMS scores tend to underestimate the effect of wind on island sites.

For larger or sensitive sites, a vegetation survey may be useful, and is sometimes required if grant support is being sought. This is a more specialist piece of work, which provides an excellent basis for plotting out what type of woodland cover will best fit different parts of the site. For improved land, or small sites with relatively uniform vegetation, a vegetation survey should not be necessary.

The sort of mosaic of wet heath, bog and woodland that can be established on typically poor ground with patchy bog. Scots pine and birch planted on drier raised moraines without mechanical mounding.

Peat Depth

Planting on peat of greater than 50cm depth is considered to be poor practice. Not only does cultivation for planting release carbon, most species do not thrive on deep peat unless extensive drainage and fertilization is undertaken. Peat over 50cm depth is regarded as 'sensitive' under Environmental Impact regulations (see below), and any proposal to plant on deep peat is likely to trigger the requirement for an EIA assessment. Such areas of deep peat are not eligible for woodland creation grant support. A peat depth survey will normally be required as part of a grant application, if the site is likely to have deep peat.

For more on peat see Section 2, Woodland Establishment.

See Section13 for a view from SW Norway on natural regeneration of woodland on peat.

Agriculture

If seeking grant support for a larger site on agricultural land, particularly good agricultural land, extra evidence of how the planned woodland integrates with other land uses may be required, and neighbours and others may be consulted about the impact of your proposal on local agriculture.

Existing habitats and species

Generally the creation of new native woodland has a positive effect on local bio-diversity, however it is important to be aware of the species and habitats already

present on the site, and consider any negative impacts upon them. Some of these will come under legal protection (see below), but others may need you or your agent to recognise their value and allow for them in the woodland design. For example an area of species-rich grassland with orchids might be accommodated in an open ground feature in the wood. Local and regional field clubs can be excellent sources of advice and information.

Natural Heritage Designations and Protected Species.

Scotland's Environment Web includes the 'Land Information Search' for sensitive and designated sites, and the 'Habitat Map of Scotland'. https://www.environment.gov.scot/

There are many protected sites across Scotland – including Sites of Special Scientific Interest (SSSI), Special Areas of Conservation (SAC) and RAMSAR sites (wetlands of international importance). Planting trees in or close to many of these sites may be entirely acceptable, but in some situations there will be conflicts. It is sensible to consult with the local SNH office at an early stage.

All wildlife species are protected to a greater or lesser degree, so it is important to know what is on, or using, your site so that you can avoid negative impacts and meet your legal obligations. For new woodland plantings in Scotland, the species that are most likely to affect development plans are otters, water voles, and woodland grouse species (black grouse, capercaillie). Different species have different levels of protection, eg the otter is a European Protected Species, which means that even unintentional disturbance can be a criminal offence. If the presence of European Protected Species is known or suspected, it will be necessary to carry out a survey and design protection measures into the scheme.

Archaeology

The Pastmap website allows you to identify any recorded archaeology on your site https://pastmap.org.uk/map

Any works affecting Scheduled Ancient Monuments will require consent from Historic Environment Scotland. For other archaeological remains, it is good practice (and a grant-aid requirement) to leave an undisturbed buffer zone around the feature. The size of the buffer will be dictated by the nature of the feature. Where a cluster of archaeological remains is on, or partially on, the site, you may be required to maintain sightlines between them. Recorded archaeological features can be identified on the Pastmap website, but it is not unusual to find features which have not yet been recorded. The Council Archaeology Services will be able to advise on any special measures necessary to protect features on your site, although this may incur a charge. A specialist archaeological survey may be required for a site with extensive or important features.

Public Access

Under the Scottish Outdoor Access Code, land managers have a responsibility to facilitate reasonable public access. If there is an established route across your site, you may need to provide signage and alternative access routes while site operations are taking place. You will need to provide appropriate gates if fencing across an existing path, and even if there are no established paths, you may be expected to provide gates or stiles at locations where people might reasonably be expected to cross.

Landscape Character

In an open landscape, or where trees are few and far between, the visual impact of new planting and fencing can be significant. Scottish Natural Heritage has published landscape character assessments for distinct areas of Scotland, which identify their typical characteristics and suggest how development, including new woodland, could be designed and sited to minimize their impact.

Fit with Local Authority Woodland Strategies

Each local authority has a woodland strategy. For example, the Draft Highland Forest and Woodland Strategy (2018) designates ground as either being Preferred, Potential with Sensitivities, Sensitive, and Land above 550m. At one end of the

scale, a Preferred site is considered for a range of woodland types, while at the other end, Land above 550m is considered to have some potential for predominantly montane woodland. In general the greater the site sensitivity, the more likely there will be a presumption in favour of native planting, and the greater the need for thorough site assessment and planning. You can find out what a given piece of ground has been classified by searching the FCS map viewer: https://forestry.gov.scot/support-regulations/scottish-forestry-map-viewer.
Note: until the final version of the Draft Highland Forest and Woodland Strategy is published, the previous version (2006) applies.

Access

Access routes to woodlands are important for all management operations. Any new access onto the public road will require Local Authority approval. Agreed timber transport route maps have been developed at local authority level and categorise roads in terms of their capacity to sustain timber haulage. Plans for timber haulage on public roads where any significant impact on roads, road users or the local community, is anticipated will require liaison with the roads department.

See the Timber Transport Forum website for information on Agreed Routes https://timbertransportforum.org.uk/maps/agreed-routes

WOODLAND DESIGN

The landscape impact of a new woodland is worthy of consideration, both at a personal/community level, and by virtue of the criteria applied to grant applications. The pattern of surrounding land uses can suggest suitable planting patterns, for example shelter plantings on in-bye land and around townships can be rectilinear, reflecting existing field boundaries. On the open hill a looser mosaic will be more in keeping, keyed into soil and topography and following the natural folds of the land. On these sites, 'feathered' edges with reduced planting densities and an increased proportion of shrubby species will help to avoid abrupt lines. Fences can be problematic, as the most sensible line for construction always seems to coincide with the most visually intrusive location. Avoiding skylines, and using natural folds and features in the terrain to hide or at least break up the fence will help.

The relationship of new planting to existing woodland should also be taken into account. Sites for natural regeneration will always be adjacent to existing tree cover, but where native or mixed planting is proposed, it is also beneficial to link into existing woodland, thus allowing the new planting to tap into a developed resource of flora and fauna. Many woodland species move exceptionally slowly, and are not capable of traversing open ground to colonise even nearby woodlands, so re-establishing these habitat connections is vitally important.

A planted native woodland contradicting to a degree the natural distribution of species at this altitude where the Scots pine would more naturally merge into birch above and then into willow and birch, and finally into willow and juniper scrub towards the hill top. To be fair the lower slopes were so saturated and infertile it would not have been wise to plant the pine in this zone where maybe Salix aurita and alder should have been much better represented.

FCS Bulletin 112 Creating New Native Woodlands categorises the constituent tree species into 'major' or 'minor' for each NVC type. Major species are those that dominate the canopy; minor species usually appear in smaller numbers, but are equally important for their role in enriching the habitat. Major species are usually bigger eg oak, Scots pine, while minor species are often smaller eg bird cherry, hazel, hawthorn, and may be concentrated along woodland edges where they receive more light. The relative proportions of major and minor species will depend on the woodland layout and your objectives.

Trees are often best planted in single species groups – eg 15-50 for major species and 5-15 for minor species. If planted in mixtures, the tendency is for the fastest growing species to outcompete the others – exceptions are those mixtures specifically designed to fulfill a silvicultural purpose for high quality timber. The size of a single species group will depend on the overall scale of the planting, and on the future intentions for the site – if you plan to harvest timber, a few larger single species blocks will make management easier than small blocks scattered across the site. Again Bulletin 112 covers this topic in some detail. Tree spacing is dealt with in Section 2, Woodland Establishment but it is worth noting that variable density planting, including both clumps and scattered individuals can contribute to the structural diversity of the woodland, as well as being a practical means of targeting planting to the best micro-sites.

Open ground within a woodland can accommodate areas which are unsuitable for planting, such as pockets of deep peat, or shallow soils, or areas that support habitats or species worthy of conservation. On sites where conditions do not naturally dictate this type of mosaic planting, open areas can be deliberately designed in. Including glades and rides in a woodland maximizes the amount of 'woodland edge' – an important habitat for wildlife. For the greatest wildlife value, east-west orientated openings provide lots of sunny, south-facing edge. To ensure that these open areas remain open, they will need to be at least the same width as the mature height of the adjacent trees – but this may not be achievable on small sites. Finally, open ground can help with future management access – if future timber extraction is anticipated, a well-planned access layout will make life much easier.

A Summary of Woodland Design Principles

- In hill areas with either an indistinct or absent enclosure pattern, woodland shapes should be related to landform; ascending up gullies, descending down spurs. If, however, the intention is for more extensive woodland cover that 'caps' an entire hill then this principle can be reversed; bring woodland off the high ground and down the ridges, leaving the gullies as open ground.
- Open ground should interlock with woodland shapes and species areas should interlock one to another.
- In all design aspects avoid symmetry, adopt asymmetry of one-third to two-thirds (open ground to forest, dominant to sub-dominant species etc).
- Lines creating shapes should respond to landform. Avoid horizontal and vertical lines; use diagonal lines curved to the shapes of the landform.
- Care should be taken to establish transitional edges where forest margins are adjacent to open ground. This can be achieved by decreasing the planting density, especially to upper margins, and including an element of scrub planting to lower margins, all to achieve a diffuse edge.

Forestry Commission Guidance Note No 23
Landscape Design and Presentation For Small Woodlands

Further guidance on landscape design in relation to creating and managing woodlands is available from SF https://scotland.forestry.gov.uk/supporting/strategy-policy-guidance/landscape

CONSULTATION

Consultation is not a one off event. It is best approached as an ongoing process that ideally progresses in tandem with information gathering. Because inputs are made from many sources at different times, the woodland plan will tend to develop organically and will need to be referred back to stakeholders for further input. Stakeholders may include neighbouring land-holders, community groups and Councils where they exist as well as residents likely to be affected by the changing landscape. Statutory consultees will include SNH and SEPA and it will be useful to speak to local authority tree or woodland and access officers.

The very first consultation is often best held before detailed surveying and mapping gets underway to establish basic areas of agreement as much as apparent conflicts of interest. It will always be better to address any problems at the outset as consultancy is expensive and energy needs to be conserved and directed carefully for what may be a quite protracted process. A good woodland consultant will often have good relationships already with statutory consultees and NGOs and can help hugely with consultation. The aim is to take all stakeholders along with you to avoid later hold-ups. Grant applications now require that, prior to submission, applicants undertake due diligence by discussing their proposals with stakeholders, undertaking any necessary surveys and completing an issues log.

Whilst valuable and successful smaller scale tree planting and woodland management may be carried out by an individual acting independently, a great deal of the potential for the development of woodlands and a well-developed, regional woodland-based economy lies in co-operative plantings and management plans. Early consultation, although instigated as an individual enterprise, might serve to kindle latent enthusiasms of neighbours or other community stakeholders and give rise to an unexpected and far more ambitious plan.

Crofter grazings committees already have in place a mechanism for making group decisions but these could readily be broadened to include others in the wider community and unexpected collaborations could result, with bigger schemes, broader objectives and wider community benefits.

Whilst crofting tenants no longer need the landowner's permission to plant trees on the in-bye, they do for the common grazings. Grazings committees will clearly need to consult closely within their own members and schemes are only likely to go ahead on common grazings where there is a strong consensus in favour. Otherwise apportionments may be the only way forward.

SF will assess all forestry projects and consider if they are likely to have a significant effect on the environment. If any proposed woodland planting (regardless of whether grant is being applied for) is within a sensitive area (including SSSI, SAC, SPA, National Park, deep peat) OR greater than 2ha and within a NSA OR greater than 20ha, then Scottish Forestry will screen the project to determine whether consent is required and if an Environmental Impact Assessment (EIA) report is needed.

Similar thresholds apply to deforestation: any felling in a sensitive area, felling greater than 0.5ha in a NSA and felling greater than 1ha for all other areas.

An EIA report will look in detail at the full range of issues described under Constraints above. If a site could potentially trigger an EIA, it is essential to consult effectively from an early stage with SF. The cost of preparing an EIA report can be considerable.

SETTING OBJECTIVES

Understanding what it is you (or your group) is trying to achieve with your woodlands, whether proposed or existing, or a combination, is an immediate priority. However, there is a certain amount of 'chicken and egg' in this decision-making process because the information gathered and the site assessment and consultation process may both lead to modification of objectives. Some may drop out but possibly new ones will be added. A good consultant will again hugely facilitate this process.

© Iona Hyde / WTML

Tree mensuration exercise at woodland planning workshop, Nov. 2017.

Objectives may be firmly economic or entirely socially or environmentally orientated. Most often they will be combinations. They may include shelter, natural drainage, biodiversity, commercial fuelwood, fast grown softwood for pulp or chip, high value conifer or hardwood for local processing. With good design, it should be possible to accommodate at least three or four of these objectives without compromising any of them.

Objectives may be quite aspirational but are necessarily rooted in the realities of the site or sites available. A clear understanding of site capability is therefore critical from the beginning. This involves detailed knowledge of species choices in relation to environmental factors including soils and local micro-climate. If growing less demanding species for lower quality timber is the objective, then clearly the choice of sites will be considerably wider and less critical than for demanding species and high quality timber produce. Once again, a good consultant can assess a large site and its likely capabilities at an early stage, steering realistic objectives before any detailed survey is undertaken.

As discussed at some length in section 6 Grazing and Woodlands, balancing the needs of stock with aspirations for woodland will often lie at the heart of woodland planning. Sometimes, and particularly on smaller units of land, compromises will be inevitable as to grow high quality hardwood requires good ground conditions and these must be identified and assessed carefully.

SF provides Forest/Woodland Plan templates for different scales of woodland. Refer to https://scotland.forestry.gov.uk/supporting/grants-and-regulations/forestry-grants/forest-plan-resources

Planning woodlands for long-term objectives is only logical given the relatively extended time periods that the more valuable species take to mature. In order to provide employment in the future means understanding existing markets while also projecting into the future with a degree of insight and ambition. Wildlife tourism, hutting and fuelwood are already developing markets but there are many niche products described in this handbook that also show potential for the future. Timber products and timber manufacturing at all scales will surely only increase in the low carbon transition and our retreat from reliance on fossil fuels and plastics.

A Forest or Woodland Plan is a strategic management plan that brings together the management objectives, the environmental, economic, and social functions and the silvicultural prescriptions for the whole woodland into a comprehensive plan to deliver long term benefits through sustainable forest management. An SF approved management plan is a mandatory precursor for a number of grant funding options, relating to woodland management. A good native woodland plan is strongly recommended for any existing native woodlands.

MAPPING

Mapping is an essential part of all consultation exercises as well as for planning and grant applications. For the very smallest schemes it may just be possible to do this by purchasing OS data and hand drawing areas. These require measurement and this can be done manually with grid squares for small areas.

However, the task is so much more easily and accurately performed by consultants using GIS systems and such mapping can then be used in all grant and planning applications (where needed).

Some industry standard GIS software can be downloaded either very cheaply or for free, if it is to be used non-commercially. For some people, especially if they have experience of using CAD software, this could be an option.

Any CAD software such as used by architects can import OS digital data and fill and dimension areas with ease but again requires some experience. Such systems can also import some survey data if in the right file types.

The survey and mapping process will combine with the adjusted objectives taking on board the feedback from earlier consultations to draw up the final proposal.

MyForest, created by the Sylva Foundation is a free on-line tool for woodland mapping and management. Woodland management plans can be created using Forestry Commission templates, and felling licence applications can be generated. Premium (paid for) membership gives access to Ordnance survey mapping. A woodland creation module may become available in the future. https://sylva.org.uk/myforest/about

GRANT APPLICATIONS

The proposal is then turned into a grant application and submitted to Scottish Forestry. A woodland officer is assigned who may make further recommendations but as they will already have been involved in the consultation and guidance process these should be minor.

Once the woodland officer is happy that the proposal meets UKFS, it goes onto the public register for 28 days and everyone that is deemed to have an interest in the proposal is invited to comment in this period. This may include neighbours, community councils, utilities companies (where sites have infrastructure on them), the statutory consultees (SNH, SEPA, Local Authority) and NGOs (RSPB being most often notified).

If the due diligence process was carried out properly, this should not throw up any issues. However, in practice it often does, in proportion to the quality of consultation. At the end of the consultation period, the woodland officer will collect all the responses, and report on the highlighted or key issues which need to be addressed. These then have to be resolved before the application can proceed. The message is clear – consult early and consult thoroughly.

EMPLOYING CONTRACTORS – carrying out the works

Individual crofters, land managers and community groups with small establishment schemes may elect either to carry out planting themselves or to use volunteer labour. As long as there is someone on a team with good knowledge of species, ground types and planting experience this can be a successful approach. Community group planting and small-scale manual woodland management and maintenance events provide excellent opportunities for building community bonds, sharing knowledge and skills development.

However some schemes are just too large for this approach to be realistic and contractors with machinery and sufficient labour are essential. This goes for woodland establishment as much as for management and harvesting operations. A good woodland consultant will know what machinery is needed for each operation, which contractors have that machinery and experience, which contractors are best suited to your conditions, and at what cost. In the case of establishment schemes, they can negotiate contracts for you and indeed manage the entire works from fencing and site preparation to planting and early maintenance. In the case of harvesting operations, they can manage the entire works from crop mensuration (assessing volume) and valuation to new roading, marketing and transport to mills.

For FISA guides refer to https://www.ukfisa.com/safety-information/safety-library/fisa-safety-guides.html

'Felling a coniferous crop produces a large increase in breeding material for both the Large Pine Weevil (*Hylobius abietis*) and species of *Hylastes* (black pine beetles). Young trees used for restocking are liable to be heavily attacked by adult pine weevils feeding on the stem from the root collar upwards and by adult black pine beetles tunnelling in at the root collar and feeding on the main part of the root system. Heavy damage can completely girdle stems and cause plant death'.

Meeting all the various statutory and regulatory requirements can be a daunting process which include the following: felling licence permission, UK Forestry Standard, health and safety regulations, forest and water guidelines, Wildlife and Countryside Act and EU directives in relation to protected species, FISA guides, biosecurity (pests and controls), use of pesticides, and timber haulage routes.

SOFTWOOD PLANTATIONS

The establishment of predominantly exotic conifer plantations on the standard commercial model – relatively short rotation, no thin, clear fell regimes – is not considered in this handbook. Where reliable advice confirms economic viability, they may be considered and could be part of larger schemes with a diversity of woodland types and objectives.

However *existing* conifer plantations of all scales have to be felled sooner or later, wind thrown or not and, at that point in time, the opportunity for re-structuring is presented that can lead to good long term economic outcomes.

Refer to sections 2 and 3 for more on CCF and higher value species of both conifers and broadleaves.

Existing conifer plantations provide excellent opportunities for diversification and gradual transition to higher value woodlands ensuring maintenance of cashflow and fewer of the problems that can beset restocking of large clearfells with the same species. Weevils are a major problem on re-stock sites and may be enough to persuade managers to switch to the entirely different model of Continuous Cover Forestry (CCF) and native or mixed species forest management. Transition to a different set of objectives including locally utilisable produce and multiple benefits is promoted throughout this handbook.

Once more, planning such long term re-structuring requires depth of knowledge across a wide range of fields and advice will be best sought.

CASE STUDY

WESTERN ISLES OVERVIEW

by Viv Halcrow

CONIFERS

Over the years since the 1997 Crofter Forestry Act allowed common grazing land to be used for forestry, crofters throughout the Western Isles have planted a variety of woodlands. Fairly large areas of conifer forests were put in, primarily on the east side of islands, using conventional techniques. These have survived but their productivity is low because of poor soils, waterlogging and exposure.

SHELTERBELTS

In contrast are the shelterbelts and small areas of woodland on in-by land. These have seen better results. The soil has been worked for decades and so is generally less waterlogged and higher in nutrients. Establishment is better because there is often a degree of shelter from buildings or just from the lie of the land. A wider range of species, including more broadleaves is often used closer to the house.

The grant support for planting has changed over the years. The Forestry Grant Scheme (2016-2020) has a specially designed 'Northern and Western Isles option' in which plantings have to comprise at least 80% native species of appropriate genetic provenance. It is based on planting at high density (ie minimum 3000 trees/ha) and capped at three hectares. It is designed for small woodlands which are highly 'native'. Woodland Trust's MOREwoods scheme is similarly focussed on small areas and is restricted to native species – with the addition of sycamore, as it is highly salt-tolerant.

Peter Smith, Shader, Isle of Lewis. Mixed native broadleaves planted in wet ground: a Woodland Trust MOREwoods scheme, to soak up water and create shelter.

Murdo Smith, Shader, Isle of Lewis. Mixed native broadleaves planted in hand-mounded wet ground: a Woodland Trust MOREwoods scheme, to soak up water and create shelter.

CROFT WOODLAND PROJECT

The Croft Woodland Project (CWP) started in the Western Isles in January 2016, with the appointment of a project officer whose post is fully funded by Point and Sandwick Trust (a local community development trust). With an initial media launch, there followed very high interest in the practical advice offered, and in grant support. In the three years to January 2019, over 330 enquiries were received, from

Barra to the Butt of Lewis. Twelve Forestry Grant Schemes have been approved since January 2016, with many more in development. Fifty-three MOREwoods schemes have been approved, also with many more in development. At least eighteen Tree Packs for communities and schools have been supplied by Woodland Trust (these can be ordered direct online so other packs may have been supplied but not come through the CWP). All in all there is a lot of activity, and over 62,000 trees have been planted so far.

© Viv Halcrow / WTML

Ian Finlayson's croft, Cross, Isle of Lewis. Mixed native broadleaved trees planted in open croftland: a Woodland Trust MOREwoods scheme.

Crofters are looking for ways to diversify land use and it is anticipated that the level of interest will continue rather than wane. As they see their neighbours' new plantings succeed, and the many benefits of trees and woodland become more widely known, more crofters may be keen to pick up their spade and get trees in the ground.

CHANGING LANDSCAPES

Ardvourlie in Harris is an interesting example of one crofter's determination to plant trees on a large scale and make it work. He planted a mix of native broadleaves around 1998, via the Woodland Grant Scheme. At the time, there were doubts as to whether the trees would flourish – it is poor, unimproved peaty ground lying to the north of the Clisham, Harris' highest hill. Where trees failed, the crofter replanted, time and again. His patience has now been rewarded, with an area of developing woodland which closely mimics a natural pattern. Trees are thriving in the shelter of steeper slopes and boulder-fields to form an intimate mosaic with the surrounding heathland.

© John MacPherson / WTML

Wind bitten birch gradually taking hold in rank heather and Molinia at Murdo's wood, Ardvourlie, Harris

A very different, but no less inspiring, planting is on a croft which formerly belonged to Alasdair Macleod in Point on the Isle of Lewis. In the 1990s, Alasdair established a horticultural business there and planted a mix of broadleaved and conifer trees around the poly-tunnels to shelter them from the strong winds. Now it is a jungle, with towering trees and a dense understorey of bramble and rose; full of birds and providing excellent shelter for nearby buildings.

These two very different plantings show some of the benefits of planting trees in a largely open landscape – namely landscape and ecological diversity, and much-needed shelter. Planting small areas of the right trees in the right place can transform island land, making it better for livestock, wildlife and people.

© John MacPherson / WTML

Alasdair MacLeod planted shelterbelts and small woods on his family croft at Aignis, Isle of Lewis to shelter his horticultural business. His first plantings were in 1985 and thirty years on they have formed impressively dense woods.

© John MacPherson / WTML

One man's dream – Murdo's wood, Ardvourlie, Harris planted 2001/2. Now being developed by North Harris Trust as an accessible community woodland, with a walking trail.

CASE STUDY

KNOCKFARREL PRODUCE, EASTER ROSS

by Jo Hunt and Lorna Walker

In 2010, Jo Hunt, Lorna Walker and their two sons Finlay and Angus scaled up from a walled garden in Cromarty to the 18ha of Ian Mhor Croft, near Strathpeffer. Together they set up Knockfarrel Produce, growing a wide range of organic food for local customers. They have always had an interest in good food, and a dislike of the supermarket model of transporting food huge distances, with little thought for the people who grew it, or for the impact on the environment. They sell their produce through a box scheme and at farmers markets within 50 miles of the croft.

One of the first initiatives when they took on the croft was to plant just under 10 hectares of woodland on land that was north facing and at some distance from the steading, so less useful to the horticultural side of the business. It wasn't simply a case of planting less productive land in trees, though. The woodland was planned to be productive and useful in a number of different ways: delivering shelter for the croft, as a site for carbon sequestration, for woodland food production, enhanced biodiversity, and in the longer term, for high quality timber production.

CHOICE OF TREE SPECIES

Jo consulted local sawmills and realised that there was an opportunity to grow conifers such as Douglas fir and larch, and hardwoods such as cherry and ash, for high quality timber, so one half of the site was allocated to these species. Biodiversity was an equally important goal, and the rest of the site was planted in a mix of native broadleaves, including birch, hazel and oak on drier ground and alder and willow in damper areas.

The Knockfarrel woodland site before planting in 2010. The site is north facing on good soil. The sunnier fields at the top of the hill are used for organic production.

The new woodland, 7 years after planting. Existing alders along the burn below and semi natural ancient woodland above; with open ground around long-established footpath, to maintain views. Within the fenced enclosure, between the apple orchard and Douglas Fir, are planted groves of 'wild harvest' trees including elder, hazel, sloe, rowan, hawthorn and crab apple – these are cropped for sale to local chefs, and used in value added food processing.

Several groves of flowering, nutting and fruiting species were included to provide a wild harvest for the food business. The boys also have an ambition to build a log cabin out of the new trees when they are big enough.

With help from the Woodland Trust and local forestry agent, Colin Blyth, funds were secured for the planting through the Scottish Rural Development Programme. Deer and rabbit fencing were erected, and the grassy site was prepared for planting by single furrow ploughing across the slope, giving a head start on weed control.

SHELTER BELTS AND HEDGES

The woodland design located the productive conifers in a central block, bisected by an existing public footpath. The broadleaved timber was planted around a new access ride and the native woodland component wrapped around it to provide important side-shelter and links into adjacent woods and hedgerows. Willow cuttings were planted in wetter areas to provide a future source of material for basketry, and on the deepest soil at the sheltered foot of the slope, wild fruiting and nutting species such as hazel, elder and gean were planted. 150 apple trees were grafted for an orchard and planted in the shelter of the new woodland, utilising cultivars selected for late flowering and hardiness.

© Lorna Walker

Apple harvest September 2018. Varieties chosen for late flowering, diploid pollination, and hardiness, include northern favourites such as James Grieve; Keswick Codlin; Charles Ross. Plus stock sourced from Norwegian plant breeding station in Bergen. The best fruit is sold through croft veg box delivery service and community markets. Good seconds are used in added value products including juice and chutneys. The windfalls go to the free range pigs. Nothing gets wasted.

Voles were anticipated as a problem, given the grassy sward, so vole guards were used to protect the trees and supplement the efforts of the local buzzards and red kites. In areas of bracken 1.2m tubes were used to keep the trees from being swamped, and to make them easier to find for future weed control.

As well as the main woodland block, 800m of hedging was planted to provide essential shelter to the productive fields, which are on an exposed hilltop, 160m above sea level.

A FLOURISHING FAMILY AND BUSINESS

Nearly a decade on from planting, the trees, the croft business and the boys have all grown a lot! Knockfarrel Produce now supplies organic veg, fruit, herbs, eggs and free range pork as well as homemade jams, pesto, pies, sausages and cordials. The trees are closing canopy, making a woodland rich with wildlife, which supplies an annual harvest of foraged ingredients and produce for the business.

One setback has been the arrival of Chalara, the ash die-back disease, which has affected all of the ash planted in the woodland. All the ash has to be removed and gaps replanted before the surrounding trees grow into the vacated spaces in the woodland – silver birch has been chosen to replace the ash.

Shelter, wild harvest and wildlife habitat are the early returns from the wood, but as much as that, the family has shared the simple enjoyment and satisfaction of watching the new woodland take shape before their eyes. They have always loved trees, and had an ambition to plant a woodland for their sons to see grow. They can now walk in that woodland and marvel at how fast the trees have grown, and share a growing legacy of both enjoyment and financial return on their family croft.

http://www.knockfarrel.com/

SECTION 12
WOODLAND ECOLOGY
From deforestation to reforestation, from mycorrhiza to trophic cascades

This section presents a number of ecology topics of particular relevance to the handbook in discrete sub-sections. In some cases these act as short summaries and in other cases they amplify key issues and topics raised in previous sections. A glossary at the end of the handbook defines technical terms that appear in brown font.

GLOBAL DEFORESTATION: THE BIGGEST CONTEXT OF ALL

Carbon emissions from deforestation and forest degradation have been estimated to account for 17- 20% of global anthropogenic CO_2 emissions

Deforestation is one of the world's greatest problems. It is the second largest contributor to global warming after fossil fuel combustion and a significant contributor to human displacement. It causes loss of biodiversity, loss of food security, and the replacement of complex and resilient agroforestry systems with simplified or monocultural, industrial models designed to feed global markets – including Scotland.

Reforestation is one major tool in the world's response to global climate change. There is now an ambitious agenda to restore, conserve, design and re-invent forest and tree-based productive ecosystems, especially those supporting sustainable human livelihoods. It is often associated with land reform and human rights. In all these respects Scotland's reforestation movement is no different. It takes its place on a world stage where it can demonstrate innovation and responsibility.

Scottish deforestation was almost complete by the mid 20th century. Since that time, commercially orientated Scottish forestry has expanded enormously. It will help meet Scotland's own industrial timber requirements – thereby taking pressure off other world forests. At the same time, ecologically motivated forestry has started the restoration of impoverished deforested ecosystems. More recently, both have come to be seen as a means of mitigating rising global greenhouse gas (GHG) production.

The task has really only just begun, yet in the space of 100 years we have increased total Scottish forest cover from 4-5% of its land area to about 19%. The two parallel projects of industrial forestry and 'native-based' or what may be termed 'social forestry' have certainly driven rather different silvicultural and ecological paths. Closer convergence of these approaches should become increasingly a beneficial shared goal. Industrial forestry has potential to embrace a greater diversity of species and management types, while social forestry seeks to broaden its remit further by putting people back into productive, often locally managed, forests. This should help to ensure long-term sustainability and ongoing employment. Both strands have potential to develop much closer integration with agriculture and become more accountable to rural communities, increasing economic opportunities and fulfilling the broad societal goals of land reform and rural development (see section 1).

See section 1 'Rural Development Forestry (RDF)'.

However small a croft, or however large a Highland estate, each presents opportunities to plant trees or woodlands. It is time to consider such tree planting as part of a larger plan for the reforestation of Scotland, and indeed the rest of the world. It may be that sheltering the sheep and the poly-tunnels seems in itself important

and ambitious enough. But sometimes it is inspiring to get up high and see that even small acts can have wider, even global, significance beyond one's own immediate needs.

We stand in the Highlands and Islands at the beginnings of a land use revolution in terms of ownership and community control. It offers us a chance to radically reappraise land use systems. Agroforestry, integration of grazing and woodland systems, diversification of forest products, forest inhabitation and woodland crofting are all part of the paradigm of 'reforestation' described in this handbook (Section 1). Together they make a progressive and coherent response to the Scottish Government's call for innovation in upland land use strategies.

Survivor – almost certainly a descendant of extensive woodland plotted in around 1750 by William Roy near Loch Nid in Wester Ross.

THERE NEVER WAS A 'VIRGIN' FOREST

Vegetational history from the Ice Age to the Romans

In Deforesting the Earth (2006) Michael Williams explains how "humans colonized the newly vegetated earth with remarkable rapidity, doing all those things that humans do: foraging, firing, hunting, selecting species and rejecting others, turning the soil, fertilizing it, trampling it, and mixing it. Some trees moved, flourished, or were eliminated, just as surely as if they had been affected by changing climate." He goes on, "It was a co-evolution of humans and vegetation… In the space of 10,000 years (a mere 500 generations) humans were going to have an effect on global vegetation only slightly less dramatic and widespread than that of the Ice Age in the 100,000 years before."

The Highlands and Islands reveal on their surface some of the oldest exposed rocks on the planet yet represent one of the youngest landscapes. The land was only released from its burden of ice between 10,000 and 13,000 years ago, just a tenth of the time it lay under one to three kilometres of ice – the depth of ice and time of melt depending on their precise location.

In the ensuing ten thousand years a forest covering between 50 and 80% of the entire land surface, including the islands north and west, has come and gone. It is not within the scope of this handbook to provide more than the barest outline of this complex and long vegetational history which, furthermore, focuses only on one component of a mosaic of ecosystems – the woodland. There are strong regional and even local differences between the way that vegetation evolved. Interested readers can consult the literature which is both extensive and largely accessible. A suggested bibliography at the end of the handbook is just a beginning.

The maximum extent of forest cover in Scotland cannot be known for certain and the Highlands and Islands may exhibit the widest variations in the country. Based on the evidence we have, it is reasonable to take the upper figure of 80% for the mainland and 50% for islands and exposed coastal areas.

Almost as fast as the ice retreated, the first plants arrived and a tundra-type vegetation formed, soon supporting low woody shrubs such as juniper, dwarf birch and willows. The freshly exposed, nutrient-rich, glacial deposits supported a rapid growth of vegetation, which in turn attracted herbivores such as reindeer, aurochs, wild horse, red deer and elk. Predators and scavengers such as wolf, lynx, fox, bear and eagles came with them.

Salmonids and other fish returned to rivers as soon as sediments had settled. They added to abundant food sources for pioneering human hunter-gatherer communities. Islands and coasts would have been particularly favourable locations for humans, because of the greater ease of movement there, and the additional marine food sources. Rising temperatures in coastal areas also helped vegetation to establish there at an earlier date than in the uplands.

Indeed, some of the earliest evidence of post-glacial human habitation in Highland Scotland comes from Rum, where radio-carbon dating of hazelnut shells shows occupation from at least 8590 BP. By that time birch and hazel woodland was already established, along with willow and juniper.

In Michael Williams' words again, "Contrary to popular opinion, the life of hunter-foragers was anything but a brutish nightmare of hand-to-mouth existence: in nearly all cases their supplies of food were secure and abundant, and their diet was varied. Fire had added a predictability to productivity and waterside locations were particularly favourable, with an abundance of shellfish, fish and fowl."

It is now generally accepted that Mesolithic (from the end of the last glaciation c. 11700 BP to about 6000 BP) hunter-gatherers actively managed woodlands for food, animal fodder and fuel. Oak and hazel were of particular importance, the latter being actively pruned to increase nut yield and coppiced for convenient fuel and probably for poles and staffs too. These activities are sometimes referred to as human niche construction. Their extent and influence continue to appear more profound as the combined disciplines of palynology, palaeobotany, and biostratigraphy become more sophisticated.

In this handbook BP stands for Before Present where present is taken conventionally as 1950 AD. This is not the same as ^{14}Cya which means radio carbon^{14} years ago and the two scales converge in a non linear fashion the farther back in time you go so that 10000 BP is nearer 9000 ^{14}Cya.

In the very broadest terms, the Mesolithic period in the Northern and Western Isles, and in the mainland north of Lochinver on the west, was characterized by birch, willows and hazel dominated open woodland, with substantial incursion of pine from around 8500-8000 at the start of the Neolithic period 6000 BP.

The Western Isles supported a 'widespread birch-pine forest with dense hazel undergrowth' (Blake 1966) between 8000 and 6000 BP. Pollen analysis indicates that Scots pine persisted in the Western Isles as late as 3910 BP. (Wilkins 1984).

Skye to Kintyre, including Argyll and the Small Isles were dominated by oak and hazel woodland. Scots pine dominated a large area from Loch Torridon north and east connecting into the heart of the central Highlands. The main mountain top areas probably supported montane scrub. Throughout this period the climate was not stable. It experienced an overall cooling after the so-called climatic optimum

Refer to Section 2 for more on montane woodlands.

A common sight throughout the region : Scots pine roots exposed in an actively eroding peat hag. This particular group is not growing on the glacial rubble substrate but on top of peat indicating a period of drying followed by wetting most likely around 5000 BP.

(6500 BP), as well as alternating periods of drier and wetter weather. There had been short-lived climatic deteriorations at 10000, 9300, 8200 BP and there was another in 6000 BP which proved particularly severe. In the driest periods, birch and pine colonized bog surfaces only to give way to peat formation when the climate became wetter again. These layers of light woodland colonization can be seen by anyone who cuts peat for fuel or in peat hags throughout our area.

Whilst there is no abrupt boundary between the Mesolithic and Neolithic cultures, a gradual transition occurred around 6000 BP from predominantly hunter-gatherers to early farmers of a sedentary type. Evidence from Orkney points to a highly developed cattle-based culture in those islands by 5000 BP, where diets also included large amounts of sheep, venison and fish (based on analysis of human coprolites). Pollen analysis confirms substantial woodland loss from both Orkney and Shetland in the Neolithic period when the stone axe was perfected.

The 'catastrophic collapse of pine populations' reported by Smout in northern Scotland around 4000 BP 'opened up entire regions in Sutherland and Caithness which have remained virtually treeless since'. A particularly wet and stormy period has been identified at this time. It has been suggested that a large number of Scots pine forests which had already been stressed by higher rainfall since 6000 BP succumbed. There was only perhaps 10% more rain than the present day, but peat was accumulating and contributed to the pine failure. In some areas deciduous trees replaced pine; in others, pine recovered and held on until c.3000 BP.

Going about the hill, throughout the greater part of our region, one encounters dramatic areas of 'subfossil' tree stumps and roots which keep alive the whole debate about the fate of our once extensive forests. However these stumps, made visible by recent active peat erosion, are of pine trees that grew on established bogs and therefore only represent some of the population of one species of the local forest. Dendrochronological studies accurately date the germination of these groups of 'bog pine' to short periods of drying of bog surfaces (falling of water table) and their demise generally within the natural lifespan of a single generation of trees (about 300 years). The demise of a large sample in Northern Highlands (north of Loch Glascarnoch) date to between 4900 and 5000 BP once again reinforcing the notion of extensive pine forests at this time that could seed opportunistically into bogs from surrounding hillsides when climatic conditions tipped favourably.

Only in those northernmost mainland areas was the pine decline total. A pollen analysis near Scourie in west Sutherland (Moar 1969) concurs with several other studies, showing pine peaking about 5000 BP and crashing at 4000 BP.

> *"Bog pines progressively declined in number, rather than died out in a single event, reflecting their growth in a marginal habitat, close to a critical ecological threshold"* (Moir et al 2010)

Smout's 'extraordinary loss of trees' coincides with a time of influx of settlers in the early Bronze Age from 4000 BP. Arrival of these better equipped settlers coincident with apparently cooler and wetter climate has led to long debate about which was the more important in this early and dramatic decline of Highland woodlands. The most likely answer is that each contributed but in varying degrees in different locations – an answer that defuses a fascinating but, to some, a rather academic debate. Its relevance to reforestation and repair of ecosystems however lies in the details it has furnished on woodland nutrition, on species response to climate shift and on species mobility.

The story of gradual woodland decline throughout the Highlands and Islands from the Bronze Age to the present day is told in many books and in a wealth of scientific and archaeological studies, a few of which are listed in the bibliography to this handbook. Section 6 Grazing Animals and Woodland picks up on the theme of silvo-pastoralism that characterizes the larger part of upland land use history from the Bronze Age to the present day.

The main points to emerge from this hugely simplified ten thousand year history are:

1. It is advisable to put aside notions of a primeval, virgin forest and think in terms of one inhabited by humans as much as by wild animals. Both modified the forest to an ever-increasing extent as time passed, so as to evolve clearings and eventually settlements and farms. The forest co-evolved with its human inhabitants from Mesolithic human niche construction through to contemporary landscape-scale management.
2. A well-wooded landscape evolved with local variations in dominant species. This changed over time, on average reaching a maximum coverage of woodland for the whole region by around 6000 BP. In this handbook we denote this maximum as 'Peak Forest'. The percentage of land covered at this time is proposed at around 70-80% (less on Shetland and the west side of west coast islands), with a treeline that varied from zero on exposed coast to as high as 3000 ft or 1000 metres in the Highland interior. Today's tree line in Cairngorms is usually cited as 700-750m though the scrub line is higher.

   Other terms for Peak Forest are 'post glacial maximum' and 'woodland climax'.
3. A period of severe losses of woodland cover is widely identified. In more exposed areas such as the islands, west and north, this constituted an almost complete loss in the space of about 1000 years, leading to a largely heath and blanket bog-dominated landscape by 3500 BP. The relative roles of anthropogenic fire, domestic grazing, and climate change are debatable but surely varied from place to place. Our region is a marginal habitat for many species. The farther west and north and the higher the altitude, the more marginal it becomes so that relative effects of disturbance, whether by people, their grazing animals, or by climate tend to be amplified.
4. The last two thousand years of woodland history are characterized by periods of intense local woodland use such as for iron smelting or naval ship building. These did not necessarily result in widespread loss. However, the cumulative effect of clearance for agriculture, grazing, construction, and fuelwood certainly did.

5. Throughout the region isolated but significant woods have been lost, or badly diminished, in the last couple of centuries by combined grazing pressure of sheep and wild deer. Unenclosed woodland continues to be lost to these pressures whilst new woodlands are being planted and some regenerated naturally.

Deforestation on landscape scale in only the last 200 years. Not all Highland deforestation occurred over millennia. This glen was mapped by William Roy in 1750 as an extensive Scots pine dominated forest. Today all that remains are a few scraps of alder along the river which will also disappear without some fencing in the short term.

A NOTE ON 'NATIVE' AND 'NATURAL'

Both beech and sycamore produce high value timber when managed well on good sites in the Highlands but should not be introduced into native woodland remnants as can become dominants to the detriment of the whole woodland biodiversity. Refer to section 3 for their use in restructuring conifer plantations for instance.

The terms 'native' and 'natural' have their uses but both can be misleading at times. 'Native' usually requires qualification in both space and time. For example, it is common to say that Scots pine is not native to the Western Isles when we know that it formed woodland there at least as recently as 4740 BP. We cannot even be sure that it wouldn't have survived through to the present day in more sheltered places but for the pressures of sheep and fire. Beech and sycamore are not considered as native to the Highlands but have been widely introduced and both are capable of natural regeneration. If the forest had survived intact who is to say that they wouldn't have migrated north in the last 5000 years and become components of woodland in our region?

The term natural can be highly contentious and sometimes leads into fruitless debate about the place of humans in the natural evolution of ecosystems. In the context of restoring land and people to the Highlands and Islands, the term 'natural' is most useful when applied to processes rather than endpoints, be they specific environments or habitats. We might reasonably say that the hilltops are

more natural than gardens, meaning that human influence is less marked, but even the former are grazed by sheep and deer and we control the numbers of both. The term 'semi-natural' is often introduced to indicate a relatively light human intervention. It is used here and there in this handbook.

In designing the new land-use systems and ecosystems of the future, we would be well advised to work with underlying ecological processes and principles. This is most likely to achieve a functionality that may be recognized and defined by criteria such as stability, reproductive health, adaptability to change, diversity of species, carrying capacity, as well as the potential for sustainable economic husbandry. In doing so we would be making sure that all those valuable 'ecosystem services' such as pollinators, soil stability, natural flood protection, and clean air were well established. At the same time, we would be maintaining a wide range of habitats by bestowing ecological resilience.

HERBIVORES AND WOODLANDS – FINDING THE ELUSIVE BALANCE

An earlier section, Grazing Animals and Woodlands, suggests examples of modern silvo-pastoral models for the integration of sheep and deer with woodlands. This section emphasises how finding that balance of grazing and woodlands is central to the idea of reforestation and to providing economic and cultural continuity to our land use systems. Firstly, it examines the nature of current grazing regimes in ecological terms.

Analysis

Grazing and browsing are key natural processes essential to the development and biodiversity of managed and semi-natural woodland ecosystems: that is to say woods, shelterbelts and plantations forming mosaics with open ground such as heaths, meadows, bogs and montane zones.

It can be argued that, second only to soils, grazing and browsing by domestic and wild animals together constitute the most significant, all-embracing ecological factor shaping the vegetation. This in turn has shaped most other terrestrial, and even freshwater life over the last 5000 years. As emphasised elsewhere in this handbook, grazing animals and woodlands have co-evolved, with humans playing an intermediary role. They have assumed some of the roles of top predators in the case of deer, and managed parts of the process carefully, yet have left other bits almost to chance.

An essentially unenclosed form of management has evolved throughout much of the Highlands and Islands. Although this may be changing in favour of in-bye systems, the reality is that dykes and fences do not keep out deer. As sheep numbers have dropped, crofts amalgamated and labour input declined, year-round use of in-bye has evolved with importation of winter feed frequently replacing locally grown hay and silage. Increasing deer pressure and declining fence maintenance result in deer utilizing the same grazings as stock. Pasture declines in both quantity and quality, with rush and bracken infestation and relatively low human input regimes. In many cases the domestic and wild herbivores are under more or less independent management and therefore appropriate grazing levels or densities are hard to plan. Furthermore, such lack of integration makes the relative pressures and effects of the different grazing animals hard to assess.

In the absence of natural predators, populations of wild deer (up to three species in the same wood) are controlled primarily by human culling: numbers and sex ratios being agreed between groups of adjacent land managers. Another control

on population numbers is the number that can be supported through the winter by the available forage. This varies from year to year within a given location according to the condition of both forage and beasts. Artificial feeding allows populations to exceed this constraint (the carrying capacity) on many estates.

A key aspect of the current grazing regime is its topographically extensive nature, operating from the seashore to the top of the highest hill. In many locations, although sheep flocks are 'hefted' (belong to the specific area in which they were reared), they nevertheless free range within wide limits, often with unrestricted access to woodlands and montane zones. Much the same goes for red deer.

This leads to year-round grazing of the great majority of the environment, thereby drastically reducing the chances of tree and shrub regeneration, as well as the flowering, and therefore fruiting and reproduction, of many herb and shrub species. It is not hard to see how this reduces biodiversity considerably over time and maintains a relatively uniform vegetation of plants well adapted to continuous grazing.

See Trophic Cascades later in this section.

A second key aspect is the way an absence of predators affects wild deer grazing behaviour, allowing them to spend much greater time in favoured areas. Without natural predation there is less movement of herds, which would otherwise help to spread grazing pressures. Left to their own devices, herbivores (except when seeking a mountain breeze to disperse flies) will naturally focus on the most nutrient-rich and sheltered areas of any range. In our landscapes this is often in the riparian zone where alluvial deposits have gathered, former shielings with residual fertility, and the remnants of unenclosed woodland. Prime grazing areas are thus coincident with prime ground for woody vegetation or bio-diverse grassland. Without intervention this often leads to its loss or degradation.

The state of various parameters on SSSIs is published annually on SNH website for each SSSI https://www.environment.gov.scot/data/data-analysis/protected-nature-sites/

In summary it can be said that in much of the Highlands the herbivore-soil-vegetation complex is managed primarily to maximize the harvest of male deer and support a certain number of sheep or red grouse in some areas. Only on SACs and SSSIs is the quality of the vegetation (and other features of interest) monitored. This will include the heath and any remnant woodland, which are scored against certain criteria. Whilst some managers are deeply involved in woodland and fishery management, the majority of land is not managed holistically. There is almost no profound consideration of wider components of the ecosystem such as insects, fungi, bacteria, and lichens that actually drive fundamental processes such as soil formation and nutrient flows. Management is thus essentially short-term and superficial over wide areas.

Most notably, nutrient flows and cycles are seldom explicitly part of the picture (discussed in section below). Herbivores are harvested from the ecosystem along with all their nutrients. Little or nothing is returned to the system. Even the carcasses and gralloch are most often removed or buried to deprive the scavengers. Muirburn removes further nutrients. Inputs are almost only from rainfall, which is acidifying although it introduces trace elements by so-called occult deposition (see nutrient recycling below).

The result of the above mix of the intentional and unintentional, the anthropogenic and the natural ecosystem processes can be summarised in two groups which inevitably overlap.

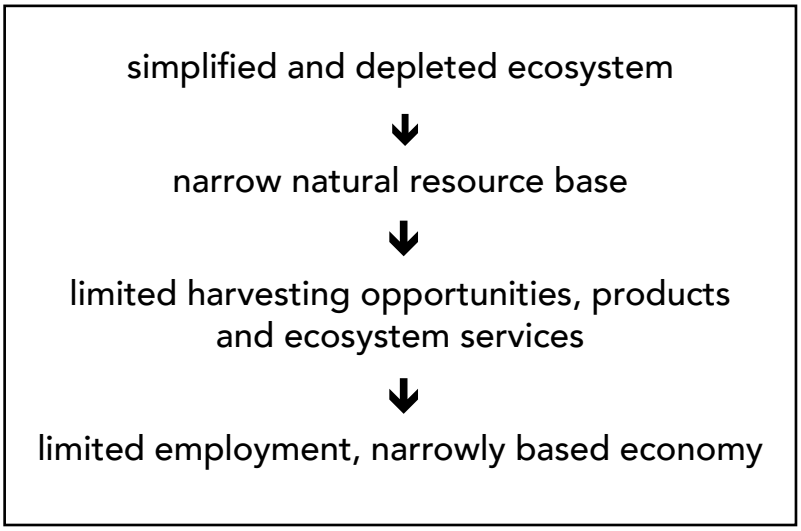
<u>Ecological outcomes</u>

- Cumulative nutrient depletion of whole system. Serious shortage of phosphorus and calcium affecting herbage quality and entire food web from vegetation, to insects, to birds.

- Increasing acidification of both terrestrial and freshwater environments due to shortage of tree leaf litter inputs.
- Ongoing decline of ancient woodland in terms of overall area, species diversity, spatial diversity, lack of understorey development, etc.
- Lack of, or severe constraints to, natural regeneration both within and without existing remnant semi-natural woodlands, leading to spiralling downward trend.
- Unquantified loss of biodiversity in plant, insect and bird species accompanied by associated microbes.

Several of the above trends exhibit feedback loops, self-reinforcing their own declines as well as those of other parameters: eg tree cover lost –› exacerbated leaching as more rainfall reaches ground –› acidification accelerates –› peat formation extends –› seed sources decline –› tree regeneration is inhibited by ground condition, shortage of nutrient availability and seed.

TREND is such a useful concept in managing ecosystems and especially grazing. Trend should always be upward or stable – never downward. This concept is enshrined in SSSI and conservation management, monitoring and reporting but is too infrequently applied to the wider environment.



Economic outcomes

- Damage to commercial forests in a variety of ways, including destruction of newly planted trees.
- Burden of ongoing stalking and fencing costs.
- High costs of woodland establishment.
- Limited choice of silviculture and species selection.
- Need for mounding and fertilisation to combat loss of nutrients from upper horizons, poor drainage due to lack of tree root aeration (loss of soil structure), extensive anthropogenic peat formation.
- Direct competition of deer with domestic stock for grazing both in-bye and on the hill.
- Damage and increased protection costs to horticultural activities.
- The opportunity cost to 'lost' production particularly NTFPs such as wild fruit (inestimable and potentially huge).
- fewer opportunities for hunting, fishing and wildlife tourism.

"Reducing herbivore impact is the biggest issue to be addressed to improve native woodland health and survival. A third of areas suffer from high or very high impact levels that would prevent future regeneration. Some areas in the

medium impact category will also be sub-optimal in terms of the diversity of regeneration that can result… Deer are by far the most widespread type of herbivore recorded and are likely to be the major source of impacts…(there has been) a real loss of (native) woodland area of up to 14% in the last 40 years, nearly all to open unenclosed areas". Native Woodland Survey of Scotland 2014 FCS

© Bernard Planterose

Monarch of the Glen ; lone survivor of extensive woodland mapped by William Roy in 1750 in Wester Ross.

A question of balance

As pointed out by so many – no coincidence that the Greek root of ecology and economy is the same – Oikos – home.

How do we re-establish balanced grazing at the heart of upland land-use systems in its critical role as the primary regulator of vegetation diversity, growth and health? These underlie the functionality of the entire land-use economy and ecology. How do we simultaneously balance the books ecologically and economically? How do we balance the flow of nutrients in and out of the system?

This handbook attempts to offer at least a beginning to the answers to this central question. They must lie in a multi-pronged approach that will take time. It will involve systemic change in both thinking and practice, in advice and subsidy and even in legislation. The concept of sustainability, degraded and trivialized to some extent by over- and mis-use, needs to be extended and deepened to embrace understanding of nutrient flows and soil formation, the significance of the unseen micro-organisms and processes that sustain life, in short the complexity of ecosystem functionality. Without this deeper understanding, our prescriptions and strategies are destined to continue to skate over the surface, never addressing the root causes of our depleted natural resource base. This handbook tries to look beyond our traditionally narrowly defined approach to the management of just one or two animal species at the expense of wider communities of mammals, birds, plants, insects, and other life. It urges a more holistic and scientifically informed approach aimed at the creation and long-term support of a far more diverse and productive landscape that will offer a wider world of employment opportunities.

Three prongs of a solution are described in this handbook, leading away from the currently simplified resource base towards a more complex one with greater employment and productivity. They can be expressed thus:

1. Improve the economy of domestic grazing, increasing its productivity and yield by improving its total environment. Improvements to natural drainage, shelter, fertility (through natural fertilization) and forage quality are all achievable by close integration with woodlands and tree management.
2. Provide alternatives to the extensive grazing needs of sheep and deer through complementary development of horticulture and woodland products including both timber and NTFPs.
3. Diversify from traditional sporting approach of deer management to more integrated wildlife management that maximizes quality, improving some parts of the range and lowering densities to allow regeneration of all vegetation including montane. Introduce some complete grazing exclusion or very low-density herbivore zones to allow regeneration and recovery of vegetation and soils. Explore ways to move herbivores around to avoid concentration in particularly sensitive areas. Pursue opportunities for the creative development of other land uses.

Refer to FPG paper(s) on website: Deer management in Scotland: six key attributes of a better system.

ECOSYSTEM NUTRITION – NUTRIENT CYCLING and ACIDIFICATION

This challenge kicks off the Wester Ross Fisheries Trust website ('habitats' tab).

"Levels of production of fish and other wildlife in Wester Ross are limited by a lack of nutrients, particularly phosphorus. Soils are degraded and thin. Ecosystems based on the recycling of nutrients from vegetation to herbivores to large predators and back into the soil are dysfunctional. Many catchment areas are unnaturally barren as a result of decades of deforestation, loss of top predators, overgrazing, moor-burn and a lack of awareness and understanding of the potential to restore and rebuild more productive, biodiverse and vibrant ecosystems. Can the Scottish Government through agencies SNH and SEPA help to develop and demonstrate soil and fertility restoration methods… and thereby play a leading role in an increasingly vital global challenge or will visitors still be looking across barren, man-made rockscapes (scenically attractive though they may be to some) in another 50 years' time?".

Whether we are embarking on planting a few trees around the croft or a major woodland on the hill, whether we have some definite plans for future use such as stock shelter or are planting for wildlife and landscape, it is important to understand something of the way our actions are about to both influence and be influenced by the largely hidden world of soils, microbes and nutrients. These interactions are often profound and long lasting. Knowing even the basics will help us understand failures and successes alike and inform the efforts of those who follow. Just as one cannot achieve success as a gardener without understanding something of nutrient requirements, flows and sources, neither can one care for, let alone improve, upland land use or choose species for woodlands correctly without similar knowledge.

It is well outside the scope of this handbook to delve into the complex biogeochemistry of soil nutrient availability and cycling in all but the most general terms. The scope here is only to introduce to tree planters and land managers some of the more important aspects of these cycles. What are these key aspects?

Due to a combination of natural processes, particularly prevalent in northern temperate locations, essential plant nutrients once dissolved in water tend to be leached downwards through soils beyond the reach of most plants. This process

Bristly swan-neck moss (Campylopus atrovirens), colonizing badly burnt bare ground that has suffered sheet erosion in Wester Ross with beginnings of soil formation and re-colonization by heather. To get this far has taken nearly 40 years as bedrock yields so little nutrient! Succession in action: from rock to woodland perhaps…

takes place over long time spans and is ongoing. It has been cited as one of the great planetary cycles whereby some types of ecosystems after a period of great fecundity and fertility have a tendency to become naturally less fertile and are essentially renewed by the cycle of recurring glaciations.

The conditions of the north and west Highlands and Islands combine especially high rainfall and predominantly siliceous bedrocks. This creates a strong tendency to the formation of acidic soils and relatively nutrient poor soils (though with important exceptions where limestone and other basic rocks outcrop).

Trees, by virtue of their deep, far-spreading and rock-penetrating roots, have an ability to reach down deeply into soils and even bedrock to take up mineral nutrients. They return them to the surface each autumn as leaf fall, in the case of deciduous species, and throughout the year as needle fall in conifers. In this way we can say that forests retain nutrients in their vegetative parts but also in the litter, soils and rooting systems and massive associated below-ground fungal (mycorrhizal) and bacterial communities.

Tree litter fall feeds a host of above and below ground invertebrates as well as falling into freshwater systems to feed invertebrates that in turn feed fish and birds. The above-ground associated invertebrates feed a great web of other organisms including birds, reptiles, amphibians, mammals etc. When these die they return their nutrients to the soil or to the freshwater.

Refer to section 7, 'Freshwater and Woodlands'.

Tree litter is decomposed by a host of invertebrate, fungal and bacterial life of which fungi, earthworms and ants are only the most visible and well-known components. This web of organisms, that comprises the greater mass of what we call soil, breaks down complex organic molecules in plant detritus to make nutrients in available forms for plant uptake. Through the mechanism of root uptake and litter fall, the nutrients necessary to all life are cycled and recycled, some naturally returning to the sea by way of surface run off.

Complex organic matter or litter must be broken down into the soluble and simple elements that plants can absorb through their root systems and this is achieved not just by animals and microbes but also critically by fungi. Our understanding of the central role of mycorrhizal fungi in ecosystem nutrition is still emerging and

relatively new. Knowledge about their role is influencing and informing reforestation and agricultural restoration projects throughout the world. They are such an important subject that they are discussed as a topic below.

Deforestation in our part of the world has dramatically disrupted nutrient cycling mechanisms, replacing deep rooting trees and their complex mycorrhizal communities with shallow-rooting heath or grass land vegetation. Whilst clearly this vegetation captures and recycles sufficient for its own survival, it has no ability to draw on deeper reserves. Its associated acidic litter leads to long-term soil podsolization and iron pan formation. In the wettest locations it leads to peat formation.

See topic BOX 'Peat' below.

Beyond the initial resources bestowed on ecosystems by glacial rubble after glaciations and the bedrock on which they have come to rest, ongoing or subsequent natural inputs are limited. Minerals are added by direct (airborne) particulate deposition, dissolved in precipitation, by anadromous fish, by seabirds and seaweed-eating animals visiting the land (including sheep), by ongoing weathering of rocks and by atmospheric nitrogen fixation by plant symbiotic bacteria. Many animals transport nutrient between different ecosystems.

The role of salmon and sea trout (anadromous fish) in recycling nutrients from the sea and nourishing terrestrial ecosystems is fundamental and yet largely now lost. See Section 7 'Woodlands & Freshwater' for more about it.

Anthropogenic inputs include artificial fertilizers derived from rocks and oil, and human waste, which includes minerals from the sea and various mined sources (from industrial activities). These inputs have tended to increase fertility in close environs of where people live but clearly not on the hill.

Whereas artificial addition of fertilisers can maintain nutrient levels for crops in gardens and fields, most hill land suffers losses from harvesting of animals both wild and domestic but with little or no compensatory input. This defies all common agricultural and horticultural principles.

Furthermore, burning of heath (muirburn) leads to further nutrient losses, especially where ash is washed away by subsequent rainfall and smoke takes away nutrients in solid airborne particles.

Muirburn has removed all the lichen and moss from rocks on this hillside: two years on and all species are struggling to recover. This site is within the Fannich Hills SSSI and SAC.

The combined nutrient losses from our hills through harvested animals and loss of woodland, along with muirburn, destruction of nitrogen fixing vegetation such as gorse and alder, and a lack of anadromous fish, has led to declining levels of

fertility. In addition, we have the losses of a diverse range of plants which have the potential to help capture and cycle a wider variety of nutrients, not least on account of their various fungal symbionts.

This is somewhat simplistic as nitrogen is also a nutrient and so anthropogenic pollution can paradoxically lead to enhanced plant growth in some circumstances – such as commercial conifer plantations where it is seen as beneficial and in moorland habitats where it is seen as detrimental! Complex outcomes, the quality of which often depends on land management objectives or ecological perspective!

Unfortunately, the trend of nutrient loss has been exacerbated significantly by acidification processes brought about by dramatically increased levels of gaseous nitrogen oxides (NO_x), sulphur dioxide (SO_2), and ammonia (NH_3) along with particulate emissions of acidifying compounds in the atmosphere from industrial pollution ('acid rain'). SO_2 and NO_x are converted to sulphuric and nitric acids.

On top of these trends, atmospheric carbon dioxide (CO_2) naturally combines with water to produce carbonic acid. In short, increasing CO_2 levels lower pH and lead to lower availability of calcium carbonate, vital in the formation of skeletons and shells of organisms such as corals, crustaceans, molluscs and echinoderms. We can therefore make a link from deforestation –› rising atmospheric CO_2 levels –› freshwater and terrestrial acidification –› reduction in calcium carbonate –› failure of crustaceans –› to lower food sources for animals higher up the food chain including humans that feed off seafood and freshwater molluscs.

Acidification of soils and peats increases leaching of base cations (notably calcium Ca+ and magnesium Mg+) and enhances the availability of aluminium (Al) which further reduces base cation availability for plant uptake.

See topic BOX 'Mycorrhiza' below.

A major effect of acidification of soils has been disruption of mycorrhizal and other microbial activity which is responsible for capturing and transporting the major portion of the below ground phosphorus (P) in our generally depleted soils.

Nutrient limitation – phosphorus.

"Phosphorus limits the productivity of plants in many terrestrial ecosystems and is often the first or second element limiting above ground net primary productivity of forests". (Plassard and Dell 2010). In the uplands of the UK a great many studies confirm the view that phosphate concentrations in soil solutions are small. It has low mobility and is bound to clay particles or within the soil organic matter. Its immobilization increases with increasing acidification. With their extensive and far reaching root systems, mycorrhizal root symbioses of trees and most other plants represent the major mechanism for capture and retention of P in our upland environments. The penalties of woodland loss are clearly very high in terms of phosphorus availability to all other living organisms.

Nutrient limitation – calcium

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Carcass of a red deer starved to death in snow of March 2018 but now returning its nutrients to the land and adjacent burn.

It is also increasingly recognized that calcium (Ca+) is naturally in short supply in many upland soils and peat and, as noted above, is further reduced by ongoing acidification. *"Growing evidence from around the globe indicates that anthropogenic factors including pollution-induced acidification, associated aluminium mobility and nitrogen saturation are disrupting nutrient cycles and depleting base cations (eg calcium) from ecosystems" (Schaberg et al 2010).* Forest removal leads to massively increased leaching of all nutrients and calcium is no exception. Calcium is particularly critical in the

formation of gastropod shells and many invertebrate exoskeletons both in terrestrial and freshwater systems (as indeed also in marine systems). Limited calcium availability hinders the success and reproduction of these critical groups on which rely all other life further up the food chains.

Trophic cascade

Indeed, a particularly damaging chain reaction or 'trophic cascade' has been elucidated, leading from shortage of calcium in the soil to inhibition of gastropod shell and invertebrate exoskeleton formation and therefore shortage of calcium in many bird diets. Shortage of calcium in female birds leads to breeding failure due to thinning and breaking eggshells. The increased effort in seeking calcium rich food sources also leads to an inability to feed as many young. These effects are now thought to affect large parts of northern Europe with acidic rocks and soils and may well contribute to the exceptionally low avian faunas of our large tracts of heathland and blanket bog. As trees and woodland are lost from our environment, so is the amount of calcium available to support invertebrate populations, leading to less calcium for breeding birds. Could this be contributory to the failure of bird populations to rebound since the major depletions caused by the so-called 'Victorian Holocaust'? (see below – Shifting baseline syndrome).

Ecosystems are sometimes both nitrogen (N) and phosphorus (P) limited and this appears to be particularly the case in early successional stages on immature soils but also in water-logged environments such as ours. Most relevantly to us, peat and infertile peaty soils are very low in available nitrogen. In these situations legumes, trees and shrubs that can fix atmospheric nitrogen themselves have a clear competitive advantage over other vegetation. This is such an important process for tree planters and agriculturalists alike that it is treated as a separate subject in this section. In summary here we can say that nitrogen fixing plants play a critical role in maintenance of fertility, especially in poor and wet soils. They form an essential part of the ecological restoration tool kit in their ability to colonise damaged ecosystems and pump prime recovery.

See topic box Nitrogen Fixers below. The main N fixing plants in our uplands are alder, bog myrtle, gorse and broom.

Deep-rooted trees are essentially tapping into glacial rubbles and brown forest soils developed over millennia since the Ice Age. In places they are also literally breaking rock to extract nutrients. When they are removed they are generally replaced by shallower-rooting heath species predominantly heathers, bog cottons (*Eriophorum*) and purple moor grass (*Molinia*) as well as *Vacciniums* (eg blaeberry) and a range of lichens and mosses. These shallow-rooted species are unable to bring up nutrients from deeper layers and replenish the system, so their leaves and litter tend towards the acidic. The acidic litter falls to the surface of the soil and is harder to decompose and only yields a restricted range of nutrients. Biodiversity of both plants and invertebrates decreases when deciduous woodland is replaced by heath. pH of soils falls and earthworms and ants disappear. Podzols typically form under such conditions with iron pans that further seal off the lower soil horizons.

Under these conditions peat begins to form. Whilst peat may be considered a natural formation in certain flat and ill-drained situations, across many parts of the Highlands and Islands it is a product of deforestation. Depending on one's view of the relative importance of human deforestation as opposed to climate induced forest decline, peat formation may be considered as a more or less anthropogenic outcome or plagio-climax in ecological terminology.

Upland heath (31% area of Scotland) and blanket bog (23% area of Scotland) habitat type areas of Scotland are significant in terms of European totals. A number of species that occur in them are rare or endangered and it is important to conserve viable areas for these species to survive.

Over large areas where forest could have survived continuously from the Ice Age to this day, peat may be considered an unfortunate consequence of deforestation with its attendant low biodiversity, fertility, low rates of nutrient cycling and inhibition of nutrient recovery from lower horizons and bedrock.

Peatlands and the heath communities they support certainly have intrinsic value, and the carbon sink of peat is significant. However, these qualities need to be carefully weighed alongside the more biodiverse, biologically productive and economically useful woodlands that they have often replaced and which, in some cases, could be regenerated on them. Such woodlands would actively sequester carbon dioxide in larger annual quantities than heathland vegetation and, if harvested carefully, contribute 'fixed' carbon in durable timber construction and artefacts. Native woodland would colonise much moorland in the Highlands and Islands with lower grazing pressures, as has happened extensively throughout SW Norway in the last two centuries. The carbon balance of such an outcome has not been quantified but would vary with peat depth, type of woodland and ground cover established as well as management regime and time span considered. It may soon become an important area of research!

See section 13 for more on natural woodland regeneration on heathland in SW Norway.

11% of Scotland is covered by peat when defined as a surface organic layer more than 300mm thick.

A challenging proposition in upland Scotland is that peat (more than rock and more than podsolization) seems to represent a barrier to forest re-development. That plagio-climax, mentioned above, is an arrested vegetational succession, usually reached due to anthropogenic factors. It's a kind of accidental dead-end, where system dysfunction sends processes down a cul-de-sac with no turning point. The process of mounding, discussed elsewhere, by the simple act of giving planted trees or shrubs access to the glacial rubble that once grew a forest from scratch, proves to be one key to unlocking the closed door. Mechanical cultivation clearly does the same thing rather faster, albeit in less subtle ways with some negative side effects.

The birches have a special reputation as 'soil improvers', although it is quite possible that aspen and holly are just as good. The admixture or alternation of birch with Sitka spruce in plantation forestry could be a life changer in terms of soil nutrient retention or replenishment. Where conifer or heather induced soil changes have occurred, it has been shown that acidification and podsolization can be reversed by birch establishment, which stimulates intense earthworm and ant activity, mixing the soil horizons. However, the composition of the associated field layer will also play an important part and if heather, blaeberry and cowberry persist or colonise then the surface organic matter accumulation may continue to be a 'mor' or acidic humus.

In summary: the loss of trees and woodland cover, the loss of anadromous fish, natural and anthropogenic acidification coupled with the extractive regimes of sheep farming and deer 'ranching' all add together to cause severe disruption of nutrient cycling and therefore ecosystem dysfunction at profound levels. Such dysfunction ramifies throughout our food webs, ultimately affecting the very basis on which human resource use and economics, nutrition and health depend. We inhabit and look out at a hugely depleted natural resource base. We compensate by farming fish and deer, and importing fuels, construction timber, vegetables, and fruit, while largely failing to address the root causes of this dysfunction.

For details of long running research on effects of birch on soils, refer to https://www.hutton.ac.uk/research/groups/ecological%20sciences/research%20facilities/moorco/publications

"The changes taking place after birch has colonized heather moorland are a reversal of this historic process of ecosystem degradation, causing a more diverse flora and fauna above ground and in the soil, and increasing rates of nutrient cycling. The soil changes that have occurred within 30-60 years after birch colonization at most of the sites studied are broadly equivalent to the results of agricultural reclamation, but with no direct costs. Also, while the time span is long, areas too steep or rocky for conventional improvement can be changed under birch". Miles J (ITE)

THE NITROGEN FIXERS

Biological nitrogen fixation is a process in which atmospheric nitrogen gas (N_2) is converted into plant-available nitrogen (N). It is carried out typically in root nodules by filamentous symbiotic bacteria which convert the nitrogen trapped in the soil into ammonia via the enzyme nitrogenase. The bacteria can supply most or all of the nitrogen requirements of the host plant, which reciprocates by supplying the bacteria with carbohydrates for energy. *Frankia alni* is the species of bacterium that forms a symbiotic relationship exclusively with trees in the alder family (*Alnus* genus). It is the only named species in this genus, but a great many strains are specific to different plant species.

Such nitrogen supply increases soil fertility and builds up the soil nitrogen pool through the decomposition of N-rich litter, and the release of N from roots and nodules. Bacteria of the genera *Rhizobium* and *Bradyrhizobium* constitute the predominant symbionts for most legume species throughout the world and it has been shown that these collectively provide one fifth of all nitrogen inputs into global agriculture.

They also form symbioses with gorse and broom which are common species in the Highlands and Islands. It is ironic therefore that they should be so despised by farmers when they stabilise, develop and enrich soils. Furthermore, they are important sources of pollen for bees, especially in early spring, but then again in their later flowering season. They are also a source of fodder for goats and sheep, especially in the harshest snowy and frosty conditions when their winter foliage is still green. If left to its own devices, gorse (bracken too) can begin an ecological succession that results in woodland. They deserve our profound respect and can play an important role in the restoration of fertility and protecting and nourishing young trees.

Bog myrtle, another common component of our wet upland heath communities also forms root symbioses with nitrogen fixing actinobacteria and therefore contributes to retention of soil fertility and overall ecosystem nutrition.

This diverse collection of nitrogen fixing trees, shrubs and plants plays a crucial role, therefore, in the establishment of trees and woodlands on poor and peaty sites in the Highlands and Islands. They cycle nitrogen and assist with other nutrient flows as well as drying the ground and preparing it for more demanding later successional species.

Nitrogen fixation is a phosphorus (P) demanding process, so most legumes are also highly dependent on P-supply by arbuscular mycorrhizal fungi in natural ecosystems.

The main source of nitrogen (and phosphate) for the vast majority of non-N-fixing trees and plants is locked up in the organic matter of peats and soils in various states of decomposition and is made 'available' by the actions of mycorrhizal fungi. These form the subject of a separate box.

MYCORRHIZA

"When [plants] first embarked upon their land-based lifestyle around 500 million years ago, plants and mycorrhizal fungi were already collaborating in the form of a novel symbiosis which enabled both to abandon aquatic habitats, colonise the

land and diversify. From the start, mycorrhiza was the normal way of life for land plants and it still is for an estimated 90-95% of plants in all ecosystems on every continent. Mycorrhiza was, always has been and still is ubiquitous". James Merryweather

The problem for us as tree planters is that although some mycorrhizal fungi are generalists forming symbioses with a number of species, others may be highly specific to their symbiotic tree species partners and if you take away one of the partners in this symbioses the other will die. Take away the woodland and the fungi will die, take away the fungi and the woodland will die. We may assume that deforestation over the vast areas of the Highlands and Islands has therefore had invisible underground consequences as large as those we can more readily appreciate above ground.

Mycorrhizal fungi have been shown to form massive underground webs – comparable perhaps with the internet – connecting trees of one species to others of the same species across entire forests. They probably interlink different species for all we yet know. The 'woodland wide web' (Peter Wohlleben 2015) is used to share nutrient and water resources as well as to send chemical messages from tree to tree, even including emergency communications concerning insect attacks, which permit pre-emptive biochemical reactions in leaves to deter the invaders.

The presence or absence of the correct fungal partners in soil can be seen to be of the utmost importance in tree establishment. It is likely that their absence is the cause of failure to thrive in long deforested soils and peats over much of the Highlands and Islands. Trees in pots/containers may have some fungi in the soil that accompanies the plant but not necessarily the best mycorrhizal species. Even bare-rooted planting stock will have some soil and hopefully some mycorrhizal fungi already attached.

The heathers and other related plants form ericoid mycorrhizas with their own specific fungi. There is apparently no shortage of this group so no need to worry about our heathland in that respect at least. The ericoid mycorrhizas are completely different from the ectomycorrhizal tree fungi, the orchid fungi and the endomycorrhizal fungi that colonise roots of many tree species and the majority of herbaceous plants.

There are a number of practical implications of this evolving mycorrhizal understanding.

Natural regeneration seems often to grow faster than planted stock. This is partly attributable to stripping of fine root hairs during lifting from nursery beds and planting. But it is also likely to be because tree seeds germinate best when in immediate contact with fungi so that their fine rootlets find the right fungi faster than the damaged roots of planted stock.

Planting close to remnants of woodland could be more important than we currently acknowledge, although there is little point in planting where natural regeneration is establishing, except where diversification of species is required.

Maintaining continuity of woodlands – see LISS and CCF – becomes even more important in view of the mycorrhizal story. Our new understanding of mycorrhizal significance should strengthen commitment to continuous cover forestry. We should now be re-imagining it as continuous 'under-cover' forestry.

Mycorrhizal inoculants may play a part in the future. They are already used in nurseries and now commercially available in sachet form. Despite good intentions, it is not certain how efficacious these are.

It certainly seems the case that deforestation effects on soils are much more drastic than we perhaps thought 50 years ago. The extinction of species and ensuing alteration of fundamental ecosystem function (the dysfunction mentioned in the opening quote of this section) is more profound than we realised. Therefore, the processes of reversal may be more difficult and take more time than we thought. This should not discourage us but should help inform and widen our vision and preferably re-double our effort.

The speed at which forests colonised after the last Ice Age, which constituted massive sub-soil disruption, actually argues for a remarkable ability for natural processes to recover and plants to diversify and occupy all available niches quite quickly in terms of geological time. How these processes subsequently unfold as the soil-vegetation complex develops over millennia is another matter.

Whilst a degree of acidification over time may be part of a natural cycle, anthropogenically enhanced concentration of atmospheric CO_2 and NO_x pollution is accelerating acidification in global terrestrial (and marine) ecosystems and there is evidence that lowering soil pH is causing mycorrhizal fungal decline. This represents another worrying feedback loop where deforestation reduces atmospheric carbon sequestration and increases GHG levels –› accelerated acidification –› declining nutrient capture and recycling –› declining tree health –› further deforestation.

SHIFTING BASELINE SYNDROME: a useful concept

'Shifting baseline syndrome' was first named and described by a fisheries scientist in relation to global cultural attitudes to the declining abundance of marine fish species. It was noted across many cultures how each generation accepted as the norm a more and more depleted marine environment with poorer and poorer catches. It is as if a new generation lives in denial of its parents' perceptions and memories.

This important concept is now more widely applied to the condition of cultures globally in respect to their environments, ecosystems and harvesting industries. In the Highlands and Islands context it is striking how contemporary perception is one of a largely pristine and wild environment in which human impacts are restricted to small patches of fields and villages. Wildlife is widely perceived and interpreted as abundant and flourishing, our waters as clean. Clearly such perceptions are of benefit to our promotion of landscape tourism and our food production as especially unpolluted and 'sustainable'.

Yet many important aspects of the reality contradict this. It is nearer the truth that the state of much of the land is exhausted, the water and soils acidified, the wild fish almost exterminated, and the wildlife a mere shadow of its former self and current potential. How many residents, let alone tourists, appreciate the extraordinary declines of wildlife experienced over much of the land in only the last 150 years? Lairds like Osgood Mackenzie could, in the one year of 1868, (on his estates at Gairloch, Inverewe and Kernsary) shoot 1314 red grouse, 33 black grouse, 49 partridge, 110 golden plover, 35 mallard, 53 snipe, 91 rock dove, 184 hares 'without mentioning geese, teal, ptarmigan'. In other years he recorded shooting up to

106 snipe and 95 woodcock. His mother made capes and coats from the average 40-50 pine marten skins 'brought to her by the keepers each year'.

© Bernard Planterose

Loss of riparian woodland leading to disintegration of river banks, de-stabilisation of river courses and silting of fish habitat.

It is unquestionable to many scientists and those close to the land that contemporary descriptions of the Highlands and Islands suffer from shifting baseline syndrome – accepting the landscape and environment as 'the way things are and always have been'. And that whilst this may be helpful in the short term to existing food, stalking and tourist industries, it perpetuates an ignorance that in the longer term threatens to undermine progress towards more diverse, profitable and truly lasting productive husbandries and harvests.

OLIGOTROPHIC AND EUTROPHIC STATES

In general terms freshwater systems in the Highlands & Islands are often described as oligotrophic and our land as acidic and infertile which means poor in available nutrients. This natural oligotrophy derives closely from bedrock types, high rainfall and cool summers. But these are sweeping generalisations and may be quite untrue locally, eg where limestone or basic schists outcrop increase pH and bring a range of different minerals within rooting depth of plants. It is said that some parts of Skye and Mull for instance, which lie on nutrient rich volcanic rock, display some of the most naturally fertile soils in Britain. While the deep peats of other areas of the very same islands offer one of the least favourable mediums to either crop or forest.

It is important to differentiate where oligotrophy is natural and when human induced and equally important to make the same distinctions between eutrophic states. Neither state is 'good' or 'bad' per se but is better judged in relation to (a) ecosystem functionality and/or (b) human management goals, which may include health of humans, livestock and crop plants.

Eutrophication is often presented as something bad – excess nutrients from fertilizer or feedstuffs from farming and fish farming may both cause it with associated toxic algal blooms. In the context of ecosystem-level nutrient losses described above however, re-fertilization of land and water has sometimes been proposed by, for instance, the spreading of rock dust. This handbook presents woodland establishment and extension as the most obvious and economic form

of re-fertilizing the land and water thereby moving from relatively oligotrophic to *relatively* eutrophic states.

Oligotrophy implies a lack of fertility, productivity of both crops and natural habitats and even biodiversity. An underlying contention of much of this handbook is that this oligotrophy (a) has been significantly exacerbated by human mis-management over millennia and (b) that to some extent this can be reversed or at least mitigated by a range of different management practices.

PEAT

Hill land is characterized over much of our region by varying depths of peat overlying glacial rubbles (sometimes called boulder clays) or podsols, which in turn overlie bedrock of many different types. Peat formation can occur in wet climates like ours almost irrespective of the underlying geology. Peat varies in level of saturation and depth depending primarily on gradient, history of vegetation cover, and local climate as affected by altitude and aspect. It comprises the very slowly decomposing remains of the vegetation growing on its surface, which is often primarily ericoid shrubs (including heather and heaths) and sphagnum moss but also other heath plants such as bog cotton and sedges.

The litter of heathers, sedges and other heath plants tends to be very acidic and in the cool and wet upland environment this leads to decomposition so slow that the litter builds up and gradually forms peat. The high water table in peat bogs leads to near anaerobic conditions further inhibiting decomposition. Peat is said to grow at the rate of about 1mm/annum but this will vary with altitude and other factors. It is proposed that peat started to form around 5500 years ago when the wetter conditions of the Atlantic period started. It is thought that shallower upland blanket bogs did not begin to form until later. On steeper gradients peat is thinner and is characterised by bryophyte-rich dwarf shrub heath or acid grassland swards. These communities of shallower peat are often referred to as wet grass-heaths. In many but not all cases, these habitats are a product of deforestation and are capable of supporting woodland again.

A very common sight: an actively eroding peat hag on gently sloping ground in a bare landscape below the natural treeline, contributing large quantities of suspended peat into a burn and lochs downstream. Re-vegetation is occurring (right) where nearly 2 metres of erosion have exposed the underlying glacial rubble. Succession to scrub woodland and soil re-formation would avoid this cycle of peat build up and subsequent erosion but lack of seed sources coupled to heavy grazing and muirburn are likely to prevent it in many places.

TROPHIC CASCADES

Trophic cascades have been defined as *"Reciprocal predator–prey effects that alter the abundance, biomass or productivity of a population, community or trophic level across more than one link in a food web. Trophic cascades often originate from top predators, such as wolves, but are not necessarily restricted to starting only in the upper reaches of the food web". (Michael Pace et al 1999).*

This handbook has briefly described more than one such trophic cascade within our bioregional context. The loss of salmon from our rivers represents the loss of a major prey item of both mammals and birds which in turn are both predators and prey to each other. We have seen how this loss ramifies throughout nutritional (trophic) pathways through entire ecosystems. The decline of gastropods such as snails affects the ability of many small birds that depend on them for calcium to reproduce effectively. The decline of these species in turn reduces food sources for avian predators such as merlin and sparrowhawk. This is an example of 'bottom-up control' where regulation of food-web components by lower level producers affects upper levels.

The most publicized example of a trophic cascade is the story of wolf eradication and subsequent reintroduction in Yellowstone National Park. Wolves prey on elk and in their absence trees and shrubs suffered from over-grazing, with ensuing erosion and loss of biodiversity. Artificial elk control stabilised but did not reverse the decline and was abandoned in the 1960s. After years of heated debate, the first wolves were reintroduced in 1995 after an absence of 69 years. Ensuing predation of elk had quite rapid and dramatic effects as trees and shrub regeneration advanced along woodland edges and riparian zones. *'The constant presence of wolves pushed elk into less favorable habitats, raised their stress level, lowered their nutrition and their overall birth rate'.*

But this was not all. The coyote population was halved, favouring ground nesting birds, rodents and hares as well as foxes. Yet perhaps most significantly, beavers increased dramatically in numbers due to the restored riparian willow growth, which the now more mobile elk no longer suppressed. The beavers' dams flooded areas of surrounding land creating new habitat for moose, otters, mink, waders, amphibians and fish. Grizzly bear populations also increased due to greater berry production of the ground flora as well as to better supply of carrion from wolf kills. This also gave increased food to a very wide range of animals from beetles to eagles.

There are potentially instructive parallels in this story with the situation in our region. Here wolves once controlled deer numbers (until around 1680 but possibly later) but now only fences and humans can prevent over-grazing of particularly favoured vegetation along rivers and burns, as well as young regenerating trees at the border of existing woodlands. It is possible to imagine the cascading effects that a major reduction in red deer numbers would have on our environment and the evidence for this is currently emerging on estates and reserves such as Mar Lodge, Creag Meagaidh, Glen Feshie, Beinn Eighe and Alladale that are making manifest that vision of regeneration.

REWILDING

Depending on one's perspective, perhaps on one's fundamental relationship with nature or 'the land', 'rewilding' is either one of the most exciting or one of the most challenging concepts to emerge under the broad label of environmentalism in the last few years. For those who spend their lives in taming or re-ordering nature to make a living, and particularly for those whose relationships with a particular piece of land go back through the generations, the concept of 'letting nature manage

itself' or take over land that has taken generations to bring into productive use for humans, appears madness.

Yet this is to misinterpret the core concepts of a term with relevance to the overall vision of re-designed productive land-use systems for the future with which this handbook is concerned. To properly understand it, we need to place it in a national or even global context before seeing how it can play a part in our regional vision of productive agroforestry suitable for upland areas of the Highlands and Islands.

At the heart of the rewilding concept lies a fundamental design objective or principle that is increasingly a goal of environmental scientists world-wide. Expressed simply, the ideal is to confine or concentrate our food growing activity into a smaller portion of the planet, so as to release a larger part to nature. This broad principle can be applied at local, regional and global scales.

One of the greatest arguments against animal protein production is the large land area that it requires and its inefficiency in that regard. It is now also under attack for its large GHG contribution. In short, the world's taste for meat leads to deforestation to grow crops to feed animals. A view is growing that this is unsustainable in a world with a population set to reach 10 billion by mid century and in which over 10% are already undernourished.

Viewed from places on the planet (like ours) where large areas of the land appear to be unsuitable for anything other than extensive grazing by hardy stock adapted over centuries to extreme environments, the argument appears to fall down. But this is to set up an unnecessary dichotomy or polarisation of arguments. In a well designed or managed system there is space for a tripartite balance between agri/horticulture, grazing *and* wild land.

The current failing in our upland land use systems is that the grazing system (domestic stock as well as the fed and culled red deer population) is unnecessarily over-extensive and thereby effectively eliminates the wild land component. The answer lies in restricting the domestic range, controlling the deer to population levels that allow regeneration of vegetation (particularly woodland) and allowing the montane zone to develop into its natural wild state. At sufficiently low population levels, deer could inhabit extensive woodland to which they rightfully belong, reach a better size and health and continue to provide a wild harvest.

See section 13 for how deer co-exist with woodland in Norway.

A second way to apply the central tenet of rewilding is to include space for wild nature wherever possible within all systems. An obvious example that this handbook promotes is the shelterbelt or hedgerow, which, although a highly artificial device requiring some management to perform all its functions, can nonetheless provide critical space for a relatively 'wild' development of biodiversity. Excluding grazing from gorges and cliffs can also be highly effective in creating wild land within the more agricultural zone.

Re-introductions of individual species have been the media capturing face of rewilding, yet its potential is far more all-embracing. Restoring the missing herb species to grasslands and heathlands, the understorey to woodlands and the scrub to montane zones that centuries of over-grazing and muirburn have eliminated or driven to cliffs and inaccessible corners is arguably its wider and more important mission.

POLLEN ANALYSIS

In the following sub-section Dr Richard Tipping describes one of the principle techniques on which our knowledge of the history of Scottish vegetation is based. Carbon dated pollen analysis from around 50 sites exists for the area of the Highlands and Islands covered in this handbook and just a few of the relevant papers are given in the bibliography.

"How do we set about constructing this complex story? The principal and most successful technique has been pollen analysis. Pollen grains and spores can be identified in a great many cases to species, or at least to genus. They are made of a very resistant polymer called sporopollenin, and can be preserved for hundreds of millions of years in the geological record. The best preservation occurs in waterlogged deposits such as in lochs or peat bogs: needless to say, Scotland is more than well endowed in these.

"The sediments that accumulate in lochs and peats do so generally in continuous stratigraphic sequences. Because plants produce far more pollen than is needed for reproductive purposes there is always an abundance of pollen to find its way into these sediments, although the record of events is biased towards those plants which are wind-pollinated. This over-production means that there are many thousands or tens of thousands of pollen grains in a single cubic centimetre of lake mud or peat.

"Accordingly, very thin slices of sediment can be removed from cores sampled often ten or more metres below the surface of peat bogs and infilled lochs, or from boats in existing lochs. Layer by layer these slices are analysed for their pollen content and a record built up of the plants growing in the vicinity of the site through time. Nowadays it is a routine procedure to radio-carbon date slices of organic sediment from the cores and we can, with care, obtain a detailed and reasonably precise chronology of temporal changes in plant communities.

"A finished pollen diagram covering all of the Holocene period, the present interglacial (the period of the last c.10,000 years of warm climate and warmth-demanding tree cover after the last glacial period, when Scotland was ice covered) provides a record initially of plant migration at the end of the last glaciation, processes of colonization and extinction, soil development and maturation and climate changes powerful enough to de-stabilize vegetation patterns as well as the effects of humans in changing the landscape from wildwood to managed (and mis-managed) landscape".

WOODLAND REGENERATION AND FARMING IN SOUTH WEST NORWAY

an epilogue: by Duncan Halley

This section by Duncan Halley of the Norwegian Institute for Nature Research presents a fascinating comparison of south west Norwegian land use over the last two centuries with ours in the Highlands and Islands. It amounts to a compelling re-enforcement of many of the arguments and suggestions for innovation and action in this handbook. Above all it underlines that it is not so much soil or climate that prevents us from moving forward to a much more productive and biodiverse landscape but our traditions, land ownership patterns and grant support structures. The south west Norwegian model incorporates all our current economic activities plus more within an all-embracing woodland mosaic and economy.

CLIMATE AND GEOLOGY COMPARISON

If a crofter from 19th century Scotland had visited south western Norway he would have found the landscape, and the land use, very familiar. Small, carefully tended in-bye fields were set in much larger areas of rough grazing for sheep, cattle, and goats. The landscape was almost completely open; as in the Highlands and Islands, peat was the main fuel; drystane dykes were built for miles across the treeless glens and hillsides; wood for fuel or fencing was unavailable locally, and too expensive to import. Houses were drystone or sod construction and looked very like the 'black houses' of crofting districts. Landscape photographs from the late 19th and early 20th centuries look strikingly like many parts of the Highlands, then and now.

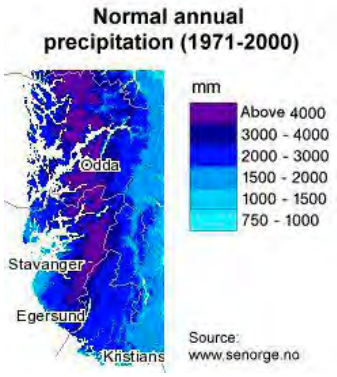
This is not surprising. The climate, geology, and landforms of the two regions are very similar indeed. Southwest Norway (the provinces of Rogaland, Hordaland, and Vest Agder, with the upland part of Aust Agder) covers 33318km^2 (Highland, Western Isles and Argyll & Bute: 35639km^2). In latitude, the area ranges from that of Ullapool/ Dornoch to Hermaness. The geology is mainly hard, infertile, acidic gneisses, schists and granites, from the same orogenies that formed Highland Scotland.

The climate is classified as 'hyperoceanic', and is dominated by the Gulf Stream and the same westerly winds as the Highlands. As a result, seasonal weather patterns are closely similar: mild, wet, and windy, with similar seasonal temperature ranges. Readers can compare climate statistics in detail for themselves at www.senorge.no and www.metoffice.gov.uk.

Oslibakken, near Stavanger, in 1911. Latitude is the same as the north coast of Scotland.

Oslibakken in 2015. Formerly, rough grazing was the only economic activity of significance. Currently, arable farming; grazing in-bye, on hill pastures (top left), and in the naturally regenerated woodland; commercial planted forestry; deer, grouse, and small game hunting (owned and used or sold by the farmers), and fuelwood extraction all take place on the same ground. Point of shot of 2011 photograph indicated by 'X'. It is now necessary to climb to the summit of the hill to find an open spot (on a cliff edge) from which to take a landscape photograph.

Extreme coastal, agricultural landscape at Ferkingstad, Karmøy kommune,Rogaland in 1913 and 2004. In this well populated environment with many small units, most woodlands and shelterbelts have been planted. This community is at the at the latitude of Fair Isle. Local weather stations record annual average, and extreme event, wind speeds in excess of anywhere at sea level in Scotland.



Overall, SW Norway has slightly stronger winds at sea level than anywhere in Scotland; and in some areas precipitation is higher than even the wettest parts of Scotland, at over 4000mm (and up to 5000mm). As in Scotland, rainfall peaks as weather systems rise over the mountains in the west; and then declines eastwards, with variations caused by local topography. Seasonal temperatures are very similar, apart from being a little colder along the central mountain ridge, as it is rather higher (1500-1600m) than Scottish mountains. Within the region it is possible to find close matches to localities throughout Highland Scotland in geology, precipitation, and seasonal temperatures.

In summary, abundant and precisely quantified climatic and geological data indicate clearly that the biophysical conditions of life in Highland Scotland and SW Norway do not differ significantly in any respect for agricultural and woodland management.

So it is not surprising that our 19th century crofter would have found the landscape, including the land cover, very familiar. His 21st century counterpart, however, will find it very different. The region is now well wooded, and that woodland cover is rapidly expanding and developing, mainly through natural regeneration. What happened?

HOW WOODS ARRIVED IN NORWAY

The story goes back a long way. People arrived in SW Norway at about the same time as in the Highlands, at the end of the last Ice Age; and they introduced agriculture and domestic animals, and started using metal tools and other technological developments, at about the same times. In the very similar climate, geology, and landforms, the effect was also very similar: deforestation, anthropogenic (man-made) in origin, was mostly complete in coastal areas by the Bronze Age. Deforestation inland continued for many centuries and reached its greatest extent in the 19th century.

Landscape history in the Scottish Highlands and Islands and SW Norway continued in parallel throughout the period in which land-use was dominated by 'subsistence pastoralism'; that is, by raising domestic animals mainly for use by the farmers and their local society (though in both regions, cattle were exported, especially later in the period). As a result, by the 19th century both SW Norway and the Highlands had been strongly deforested for a long time.

The landscape histories of the two regions have since diverged strongly. In the Highlands, subsistence pastoralism was replaced as the dominant land use by commercial sheep ranching for cash incomes from the later 18th century, mostly spent outwith the region. This was joined by recreational hunting in the 19th century. The older pattern of land use did not start to change in Norway until the 1860s.

Fidjadalen, Rogaland (SW Norway). Geology is gneisses and granites. The glen floor is at 300m asl. The climate is mild and very wet (just under 4000mm/ year on the glen floor, more at higher levels). Peat was the former fuel for the farm. Tree regeneration, all naturally seeded, largely dates to the 1960s and after. Scots pine is now appearing within the pioneering birch and aspen; rowan, juniper and bird cherry are also present. According to the farmer, 'About exactly 1000 large Dalarna sheep' are grazed in the glen and surrounding mountains in the summer.

In the Highlands, apart from commercial planted forests, which started to be established after the First World War, no significant expansion of woodland occurred in the 20th century. Remaining semi-natural woodlands continued to decline (Wilson 2015). In SW Norway, new woodlands began naturally regenerating from the 1860s on; and especially from the 1950s. In recent decades the landscape has changed from mainly unwooded within living memory, to one where most of the land below the treeline is now wooded once again. This process is continuing at a very rapid rate. In Rogaland, the most deforested province of all, in the far SW, woodland cover is predicted to increase from 24% in 2007 to 52% over the next few decades, with most of the remaining area being arable farmland, in-bye fenced and drained grazings, or high mountains above the natural treeline. In West Norway statistical region (Rogaland, Hordaland, Sogn & Fjordane and More & Romsdal provinces), 2.6% of the land area is changing from open ground to woodland every five years (Data: Statistics Norway). So far as there is a concern, it is – especially in older people – that there is *too much* regeneration. But nobody would wish to return to the old landscape with its old level of productivity.

What caused this? Much research has been done, and the answer is clear: reductions in grazing pressure, and associated land use practices such as muirburn. This happened in two main waves. The first was from the 1860s to 1914, and was due to mass voluntary emigration to the United States. The second was from the 1950s on, as ways of making a living other than hill farming became widely available and were considered more attractive. Between these was a pause or perhaps slight reversal in the 1930-40s as the economic and political conditions of the Great Depression and WWII resulted in many people staying on or returning to their parental hill farms.

Populations on the land, however, were and remain much higher than in the post-clearance Highlands (excluding cities like Inverness and Stavanger, currently

18.4/km^2 in SW Norway, 6.27/km^2 in Highland and the Western Isles); and that population, then and now, both owns and manages the land. Most combine farming with other occupations. The parallel with crofting areas of the Highlands is obvious. There are significant differences of course, but none of them are 'biophysical' – that is, in the intrinsic nature and potential of the land itself.

© Peter Emil Kaland

Natural regeneration at Fonnes, Hordaland. A coastal site facing the open Atlantic, on dioritic to granitic gneiss and migmatite. The roof ridge of the shed in the 1971 image is c. 2m high. The copse of Scots pine in the 1971 photograph was planted in 1907. Reduction in grazing pressure at the site dates to 1975. From Miljødirektøratet, 2013.

SOME COMPARATIVE INSIGHTS

Sometimes it has been asserted that the general treelessness of the Highlands and Islands is 'natural', 'inevitable', or 'irreversible'. This is nonsense. All you have to do is to look beyond Scotland, at the climates and soils in which woodlands of the relevant tree species can be seen to flourish and regenerate. In SW Norway species such as Scots pine, downy birch, aspen, juniper, alder, rowan, and bird cherry all grow and regenerate prolifically. They recolonise ground deforested for millennia, in climates both significantly wetter than, and as cool as (but without any appreciable winter snow cover) anywhere in Scotland at any period in the last 7500 years since the Atlantic climate prevailed.

See mapping data: https://artskart.artsdatabanken.no

Over most of the land area of Highland Scotland, except for some high mountain tops, the climate thus remains well within the natural capabilities of all of these species. Past changes in climate might have altered the balance of tree species within woodland, but not the extent of woodland cover.

© Rob Dewar

The author in high-altitude woodland pasture, peat over granite, Berdalen, Aust-Agder. Note the quality of the understorey for grazing. The 'alpine blue sow thistle' in the foreground is particularly sought after by grazers; in Scotland it is found on only a few inaccessible cliff ledges. Climate similar to the central Highlands. Maps and place names indicate the location was deforested blanket peat to at least the early 20th century; none of the trees are old.

© Duncan Halley

Peat bog in More, west Norway. Flat glen floor is permanently saturated; tree regeneration on all drier patches and slopes. Inset: willow/ juniper/birch association on a drier patch in the bog shown. Underlying geology quartz diorite.

TREES AND PEAT

Much of the initial regrowth in SW and W Norway observed in recent decades has occurred directly on peat. It is sometimes stated, or assumed, in Scotland that native woodland is not capable of regenerating on peat (unless it's artificially drained and planted); this can even be found in official documentation. But this, too, is nonsense.

'Myrskog' ('Peat bog forest') is so common as to be a standard vegetation class in Norway. It is described as 'Forested bog on deep, nutrient-poor peat where the peat layer has built up so that vegetation has lost contact with groundwater' and is found throughout Norway including the SW. Downy birch (the usual pioneer) and Scots pine are the usual main species. Much woodland re-establishment has happened in recent decades on peat in SW Norway, often wet and deep peat, formed as a result of earlier man-made deforestation. Trees regenerate strongly so long as the soil is not permanently waterlogged. Even on flat blanket bogs, trees are usual on any raised or slightly drier patch. The process typically 'browns' the soil, forming a new, non-peat layer and 'locking in' the accumulated peat below; so that the area may no longer be classified as bog woodland. More than 90% of the former coastal heather moorland in Norway, much on peat, has re-wooded in recent decades, after millennia of deforestation.

In climates as cool as and as wet or wetter than anywhere in Scotland, it is the simple fact that naturally regenerating woodland both maintains itself (and its soils) and reinvades any land not permanently saturated, except for on high mountain tops. This happens whenever the underlying causes of deforestation, primarily high grazing pressures but also practices like frequent muirburn, relax.

NORWEGIAN STYLE WOODLAND CROFTING

How does this all work for small farmers in Norway? The average farm has an area of in-bye fields, and a much larger area of hill; some also have common grazings. The hill areas are these days mostly wooded; there are some planted forests of conifers (these are now normally left to regenerate naturally), but mainly they are

Sheep in Krummholz (montane) pine Folldalen.

Shepherding in open montane birch & willow scrub, Hunnedalen, Rogaland.

naturally regenerated from the outset. This is a mix of species, with birch, rowan, and aspen being the usual pioneers and others like pine, oak and small-leaved lime moving in later. These woods are usually open in character, with an understorey of grasses and herbs with some heather. This is good grazing and provides shelter in bad weather. Livestock are grazed there in summer; on the coast, all year. It also supports red and roe deer, with moose in some areas, grouse, and small game. Hunting rights for these are owned by the landowner (ie the farmer, as absentee ownership is in effect illegal). He/she can use or sell them in a free market. For most farm families self-harvested game meat is a major meat source in their diet.

In addition, timber is harvested from plantations and also from naturally growing Scots pine. Deciduous wood is harvested as firewood. Usually, the older clear-cuts are left to regenerate naturally. After about 20 years, the birch and other broadleaves are harvested for firewood, leaving the pines to grow as a timber crop. The main heating for the farm families is self-harvested firewood and sales to the general public are brisk. The average household uses over 800kg a year. Building, renting, servicing, and selling cabins is also a significant money earner. Small further 'crops' include berry and mushroom picking. The difference in productivity, biological and economic, with the average Highlands and Islands hillside is, to anyone who has seen both, very obvious.

Cows in birch woodland on Kleppe farm.

Sheep and lush grazings at 650 metres asl. An old seter (shieling), Kvanndalen.

Grazing of sheep, cattle and even goats in open-structured yet regenerating woodland including within the montane zone is the norm in SW Norway. It is a matter of careful shepherding and husbandry coupled to a clear understanding of appropriate grazing densities that ensure ongoing woodland regeneration. Having the deer well under control helps enormously.

A point worth mentioning is that the red deer harvest (the term used in Norway) per unit area is more or less the same as the off-take per unit area in a Scottish pure-play deer forest. In venison terms it's much more, because Norwegian red deer are about 40% bigger. We know this is not for genetic reasons – it is because the population is properly managed at what would be considered low densities in Scotland – with the aim of maximising sustainable yield when mixed with the other uses. The faster breeding of healthy deer and very low non-hunting mortality more than compensate for the lower densities. And the same land also supports livestock grazing, timber and fuelwood harvesting, etc.

Other benefits include damping of flood and drought events, and much less erosion of the sort that blocked the main road from Oban to Glasgow a few years ago.

CONCLUSION

The climates, geologies, and landforms of Highland Scotland and of SW Norway are closely similar. Their woodland history until comparatively recently has been similar in consequence of this, with similar patterns and timings of human impacts from the end of the Ice Age onwards. The modern large differences in landscape, and in particular of woodland cover, are a consequence of significant divergences in land management practices beginning in the 18th-19th centuries.

The landscapes of both Highland Scotland and of SW Norway are primarily cultural and have been since the Neolithic. The desirable landscape for the Highlands (or for SW Norway) is open to a variety of opinions. However, assertions that the open landscapes of the Highlands and Islands are 'natural'; and/or that current

landscapes are, to any significant extent, unable to reafforest by natural means (assuming changes in management), are untrue. They are incompatible with simple observation of the climates and soils in which woodlands of the relevant tree species can and do grow; and have been seen to recolonise by natural regeneration over wide areas, after centuries to millennia of deforestation.

View of Hidra island from Kleppe. Most of the woodland in this area has regenerated naturally in the last half century and is managed for multiple benefits including venison, shelter, grazing and fuel wood. Grass patches produce silage to feed stock in the winter.

None of this is intended to suggest that Scotland should merely copy Norwegian practices. Crofters in Scotland can, and surely will, develop a distinctive pattern best suited to their own needs and interests. Many practices in Norway do, however, provide 'worked examples', which might be useful in developing croft woodlands. But the argument that it can't be done is false and should no longer get houseroom in debate.

If considered desirable, reforestation by semi-natural woodland in Scotland could be accelerated greatly by management, as compared to the largely unmanaged process that happened in SW Norway. Data indicates that following decline in grazing pressure and associated human impacts, such as muirburn, how rapidly regrowth (of woodland) occurs is first and foremost dependent on the distance to the nearest seed source.

AFTERWORD

The comparative data in this section of the handbook is summarised from material presented at the Scottish Woodland History Conference in October 2015, and in expanded form (to include modern land use practices in SW Norway) at a Nordic Horizons event at Holyrood later that year. Climate data and other comparisons were developed in more detail in those talks, including examples of areas similar in detailed climate and geology to various parts of the Highlands. As presented at Holyrood, the talk may be downloaded as a slide show, or seen as a streaming video (bottom window, 40 minutes followed by Q&A), at http://tinyurl.com/zfvwbnh. A full list of relevant scientific references can be found at http://tinyurl.com/yx8m6vwu

TREE AND SHRUB SPECIES TABLE

with site requirements and uses

key	
native species	
native to Scotland but debatably to our region	
exotic conifers	Those in the body of the table are considered the most useful. A group that may be found in existing plantations or as ornamentals but which offer nothing that the main species do not offer are grouped at the end. They are not recommended for new planting.
exotic species though widely introduced into our region	
exotic species that have been used in extreme exposure with some success	Shelterbelt and hedging species for extremely exposed sites, both evergreens and deciduous, mostly salt tolerant.

Common alder *(Alnus glutinosa)*	NATIVE BROADLEAVED TREE, NITROGEN FIXING, COPPICE
soils	Tolerates a wide variety of soil types. Thrives in damp or wet conditions. Can cope with shallow peats but needs mineral beneath.
exposure	Very tolerant.
growth	Very fast, keeps leaves late for shelter, coppices well.
timber or uses	Featureless but strong. Used in mill wheels, lock gates, clogs, brush-backs, high quality charcoal.
Grey alder *(alnus incana)*	Both non-native trees, Nitrogen fixing, Coppice Fast to very fast growing, capable of growing on poor soils and in moderate exposure. All prefer drier soils than native alder. Both of interest as SRC/SRF species (refer Sections 4 & 5)
Red alder *(alnus rubra)*	
Crab apple (*Malus sylvestris)*	NATIVE BROADLEAVED TREE
soils	Tolerates a variety of mineral soils.
exposure	Requires some shelter to thrive but also plenty of light.
growth	Moderate rate, forming a small tree.
timber or uses	Edible fruit for wine and jellies
Ash *(Fraxinus excelsior)*	NATIVE BROADLEAVED TREE, COPPICE, DISEASE (Chalara) CONTROLLED MOVEMENT !
soils	Prefers neutral to basic soils and therefore thrives in limestone areas but will grow in almost any mineral soil.
exposure	Tolerant.
growth	Fast, especially in early years. Thin branching, late flushing and early leaf fall make it a relatively poor shelterbelt tree but can grow very tall. Coppices well.
timber or uses	One of the finest and strongest of all timbers, used for furniture, tool handles, sports equipment, veneer. The 'Queen of firewoods'- lower water content than any other wood, so can be burnt green.
Aspen *(Populus tremula)*	NATIVE BROADLEAVED TREE
soils	Tolerates a wide variety of soils including poor ones though prefers freely drained. Can cope with shallow peat if mineral not far below.
exposure	Very tolerant.
growth	Medium (not fast for a poplar). Tends to spread freely by suckering and usually remains a small tree.
timber or uses	Light but strong. Not used in Scotland but elsewhere for matches, fruit boxes, baskets. In the USA for windows and doors, OSB and pulp. Historically for arrow shafts and clogs (UK) and roof beams (Scandinavia).
Beech *(Fagus sylvatica)*	NON NATIVE BROADLEAVED TREE, can be invasive - do not underplant native woods with this species
soils	Requires neutral to basic and well-drained conditions.
exposure	Tolerant.
growth	Slow, though potentially a very large tree. Shade tolerant.
timber or uses	Very strong. The most commonly used hardwood, especially in furniture, tool handles, domestic ware, toys, flooring and also for pulp and firewood.

Douglas fir *(Pseudotsuga menziesii)*	NON NATIVE CONIFER TREE
soils	Requires well drained, fairly fertile and deep soil.
exposure	Not tolerant.
growth	On good sites fast, potentially very large tree. Shade tolerant.
timber or uses	HIGH VALUE TIMBER, heartwood reddish and well-grained. Naturally moderately durable and, when treated effectively, can be used in demanding exterior conditions. Used for construction, telegraph poles, particle boards, plywood and pulp. The very best is used in joinery work.
Downy birch *(Betula pubescens)*	NATIVE BROADLEAVED TREE, the birch for the west and north Highlands, Western Isles, Orkney and Shetland
soils	Tolerates a wide variety of soil types including poor and very damp ones. Can cope with shallow peat if mineral soil beneath.
exposure	Very tolerant.
growth	Medium to fast. Coppices quite well but declining in vigour relatively young.
timber or uses	Strong and versatile with a wide range of grain types. Because of poor form mostly used as firewood in the Highlands. Increasing use, though, in furniture, flooring, panelling, toys and utensils. Some burred and flecked timber sought after for craftwood. Sap is widely used for wine making.
Dwarf birch *(Betula nana)*	NATIVE BROADLEAVED MONTANE SHRUB
soils	Tolerant of poorest shallowest substrates.
exposure	Tolerant of extreme cold and wind.
growth	From prostrate to erect (0.3-1.0m).
Silver birch *(Betula pendula)*	NATIVE BROADLEAVED TREE, the birch for the east, central and southern Highlands.
soils	Tolerates a wide variety of soils but far less tolerant of wet than downy birch.
exposure	Tolerant but not as much as downy birch.
growth	Coppices quite well but declining in vigour relatively young.
timber or uses	Usually much superior to downy birch due to straightness of stem and greater size. All the same uses as downy birch but also high quality plywood (Scandinavia).
Blackthorn/sloe *(Prunus spinosa)*	NATIVE BROADLEAVED SHRUB
soils	Tolerates a range of mineral soils.
exposure	Tolerant.
growth	Medium rate, a very dense shrub ideal for shelterbelts. Suckers wildly! Beautiful spring blossom.
timber or uses	Walking sticks. Edible fruit used for flavouring drinks such as gin.
Broom *(Cytisus scoparius)*	NATIVE EVERGREEN SHRUB, NITROGEN FIXING
soils	Tolerates a wide range of mineral soils including poor and moderately acid ones. Fixes own nitrogen.
exposure	Moderately tolerant.
growth	Very fast, making a good thick bush when planted in clumps.
timber or uses	Flowers and buds in salads, wines and beers.
Sea buckthorn (*Hippophae rhamnoides)*	NATIVE BROADLEAVED SHRUB but probably not to the north and west
soils	Requires light, relatively dry mineral soils, thriving in sandy soils and open conditions often by the sea. Does not like peaty soils.
exposure	Very tolerant.
growth	Medium rate, a very dense shrub.
timber or uses	Juice extracted from berries for very high vitamin C content plus E, B1, B2 and K. It also has beneficial fatty acids, minerals and anti-oxidants.
Bird cherry *(Prunus padus)*	NATIVE BROADLEAVED TREE
soils	Tolerates a variety of mineral soils and thrives in moist conditions.
exposure	Requires some shelter to thrive.
growth	Medium rate and typically staying a smallish multiple stemmed tree. Fine blossom with fruit favoured by birds.
timber or uses	Same basic properties as gean (see below) but being generally smaller, it is less useful.

Wild cherry/gean *(Prunus avium)*	NATIVE BROADLEAVED TREE
soils	Tolerates a variety of mineral soils but thrives in slightly drier, better drained conditions than bird cherry.
exposure	Requires some shelter to thrive.
growth	Fast and grows to a bigger tree than bird cherry. Fine blossom with fruit favoured by birds.
timber or uses	Very attractive pinkish timber highly sought after for cabinet making, furniture, panelling and crafts.
Elder *(Sambucus nigra)*	NATIVE BROADLEAVED TREE
soils	Tolerates a range of mineral soils including poor and very shallow ones. Thrives in dry, light or stony soils.
exposure	Very tolerant.
growth	Medium-fast, a good shrub or small tree for shelterbelts.
timber or uses	Edible fruit and blossom used in wines and preserves
Wych elm *(Ulmus glabra)*	NATIVE BROADLEAVED TREE
soils	Requires a reasonable depth of mineral soil. A tree for better sites.
exposure	Moderately tolerant.
growth	Medium and potentially a large tree.
timber or uses	Rich, reddish brown heartwood, exceptionally resistant to splitting. Furniture, packing cases, shed cladding, chair seats, lock gates and harbour timbers. Immature seeds edible in salads.
Gorse/whin *(Ulex europaeus)*	NATIVE EVERGREEN SHRUB, NITROGEN FIXING
soils	Tolerates a very wide range of soils including the poorest. Can even grow on damp peat but thrives on better drained light soils. Fixes own nitrogen and therefore improves soil.
exposure	Very tolerant.
growth	Very fast, an excellent shrub for shelter and wildlife including bees and should be treated with high regard rather than burnt.
timber or uses	Flowers for wines and teas.
Guelder rose *(Viburnum opulus)*	NATIVE BROADLEAVED SHRUB (despite name, not a rose)
soils	Requires a reasonably fertile mineral soil.
exposure	Requires shelter to thrive but likes light and is good, therefore, at the sheltered edges of woods and beside tracks.
growth	Medium rate of growth turning into a bush with fine blossom and fruit favoured by birds.
timber or uses	Berries for edible jelly though can smell unpleasant so not often made!
Hawthorn *(Crataegus monogyna)*	NATIVE BROADLEAVED SHRUB
soils	Tolerates a variety of mineral soils including very shallow stony ones. Thrives in freely drained, light situations.
exposure	Very tolerant.
growth	Medium to slow but excellent as low part of a shelterbelt.
timber or uses	Highly valued craftwood. Edible fruit for jellies and wines. Historically eaten by Highlanders when fully ripe.
Hazel *(Corylus avellana)*	NATIVE BROADLEAVED TREE, COPPICE
soils	Tolerates a wide variety of mineral soils.
exposure	Tolerant.
growth	Slow-medium, shade tolerant – good as understorey. A small tree with good branching and suckering to give thick shelter. Coppices well.
timber or uses	Coppice stems traditionally for wide variety of country uses from pea-sticks to thatching spars, from barrel hoops to hurdles. Edible nuts

Holly *(Ilex aquifolium)*	NATIVE EVERGREEN TREE
soils	Tolerates a wide range of mineral soils including shallow and quite acid ones. Thrives on freely drained soils.
exposure	Very tolerant.
growth	Very slow, shade tolerant – good as understorey in shelterbelts being thick and bushy and evergreen. Berries favoured by birds.
timber or uses	Very hard. Highly valued craftwood.
Honeysuckle *(Lonicera periclymenum)*	NATIVE DECIDUOUS WOODY CLIMBER
soils	Wide range of types but free draining.
exposure	Moderately tolerant.
growth	Light demanding, climbs up any support including trees.
timber or uses	Important nectar source for butterflies, moths and bumblebees. The berries are eaten by many birds.
Juniper *(Juniperus communis)*	NATIVE EVERGREEN SHRUB, DISEASE WARNING ! CONSULT RECOMMENDATIONS
soils	Tolerates a range of soil types including poor ones. Can grow on peaty soils too but needs some mineral and free drainage to thrive.
exposure	Very tolerant.
growth	Very slow, making a bush of very variable form from prostrate to columnar.
timber or uses	Edible berries, used for flavouring meats and gin for instance.
European larch *(Larix decidua)*	NON NATIVE CONIFER TREE, DISEASE WARNING ! REGULATIONS APPLY
soils	Favours reasonably fertile, moist but freely drained sites. Not on peat.
exposure	Moderately tolerant.
growth	Medium rate. Light demanding.
timber or uses	HIGH VALUE TIMBER. Naturally durable, hard and strong timber but resistant to preservative treatment. Much used for fencing materials, exterior cladding, garden furniture, boat building etc.
Japanese larch *(Larix kaempferi)*	NON NATIVE CONIFER TREE, DISEASE WARNING ! REGULATIONS APPLY
Hybrid larch *(Larix x eurolepis)*	NON NATIVE CONIFER TREE, DISEASE WARNING ! REGULATIONS APPLY
Norway maple *(Acer platanoides)*	NON NATIVE BROADLEAVED TREE
soils	Requires a reasonably fertile, freely drained mineral soil.
exposure	Requires some shelter to establish.
growth	A smaller tree than its close relative the sycamore and survives more northerly latitudes. Moderate rate of growth.
timber or uses	As for sycamore but smaller lengths of straight timber.
Bog myrtle *(Myrica gale)*	NATIVE DECIDUOUS SHRUB, NITROGEN FIXING
soils	Acidic peat bogs and very wet hillsides.
exposure	Tolerant.
growth	Bushy to about 1m in Highlands.
timber or uses	Strongly scented, essential oils extracted for perfumes. Wards off midges by repute.
Sessile oak *(Quercus petraea)*	NATIVE BROADLEAVED TREE, COPPICE. The oak for west and north Highlands and Islands
soils	Requires a reasonable depth of mineral soil but quite tolerant of damp and relatively acid conditions.
exposure	Moderately tolerant.
growth	Medium rate of growth and shade tolerant. Coppices well.
timber or uses	HIGH VALUE TIMBER. Well figured, very hard and durable with wide range of uses particularly in buildings, boats and furniture. Traditionally for charcoal and the bark for tanning. Excellent firewood. Best logs for veneer (not made in Scotland).

Common oak *(Quercus robur)*	NATIVE BROADLEAVED TREE, COPPICE. More easterly and southerly though occurs mixed with sessile oak in Argyll for instance and also hybridizes with sessile oak
soils	Favours heavier types than sessile oak and requires good depth. All other features are much as for sessile oak.
exposure	Moderately tolerant.
growth	Medium rate of growth and shade tolerant. Coppices well.
timber or uses	HIGH VALUE TIMBER. As for sessile oak.
Scots pine *(Pinus sylvestris)*	NATIVE CONIFER TREE
soils	Tolerates a wide range of soil types and will grow on peat provided some mineral below. Tolerates damp conditions but thrives on dry, mineral soils.
exposure	Only moderately tolerant and not salt tolerant. Exposure tolerance often overestimated in planting schemes. Keep to leeward of knolls in exposed areas.
growth	Moderate rate. Light demanding.
timber or uses	A very fine and versatile wood, taking preservative very well hence wide range of uses from railway sleepers and telegraph poles to furniture and linings. A strong constructional timber. (Most 'redwood' from timber merchants is Scots pine).
Lodgepole pine *(Pinus contorta)*	NON NATIVE CONIFER TREE
soils	Tolerates the poorest soils including moist peat.
exposure	Very tolerant.
growth	Coastal provenances fast but of very poor form. Light demanding. Very widely planted for shelter.
timber or uses	Slightly inferior to Scots pine in strength and ability to take preservative. Due to poor form in Scotland most goes to pulp but potentially a useful sawnwood timber.
Poplar species *(Populus spp.)*	Black poplar *(Populus nigra).* Refer North Harris case study. Balsam poplar *(Populus balsamifera*) planted for its scent. The only poplar native to Scotland is aspen (see above).
Dog rose *(Rosa canina)*	NATIVE BROADLEAVED SHRUB
soils	Tolerates a range of mineral soils including shallow and poor ones. Thrives on dry sites.
exposure	Very tolerant.
growth	Fast, an excellent shrub for shelterbelts with fine blossom and fruit favoured by birds.
timber or uses	Rosehip syrup and wine. Very high in vitamin C.
Rowan *(Sorbus aucuparia)*	NATIVE BROADLEAVED TREE
soils	Very tolerant of poor, acid and shallow soils and wide range of wet and dry conditions. Thrives in drier sites though.
exposure	Very tolerant.
growth	Medium-fast rate of growth, usually a small tree.
timber or uses	Firewood and craft work. Edible berries – traditional in jellies, especially with apple.
Sitka spruce *(Picea sitchensis)*	NON NATIVE CONIFER TREE
soils	Tolerates the poorest soils including moist peats.
exposure	Very tolerant.
growth	Fast. Moderately light demanding.
timber or uses	Favoured for pulp due to long grain, low resin and high uniformity. Non-durable but Boron-treated timber is suitable for general building and construction work not in ground contact. Also used in boxes, crates, pallets, framing timber, etc. due to light weight and nailability.
Norway spruce *(Picea abies)*	NON NATIVE CONIFER TREE
soils	Requires moderate fertility and moist soils. Frequently fails in heather and seldom thrives in west. Not favoured therefore in our bioregion.
exposure	Not tolerant.
growth	Moderate rate. Moderately light demanding.
timber or uses	As for Sitka spruce but marginally stronger. Non-durable but takes Boron treatment. Used interchangeably with Sitka but favoured for transmission poles.

Sycamore *(Acer pseudoplatanus)*	NON NATIVE BROADLEAVED TREE, COPPICE, can be invasive - do not underplant native woods with this species
soils	Tolerates a wide range of mineral soils even poor and quite acid ones.
exposure	Very tolerant.
growth	Fast, making a very large tree.
timber or uses	One of the most widely used and HIGH VALUE TIMBER – hard and strong. Flooring, furniture and kitchen ware particularly. Figured timber very valuable for turnery, veneers and violin making.
Western hemlock *(Tsuga heterophylla)*	NON NATIVE CONIFER TREE
soils	Tolerates acid mineral soils and more fertile peats.
exposure	Not tolerant.
growth	Moderate requiring shade when transplanted.
timber or uses	Marginally stronger and heavier than spruce and difficult to treat with preservative. But useful for construction, pallets etc. Finishes well and resistant to nail splitting so used in joinery.
Common whitebeam (*Sorbus aria)*	NATIVE BROADLEAVED TREE but probably not to the north and west Highlands and Islands
soils	Favours more alkaline soils.
exposure	Fairly tolerant.
growth	Small tree to 15 m max.
timber or uses	Hard and white timber so used in turnery. Berries are edible.
Rock whitebeam (*Sorbus rupicola)*	NATIVE BROADLEAVED TREE - RARE
soils	Favours alkaline soils and cliffs.
exposure	Fairly tolerant.
growth	Shrub or small tree to 10m.
Arran whitebeam (*Sorbus arranensis & S. pseudofennica)*	NATIVE BROADLEAVED TREE - RARE
soils	Steep sided ravines.
exposure	Fairly tolerant.
growth	Only on Arran.
Swedish whitebeam *(Sorbus intermedia)*	NON NATIVE BROADLEAVED TREE
soils	Adaptable to poor, acidic, peaty and damp conditions.
exposure	Tolerant.
growth	Medium rate, never growing large. Beautiful foliage and red berries favoured by birds.
timber or uses	Firewood. Berries as for closely related rowan.
Eared willow *(Salix cinerea)*	NATIVE BROADLEAVED SHRUB
soils	Tolerates a wide range of mineral soils including poor and very wet ones. Can tolerate surface peat where some mineral below.
exposure	Very tolerant.
growth	Very fast, an excellent shrub for shelterbelts and on the very poorest sites.
timber or uses	Firewood/kindling.
Goat willow *(Salix caprea)*	NATIVE BROADLEAVED TREE, COPPICE
soils	As for grey willow but slightly more demanding.
exposure	Very tolerant but not quite as much as grey willow.
growth	Very fast and more often a single stemmed tree than grey willow. Coppices well.
timber or uses	Firewood (stoves only as it spits).

Grey willow *(Salix cinerea)*	NATIVE BROADLEAVED TREE, COPPICE
soils	Tolerates a wide variety of mineral soils and poor and wet conditions.
exposure	Very tolerant.
growth	Very fast. Coppices well. Dense branching habit makes it ideal for shelterbelts.
timber or uses	Firewood (stoves only as it spits).
Common osier *(Salix viminalis)*	NON NATIVE BROADLEAVED BUSH but very widely planted in the Highlands and Islands. COPPICE.
soils	Requires damp mineral soils, not too acid and does not like peat.
exposure	Tolerant.
growth	Very fast as with the other willows with which it hybridizes freely. Multiple stemmed, remains a shrub. Coppices well. Useful in shelterbelts.
timber or uses	Basketry, wickerwork and firewood.
Least willow (*S.herbacea*)	Prostrate, acid tolerant.
Tea-leaved willow (*S.phylicifolia*)	Small erect bush, acid tolerant.
Dark-leaved willow (*S.myrsinifolia*)	Tall shrub, acid tolerant.
Creeping willow (*S.repens*)	Procumbent to semi erect, acid tolerant.
Downy willow (*S. lapponum*)	Small erect bush, acid tolerant.
Whortle leaved willow (*S. myrsinites*)	RARE low growing and spreading, wide ranging soil pH.
Mountain willow (*S.arbuscula*)	Procumbent to semi-erect, lime loving.
Wooly willow (*S. lanata*)	RARE low growing to small bush, lime loving.
Net-leaved willow (*S.reticulata*)	Prostrate, lime loving.
Yew (Taxus baccata)	NATIVE EVERGREEN TREE
soils	Prefers alkaline soils such as on limestone.
exposure	Fairly resistant.
growth	Very slow: makes a very tight hedge if clipped.
timber or uses	Highly figured and very hard craft and furniture wood, used for longbows.
Austrian pine *(Pinus nigra var. nigra)*	NON NATIVE CONIFER TREE : many exotic pine species will grow in the Highlands and Islands and any of this group may be found in small groups in plantations of other species. The pines should not be planted at this time due to disease concerns (red band needle blight). The firs can make impressive trees on sheltered sites with moderate fertility but none show any outstanding advantages over the other exotic conifers in this table. Despite its straightness, the timber is neither particularly strong nor durable and therefore nowhere near the value of Douglas fir or larches. Western red cedar does have durable timber and has been successfully grown in plantations on good sheltered ground in Morayshire. Lawson cypress is probably best reserved for suburban hedges but can make a tall ornamental tree in the Highlands. (For full information on all these exotic conifers and more refer to Scott Wilson “Using alternative conifer species for productive forestry in Scotland).
Corsican pine *(Pinus nigra var. maritima)*	
Grand fir *(Abies grandis)*	
Noble fir *(Abies procera)*	
Silver fir *(Abies alba)*	
Western red Cedar *(Thuja plicata)*	
Lawson cypress *(Chamaecyparis lawsoniana)*	
New Zealand holly (*Olearia macrodonta)*	NON NATIVE SHRUBS (some EVERGREEN, some DECIDUOUS !) all these exotic species have been used in extreme exposure with some success but not all are equally hardy or salt tolerant. Hooker’s willow can even grow in a saline soil and is said to be especially exposure tolerant. NZ holly is widely used in coastal locations due also to its salt tolerance and heavy flowering habit.
Escallonia spp.	
Ramanas rose *(Rosa rugosa)*	
Sitka alder *(Alnus sinuata)*	
Alaskan felt leaf willow (*Salix alaxensis*)	
Hooker's willow *(Salix hookeriana)*	
Betula pubescens var. tortuosa (Icelandic prov.) downy birch	
Fuschia (whole genus of shrubs)	
Mountain pine *(Pinus mugo)*	

GLOSSARY AND ACRONYMS

coppice terms are in green

acidification : natural acidification can occur in temperate ecosystems but in this handbook the term is used to denote anthropogenic acidification caused by increasing atmospheric carbon dioxide, SO_2 and NO_x along with particulate matter deposited by precipitation. Consequent lowering of the pH of marine, freshwater and terrestrial ecosystems is significant and in general terms reduces nutrient availability with cascading effects on all life forms.

adventitious roots : arise from a plant organ other than from rooting tissue, usually from a stem or tuber. Occuring naturally in species like bramble when a stem will form new roots itself in contact with the ground, the characteristic can be exploited intentionally in the technique of layering.

agroforestry : land use systems that include elements of managed agricultural or horticultural production, integrated with tree or woodland management on the same unit at the same time.

allochthonous : any matter, but usually a source of nutrients, entering a water body from outside sources. In this handbook refers to tree and vegetational litter falling into freshwater bodies.

alluvium, alluvial : unconsolidated mix of silt, clay, sand and gravel moved by water and often deposited in flats alongside rivers and burns. Often relatively fertile compared with surrounding land and capable of supporting lush grassland or diverse and productive woodland.

anadromous : ascending rivers from the sea (primarily to breed in the case of salmon, sea trout, eel and sea lamprey in the UK). It is a critical transport mechanism for nutrients from marine to terrestrial ecosystems. Applied in this handbook to any other animal that transfers marine nutrients into the terrestrial environment eg otter, heron, osprey, gulls.

anthropocentric : placing humans at the centre of a viewpoint.

anthropogenic : of human origin or human induced – as in climate change, as of Scottish landscapes.

autochthonous : matter, usually plant matter or detritus that arises by growth or formation within the water body itself as opposed to falling in (see allochthonous)

basic (or alkaline) : as applied to soil or rock in this handbook, with a pH >7.

beating up : replacing dead trees in planting schemes – usually in 1-3 years.

biodiversity : can be defined at three levels – species diversity, eg. the number of species in a community; genetic diversity, variability within a species; ecosystem diversity, diversity of the health and complexes or functional diversity.

biological potential or productive potential : in this handbook used to denote optimum reproductive and growth conditions of ecosystems whether natural or managed : can be applied also to an individual species to denote potential reproductive or growth capacity under optimum conditions.

bioregion, bioregional : one way of dividing up the globe into similar environments – this handbook assumes the north and west Highlands and Islands as a particular 'Atlantic' bioregion distinct from the more continental interior and drier east coasts.

biostratigraphy : assigning the relative ages of rock, peat or other strata using biological material, usually fossils.

biotic or food web : a fundamental attribute of ecosystems is their organisation into multi-linked webs of species with multiple interdependencies between different forms of life (biota) from plants to animals.

BP : The number of years before present, conventionally taken as 1950 AD.

brown earth (brown forest soil) : a well aerated, well drained, well decomposed, brown soil type characteristic of developed broadleaved woodlands. Generally fertile and alkaline but will depend on parent material and the overlying vegetation.

butt log : the lowest or first log of a felled tree in relation to the ground.

CAD software : Computer-aided design software.

calcifuge : a plant that does not tolerate alkaline soil.

callus (callus buds) : in this handbook refers to thickened and hardened tissue around a cut stem in pruning or coppicing. Callus buds form around the rim of a coppice stool.

cant : a squared off length of timber that is usually intended to be re-sawn at a later date.

carbon management and carbon emissions, sequestration, fixation : Carbon dioxide emissions make up a part of all greenhouse gas (GHG) emissions. Carbon sequestration refers to the extraction of CO_2 from the atmosphere through photosynthesis by vegetation including trees. Carbon fixation refers to the conversion of CO_2 into carbon rich solids such as cellulose which make up most of timber. This can then be stored, for example in furniture and timber constructions, for as long as those items do not rot or combust. Carbon management refers to the total measures that a country (or individual) takes to mitigate increasing atmospheric carbon dioxide levels.

carr : (usually alder carr) a woodland usually predominately of alder on a floodplain experiencing occasional or frequent inundation. Often includes other species notably willows.

carrying capacity : the population (density or number) of a species that a given unit of land can support without damage to its biological or environmental attributes such as soil – damage being taken to mean causing of decline rather than simply change (see trend).

cation : an ion that has a positive charge (eg Mg_2+, Ca_2+, Al_3+).

CCF – continuous cover forestry : management systems for forest and woodland that minimise disruption of ecosystem function by felling only small groups (coupes) or single stems. 0.25ha has come to be accepted as a maximum felling coupe size in Scotland to qualify for this designation.

cell (container) grown stock : a method of growing plants including trees and shrubs in small cells of artificially created growing media. Such planting stock forms compact root plugs making planting easy.

clones, cloning : genetically identical individuals. In this handbook, clones refer to trees reproduced by taking cuttings. This is perfectly appropriate in growing willows for basket making or as energy crops but genetic diversity is in general desirable in trees and plants to reduce disease risk.

common grazings : land shared by a number of crofters in a township with shared responsibilities.

compartment : compartments are used as a way of organising tree plantations for the purposes of management.

conditioning (of timber) : positioning timber in its proposed place of final use to become acclimatised to the environmental conditions it will encounter in its use, eg timber for making furniture.

coppice and coppice crafts : coppicing is the intentional act of using the natural ability of any tree or shrub that grows back from its base or stump after cutting. In Scotland nearly all native broadleaves exhibit this basic ability and the regrowth of coppiced plants has been used over millennia.

coupe (felling coupe) : a defined area of plantation or woodland designated for felling or cutting in coppice management or other management operation.

cruck (frame) : in typical houses of the Highlands and Islands until the 20th century, pairs of curved timbers, often made from a single tree divided by a longitudinal cut, joined at the top to carry the weight of the roof directly to the ground (thereby taking the strain off the side walls).

culling targets : in this handbook referring to how many red deer to be shot annually as part of population management. Organised by district Deer Management Groups. Setting of cull targets and annual returns are mandatory under Section 8 of the Land Reform (Scotland) Act 2016.

cultural landscape : according to the World Heritage Committee, "the cultural properties [that] represent the combined works of nature and man", as is the case for most Scottish landscapes.

cutting cycle : the time between cuts (harvesting) in coppice management : the same as rotation length in silvicultural practice where trees are felled not expecting regrowth.

DAMS : Detailed Aspect Method of Scoring : DAMS data provide an indication of relative windiness (exposure) which has been applied to the whole of the UK using a digital terrain modelling technique.

DMG : Deer Management Groups comprise groups of landowners across the red deer range who are required to adopt and execute deer management plans for their different areas under Section 80 of the Land Reform (Scotland) Act 2016.

drumlin : a small hillock of glacial deposits, usually boulder clay, formed under relatively fast-flowing ice. A common glacial feature all over the Highlands and Islands. Usually occurs in large groups, with longer axis aligned in direction of ice flow. Often make excellent, well drained planting sites with shelter to leeward.

ecocline : is the gradient of any environmental factor exhibited within an ecotone, eg at the edge of a woodland the daylight intensity will gradually fall from the outermost edge to an inner point where the canopy can be said to be 'closed'.

ecological restoration : holistic regeneration of land, its soil, vegetation and animal complex. In this handbook this is taken to include the human economy, ie rural regeneration and land restoration.

ecosystem functionality and ecosystem dysfunction : when viewed from an anthropocentric viewpoint, ecosystems may be said to be functioning adequately when trends in numbers of different species (species diversity) and the populations of those species are relatively stable over decadal time frames. Nutrient cycles and fluxes should also be exhibiting stable or improving trends. When any of these conditions are not being met, dysfunctions tend to occur, the causes of which may lie outside the ecosystem in question. Disruption of salmon survival and migration outwith river systems is a case in point.

ecosystem services : an anthropocentric term to denote the environmental benefits that can be derived by humans from managing ecosystems soundly.

ecotone (see also ecocline and edge effect) : the transition zone between two ecosystems, communities or habitats. Often exhibits particularly rich species diversity as utilized not only by members of each community but often by a third group of specialists that exploit the boundary conditions. Woodland margin or loch shorelines are good examples.

edge effect : the enhancement of species that is apparent along the boundary or interfaces of different communities or habitats, ie in the ecotone.

EIA : Environmental Impact Assessment

enrichment : (typically of woodland but can be of any habitat type) – the addition of species to a semi-natural woodland or entirely artificial plantation in order to increase or diversify production as part of agroforestry or simply to try and restore components that are considered as depleted or even eliminated by anthropogenic factors.

epicormic (buds and shoots) : form from epicormic buds which usually lie dormant beneath the bark. Under certain conditions including damage or sudden exposure of a stem or trunk to light, they develop into active shoots. Coppicing depends on epicormic growth but is best when from buds at or just below ground level.

epiphyte : an organism that lives on the surface of a plant but not as a parasite. There are many lichens, mosses and algae that are epiphytes on trees in our wet bioregion.

ericoid, ericaceous : in this handbook, ericoid refers to low bushy heathland plants of the heather community such as, crowberry, bearberry and cowberry. Ericaceous means, more precisely, species of the family *ericaceae* the most abundant of which is *Erica cinerea*, bell heather.

ESC – Ecological Site Classification : the official scheme for classifying ecosystems down to highly detailed sub-divisions. Information about ESC and how to use it is available in the Forestry Commission's Research Information Note No 260 and Technical Paper No 20.

exoskeleton : external skeleton protecting an animal's body. Can be a shell. Sometimes moulted (sloughed or shed) when outgrown.

FCS – Forestry Commission Scotland : The Scottish Government Department responsible for forest and woodland policy in Scotland until April 2019, now called Scottish Forestry.

FE – Forest Enterprise : now Forest & Land Scotland, the executive agency of the SG responsible for the business side of forestry.

FHN – Forest Habitat Network : the functional connectivity of a landscape, often consisting of corridors of woodland that allow species to move around.

FISA : Forest Industry Safety Accord

flushes (flushing) : wet ground over which water flows without being confined to a definite channel. Frequent on hillsides over glacial deposits where issuing ground water may be sufficiently alkaline to support richer plant community than surrounding land.

forwarder : a machine (wheeled, tracked, driven or pedestrian lead) that transports felled trees out of the forest or woodland to a landing or to roadside where they can be loaded onto a lorry or milled on site.

FPG – Forest Policy Group : an independent think tank contributing to progressive thinking and innovation in forest and woodland policy especially in the realm of small and medium scale woodland management.

fungal webs : the filamentous webs formed by the hyphae of fungi – usually of many species – that occupy the litter and upper horizons of the soil especially under woodland.

gastropod : a large class of invertebrates within the Mollusca phylum including snails and slugs.

GHG – greenhouse gas : atmospheric gases giving rise to the greenhouse effect include water vapor, carbon dioxide, methane, nitrous oxide, ozone, chloro- and fluorohydrocarbons. They all absorb and emit radiant energy.

GIS : Geographic Information System mapping technology.

gley : a soil type saturated with groundwater for sufficient periods of the year to develop characteristics such as a blue grey colour and sulphurous smell. Conditions in the gleyed zone are generally anaerobic. Such soils have developed under heathland peat throughout the Highlands and Islands.

grazing pressure : refers to the cumulative grazing effect of all the herbivorous animals wild and domestic on any habitat from semi-natural woodland to managed pasture (see also carrying capacity).

Great Wood of Caledon : *silva caledonia* is the title said to have been bestowed by the Romans on the Highland forest but is used today to denote the mosaic of woodland dominated terrain that spread across the whole country reaching its peak extent and diversity between 5000 and 6000BP.

GYC – general yield class : an index of the potential productivity of even-aged stands of trees based on the maximum mean annual increment of cumulative timber volume achieved by a given tree species growing on a given site and managed according to a standard management prescription. It is measured in units of cubic metres per hectare per year (m^3 ha^{-1} yr^{-1}).

hag (peat hag) : a feature of active erosion in peatlands widespread in the Highlands and Islands. once started, exacerbated by animal rubbing, trampling and wallowing, wind and rain.

heartwood : the dead tissue in the central part of a tree trunk that becomes hard and usually darker in colour than the live tissue (sapwood). In some species it becomes naturally decay resistant but will not take preservative treatments.

home economy : home-grown produce or home-made commodities contribute directly to a household's food, welfare or other needs – in total the home economy

hut and hutting : hutting is a Scottish tradition of staying in small, simple accommodation (most often made of timber) for holidays or informal recreation. The concept is supported by changes to Building Regulations in 2017 giving exemption for huts under 30 sqm from Building Warrant.

iron pan : a hard compacted layer of oxidized iron most often formed in gleys and almost impossible for the roots of plants to penetrate, effectively sealing off any nutrients in lower soil horizons.

kerf : the width of the cut made by a saw blade which therefore determines the amount of wastage or milling efficiency.

land reform : an ongoing process in which the Land Reform (Scotland Acts) 2003 and 2016 and Community Empowerment Act (Scotland) 2015 have most recently created new conditions for, amongst other things, public access rights and community rights to buy land including that in public ownership.

LCA – Land Capability for Agriculture (in Scotland) : official agricultural (seven class) classification system used to rank land on the basis of its potential productivity and cropping flexibility. Determined in relation to soil, climate and relief constraints.

LISS – low(er) impact silvicultural systems : a suite of woodland and forest management regimes that include small coupe felling and shelterwood systems with the use of predominantly, but not exclusively, natural regeneration. The aim is the creation of a varied age class containing a range of species with understory and high biodiversity.

maiden (coppice term) : the uncut saplings in a coppice wood generally to be grown on into standards but may also be subsequently coppiced.

monoculture : any managed cropping system reliant on just one species over a significant area whether this be trees in a plantation or arable crops in a field.

montane (zones) and mountain woodland and scrub : in Scotland generally montane refers to all land above the natural treeline including the ecotone of shrubs and scrub woodland that merges into montane heath.

mor (humus) and mull humus : the topmost soil horizon composing mostly of plant litter and the organisms that exist by decomposing it. Broadleaves tend to form a relatively basic (alkaline) mull humus while conifers tend to

produce a mor (acidic) humus. Ericaceous shrubs also tend towards mor humus formation leading in turn to peat formation.

mounding (and inverted mounding) : the method of turning over a turf to create a planting position for trees and shrubs. The inverted turf can be laid on top of the ground (hinge mounding) or replaced into the hole from which it was dug (inverted mounding). Now done mostly by machine, it can be done manually with a spade.

muirburn : the controlled (or not) practice of burning heathland to reduce woody growth of shrub or coarse vegetation. In grouse management to create a mosaic of different aged ericaceous shrubs but in the north and west to provide a 'spring bite' of fresh grass for sheep and deer.

mycorrhiza (mycorrhizal association) : symbioses between fungus and the roots of plants playing a major part in plant nutrition. The fungus dramatically improves nutrient availability to the plant by the use of enzymes and in return the plant provides hydrocarbons to the fungus. Commonly divided into ectomycorrhizas and endomycorrhizas, the latter penetrating the cell wall of the plant roots.

native (native authenticity) : animals and plants taken to be naturally present at a given location at a given time (today unless stated otherwise). Can be contentious due to anthropogenic factors and presumed to be changing with climate change. Native woodland restoration sometimes aims at authenticity by reference to NVC.

natural regeneration : the process by which a woodland regenerates itself by natural seeding either within or beyond its existing boundaries.

NGO – Non-Governmental Organisation : typically refers to a charitable wildlife conservation or land-use campaigning or educational body in this handbook.

nitrogen fixer, fixation : whilst most plants procure nitrogen in the form of nitrogenous compounds from the soil through their roots, there are species of trees, shrubs and legumes that procure ('fix') gaseous N_2 from the atmosphere either above or below ground. They do this by symbioses with a range of bacteria typically inside visible nodules on the roots.

NNR – National Nature Reserve : Government designated sites for nature conservation. 43 in Scotland covering less than 1.5% of land area.

NSA : National Scenic Area

NTFP – non timber forest products : also non wood forest products and wild forest products : the wide range of produce that can be harvested from woodlands other than logs for timber.

nurse (species or crop) : in woodland establishment, faster growing pioneer tree species with less demanding site requirements are sometimes used to help along (to nurse) more demanding species by providing early shelter, shade and or nutrients (eg due to nitrogen fixing ability).

nutrient cycles and cycling : the fundamental ecosystem process of continual recycling of both organic and inorganic components. The carbon cycle, sulphur cycle, nitrogen cycle, water cycle, phosphorus cycle, oxygen cycle, among others contribute to whole ecosystem nutrition and function.

NVC – national vegetation classification : the official system of classifying all natural habitat types in the UK according to their plant species. It describes 18 main native woodland types plus seven scrubs or underscrubs, most of which are divided further to give a total of 73 sub-communities (see table section 2)

oligotrophy, oligotrophic : an ecosystem state of few nutrients often leading to relatively few species. Whilst this state can be a natural consequence of poor rock type, low pH or low temperature, large parts of upland Scotland are in a state of anthropogenic oligotrophy, the root cause of which is deforestation.

origin : for tree and shrub species, defined by 'The Forest Reproductive Material Regulations' (1977) as the geographic locality within the natural range of a species where the parent seed source or their wild ancestors originally grew.

orogenesis : mountain building, (orogenies – mountain building events).

palaeobotany : study and identification of plant remains including fossils helping to reconstruct knowledge of past environments.

palynology : the study of pollen and other spores usually extracted from peats or sediments by core sampling. In combination with radiocarbon dating gives a dated chronological sequence of past vegetation within local area.

PAR : planed all round, as in timber that is planed on all sides. (dressed is another word for planed).

PAWS – plantations on ancient woodland sites : native woodland cleared for establishment of commercial plantation or underplanted with commercial species. These are now a focus for restoration to native woodland, as they often retain some native seed sources.

peak forest : denotes the period of maximum forest extent in the Highlands and islands between 5000-6000 BP depending on location but note that decline was possibly earlier on Orkney and Shetland.

pioneer species : in this handbook refers to tree and shrub species particularly evolved to colonise bare or disturbed land due, in most cases, to an ability to fix atmospheric nitrogen as opposed to having to extract it from the rooting substrate. Alders, gorse and broom are the main nitrogen fixing pioneers in the Highlands and Islands.

plagio-climax : arrested development of an ecosystem (arrested succession) generally caused by anthropogenic factors such as tree clearance, cultivation or drainage. Much heathland in the Highlands and Islands is a plagio-climax.

podsol, podzol, podsolisation : soil process prevalent under mor forming conifers and ericaceous heaths whereby iron and aluminium are leached from the A Horizon, to the B Horizon along with many bases such as Calcium and Potassium which are critical plant nutrients.

provenance : refers to the location that seed or cuttings (of trees and shrubs) are taken from for propagation or growing on in the nursery. Thus it would be possible to grow Scots pine of Wester Ross provenance that is in fact of German origin if seed was collected from trees planted in estate grounds for instance.

RAMSAR sites : wetland sites deemed to be of international importance.

rankers : a group of acidic soil types characterised by very abundant angular stones, often in hilly terrain over eroded non-calcareous rock close to the surface and outcropping. They generally lack a subsoil.

RDF – rural development forestry : international term for eco-political process in which woodland and forest based land use systems are used to form the backbone of sustainable economic development and employment.

reforestation : in this handbook taken to mean re-establishment of a woodland economy and woodland based land use systems on anthropogenically deforested lands.

re-inhabitation and re-population : the gradual process of re-establishing human communities in regions formerly more populated. It requires the synchronous re-development of sustainable land use and employment, carbon neutral utilities and services.

resilience (of human culture and environments) : a developed or learned ability of ecosystems and human culture or populations to survive, if not thrive, in challenging environmental or political conditions. Currently used in relation to climate change, global loss of biodiversity and spread of diseases as much as to corporate power and deregulation of market economies.

restructuring (plantations or woodland) : silvicultural process of converting species-poor plantations and woodlands towards more productive ones with a diversity of age classes and species that will provide more products and human benefits.

riparian : associated closely with the edges of freshwater bodies, lochs, burns, water courses of all sizes.

rotation length : the length of time between forest harvests whether of logs or coppice wood.

SAC : Special Areas of Conservation (also formerly Scottish Agricultural Colleges, now SRUC).

sapwood : the softer living tissues between the bark and the heartwood of a tree trunk. Very little natural resistance to decay, it does however tend to take pressure treatments of preservative relatively well. Ideally it is separated from the heartwood boards or cants in saw milling and used for internal applications or fuelwood.

sawlog : the logs cut from felled trees that are of sufficient size and quality to be milled into timber as opposed to processed to firewood, chipped or pulped.

scarify, scarification : in this handbook refers to the scratching, tearing or roughing up of the vegetation, humus and or top few cms. of soil to assist natural regeneration of tree and shrub seed. It exposes an amount of bare soil whilst maintaining the protection of the torn vegetation and can produce ideal conditions for germination of light seeds such as birch and alder that would otherwise be held off the ground and die of desiccation.

Scottish Forestry (SF) : the Scottish Government Department that replaced FCS and is now responsible for forest policy and administration in Scotland. Confusingly, Scottish Forestry is also the name of the journal of the Royal Scottish Forestry Society.

screef, screefing : removal of surface vegetation to create a short-term, relatively competition free space for planting of a tree or shrub. Can be done with a mattock, spade, mechanically or with spot herbicide application.

secondary timber processing : after milling and air drying, secondary processing can comprise any of re-sawing to size, kiln drying, planing, sanding and finishing of timber.

seed load or rain : refers to the amount of tree, shrub or other plant seed transported through the air by natural currents. In the case of trees, relates to the amount of local woodland cover and also the way it is distributed. In a woodland mosaic of the type promoted in this handbook, the seed load would be sufficient to ensure natural regeneration of woodland was a frequent occurrence wherever ground conditions were either naturally suitable or made suitable by human intervention.

semi-natural (woodland or habitat) : an imprecise or problematic term used in this handbook to signify habitats relatively unaltered by human management. That is relative to the majority that are significantly altered by human management.

SG – Scottish Government : the executive government of the Scottish Parliament established in 1999 and based at Holyrood, Edinburgh.

shelterwood : one of four main silvicultural systems considered under continuous cover forestry (CCF). It is an even-aged system involving clearfell, but where the successor stand of trees is secured by natural regeneration.

shifting baseline syndrome : first elucidated and named by a fisheries scientist in relation to a globally observed characteristic whereby each succeeding human generation accepts the current (declining) catch levels as they find it, in denial, to varying extents, of previous accounts. The term now has wide application to the way that environmental states (however degraded) tend to be accepted as norms with great rapidity.

silviculture, silvicultural : the science of tree and woodland cultivation and care with a focus on techniques and systems of management that optimise form to achieve specified ends.

sned, snedded : to remove the side branches from a tree once felled, prior to transport or processing.

SNH – Scottish Natural Heritage : is the Scottish Government's agency responsible for the country's natural heritage, especially its natural, genetic and scenic diversity.

SPA – Special Protection Area : strictly protected sites classified in accordance with Article 4 of the EC Birds Directive.

spalting, spalted : timber with usually darker flecks and lines (zone lines) caused by a range of fungi operating in both living and dead wood. Common in birch, beech and maple, adding considerable decorative value.

SPHN – Statutory Plant Health Notices : consult latest FCS information online. Currently such notices relate to larch and *Phytophera ramorum* ; ash and *Chalara fraxinea* ; juniper and *Phytophthora austrocedri*.

SRC – short rotation coppice : industrial version of coppice management developed mostly to feed power stations involving intensive management, planting and harvesting with specialized machinery and the use of fertilizers.

SRDP : Scottish Rural Development Programme

SRF – short rotation forestry : growing single-stemmed, fast growing tree species over short rotations (typically between 10 and 20 years), using conventional forest establishment and harvesting techniques, to produce fuel wood. This could be destined for domestic market as split logs or industrial energy markets as chips or pellets.

SSSI – Site of Special Scientific Interest : a statutory designation made by Scottish Natural Heritage under the Nature Conservation (Scotland) Act 2004. Scotland has 1,423 SSSIs, covering just over 1,011,000 hectares or 12.7% of Scotland's land area.

standard : an individual tree (typically an uncut maiden) left to grow on to maturity within a coppice. 'Coppice with standards' is a typical system in parts of England but less appropriate in Scotland due to higher exposure.

stool : the stump or base of a tree already coppiced at least once.

stored coppice : trees in a coppice wood that have been left longer than their usual rotation length perhaps awaiting better market conditions for cutting.

stratification (of seeds) : the process of breaking dormancy of seeds either naturally or artificially. Many tree and shrub seeds require some rotting of outer cuticle followed by alternating period(s) of hot and cold which can be artificially accelerated in controlled nursery environments.

succession, successional : the natural development of vegetation, typically from bare ground after glaciation or other disturbance, through phases of herb or heath dominated communities towards woodland dominated habitat mosaics.

symbiosis, symbiotic, symbionts : mutually beneficial inter-dependency of two or more species. eg. bacteria and tree in nitrogen fixing tree species.

thermophilic : warmth loving. More thermophilic species may expand into Scotland (or become more appropriate to plant) as average temperatures increase.

thinning : the silvicultural practice of removing stems from a tree plantation in an organised manner at intervals to improve the growth and or form of the remaining stems.

timberline : the supposed altitudinal limit of commercial timber production in a given location.

treeline : the treeline forms a transitional zone or ecotone rather than a definite boundary where woodland merges into montane scrub woodland or montane shrub. In Scotland it may be recognised as a band where trees no longer grow more than 2 m high. This may lie at sea level in the most exposed locations.

trend : a critical parameter for assessment of ecosystem health. Used in Scotland rather sparingly for reporting the condition of SSSIs as 'favourable', 'recovering' or 'unfavourable'. The declining trends in terms of acidification of land and freshwater, loss of biodiversity and declining nutrient status in our bioregion is arguably under researched and under reported.

trophic cascade : food webs and chains operating in all ecosystems mean that changes within any one component or group of organisms have a tendency to cause adjustments in other communities or populations both up and down trophic levels. Removal of woodland leading down through the food web to decline in freshwater fish populations is an example of a major Scottish trophic cascade.

tushing : a horse logging term for forwarding logs out of woodland by skidding with chains behind the horse.

understorey (understory) : the lower level or levels of shrubby vegetation under the tree canopy in a developed woodland with natural regeneration and in balance with grazing and browsing herbivores.

UKFS – UK Forestry Standard : the reference standard for sustainable forest management in the UK, defining standards and requirements, and providing a basis for regulation and monitoring.

uplands : In Scotland generally defined as the land above the level of agricultural enclosure, which is typically 300-400m above sea level (ASL) but in our bioregion can extend as low as sea level.

Victorian holocaust : a term given to the indiscriminate and ecosystem changing massacre of wildlife particularly at the hands of the Victorian and Edwardian landed gentry in the Highlands and Islands.

wattle, wattling : interwoven mesh of twigs or cut branches : in our region whole house walls were constructed of wattle made from coppiced stems of hazel, willows and birches. These were known as creel houses.

woodland mosaic or woodland matrix : the natural distribution of habitat types through much of the Highlands and Islands ; heath, bog, grassland, machair, mountain – scattered through a matrix of woodland of greatly varying density and abundance sometimes forming closed canopy woods but in more exposed locations only of pockets favoured by natural fertility or shelter.

WWOOF : World Wide Opportunities on Organic Farms. Volunteers sign up to work for hosts for agreed lengths of time from a weekend upwards. The host accommodates and feeds but does not pay them.

SELECTED REFERENCES
and bibliography

SECTION 1 – woodlands for the future

Armstrong H, Holl K, Halley D. (2014), *Restoring the Scottish Uplands*: in Agriculture and the environment – Delivering multiple benefits from our land: sustainable development in practice, Proc. SRUC and SEPA Bienn. Conf.

Broadmeadow M, Mathews R. (2003), *Forests, carbon and climate change : the UK contribution*, Forestry Commission Info Note.

Hunter J. (1995, 2014), *On the other side of sorrow – nature and people in the Scottish Highlands.* Birlinn ISBN 978 1 78027 187 3

Williams M. (2006), *Deforesting the Earth – from prehistory to global crisis – an abridgement*, Uni of Chicago press, ISBN : 0 226 89947 0

SECTION 2 – woodland establishment

See also further reading (below) for references to books by T.C Smout and Scott Wilson

Alexander K, Butler J, Green T. (2006), *The value of different tree and shrub species to wildlife*, British wildlife

Gilbert D, Horsfield D, Thompson D. (Eds) (1997), *The ecology and restoration of montane and subalpine scrub habitats in Scotland*, Scottish Natural Heritage Review No.83

Grant A, Worrell R. (2012), *Achieving diversity in Scotland's forest landscapes*, Forestry Commission Scotland, Practice Guide

Hall J, Kirby K, Whitbread A. (2004), *National Vegetation Classification: Field guide to woodland*, Joint Nature Conservation Committee

Hubert J. et al (2010), *Broadleaved tree breeding in Scotland; recent progress and future priorities*, Scottish Forestry. 64, No.3

Lee S. (2017), *Choice of silver birch planting stock for productive woodlands*, Forestry Commission, Research note

Morgan S, Ireland D. (2004), *Excavator mounding on restocking sites*: Forestry Commission, Technical note.

Morison J, et al (2010), *Understanding the GHG implications of forestry on peat soils in Scotland*, Forest Research.

National Vegetation Classification, https://gateway.snh.gov.uk/natural-spaces/dataset.jsp?dsid=NVC

Orkney Woodland Projects, *A woodland design guide : selecting trees for woodland projects in Orkney.* http://www.orkneylibrary.org.uk/OBRC/assets/woodland_design_guide.pdf

Patterson G, Nelson D, Robertson P, Tullis J. (2014), *Scotland's native woodlands – results from the native woodland survey of Scotland*, Forestry Commission Scotland.

Pyatt G, Ray D, Fletcher J. (2001), *An Ecological Site Classification for forestry in Great Britain*, Forestry Commission Bulletin 124

Rodwell J. Patterson G. (1994), *Creating new native woodlands*, Forestry Commission Archive Bulletin 112

Shetland Amenity Trust, *Selecting sites and trees for woodland in Shetland*. https://www.shetlandamenity.org/assets/files/Woodlands/InformationFinal1A.pdf

The Scottish Government (2011), *Getting the best from our Land – The Scottish Government's Land Use Strategy* : https://www.gov.scot/publications/getting-best-land-land-use-strategy-scotland/

Thompson R.(2003), *Restoration of Native Woodland on Ancient Woodland Sites*, FC Practice Guide

Wilson S. McG. (2006), *The European Beech (Fagus sylvatica L.) in Scotland: history, distribution and ecological potential*, Scot For 60 No.4

Wilson S. McG. (2011), *Using alternative conifers for productive forestry in Scotland*: Forestry Commission Scotland

SECTION 3 – woodland management and harvesting

Cameron, A. (1996), *Managing birch woodlands for the production of quality timber.* Forestry 69 (4)

Forest Research (2015), *Small and mini harvesting & extraction machinery : a guide to their selection for safety*, Forest Research TDJR131

Forestry Commission, *Managing Continuous Cover Forests* – Forestry Commission operational guidance booklet No.7

Hart C. (1995), *Alternative silvicultural systems to clear cutting in Britain*: a review, Forestry Commission.

Kerr G, Haufe J. (2011), *Thinning Practice – a silvicultural guide*, Forestry Commission

Mason B, Kerr G, Simpson J. (1999), *What is Continuous Cover Forestry?* Forestry Commission Info note

Mason B, Kerr G. (2004), *Transforming even-aged conifer stands to continuous cover management*, Forestry Commission Scotland Information note.

Price A, Macdonald E. (2012), *Growing birch in Scotland for higher quality timber,* Forest Research.

Simpson C, Jacyna S. (2007), *Pruning to improve timber quality*: Scottish Agricultural College, Technical note 594.

Stokes V, Kerr G. (2009), *The evidence supporting the use of CCF in adapting Scotland's forests to the risks of climate change*, Forest Research

Wilson S. McG. (2011), *Approaches to the retention of timber pPotential when restoring or enhancing PAWS sites*, Forestry Commission Technical report

Worrell, R. (1999), *The birch woodland management handbook*. Highland Birchwoods, Munlochy, Scotland.

SECTION 4 – coppice woods

Coppins A. & Coppins B. (2010), *Atlantic hazel*. Scottish Natural Heritage

Harmer R, Howe J. (2003), *The silviculture and management of coppice woodlands*, Forestry Commission ISBN 0 85538 591

Harmer R. (2004), *Restoration of neglected hazel coppice:* Forestry Commission, Info note

SECTION 5 – woodlands for energy

McEvoy C. (2015), *Short Rotation Forestry trials in Scotland – progress report*, Forest Research

Krajnc N. (2015), *Wood fuels handbook*, FAO

SECTION 6 – grazing animals and woodlands

Albon, S.D., McLeod, J., Potts, J., Brewer, M., Irvine, J., Towers, M., Elston, D., Fraser, D. & Irvine, R.J. (2017), *Estimating national trends and regional differences in red deer density on open-hill ground in Scotland: identifying the causes of change and consequences for upland habitats.* Scottish Natural Heritage Commissioned Report No. 981.

Clarke R. (2014), *Two hundred years of farming in Sutherland, The story of my family,* The Islands Book Trust, 2014. ISBN 978-1-907443-60-2.

Forest Policy Group (2013), *Getting deer numbers under control – a proposal for a new licensing system in Scotland*, website http://www.forestpolicygroup.org/wp-content/uploads/2014/08/Getting-deer-numbers-under-control.pdf

Gill R. (2000), *The impact of deer on woodland biodiversity*, Forestry Commission, Info note

Putman R, et al (2011), *Identifying threshold densities for wild deer in the UK above which negative impacts may occur*, Mammal Rev.

Quelch P. (2005), *The Sunart Oakwoods: a guide to their sustainable management*, Highland Birchwoods

Sibbald A. (2006), *Silvo-pastural (sic) agroforestry: a land use for the future*, Scottish Forestry Vol.60 No.1

Stiven R, Holl K. (2004), *Wood pasture*, Scottish Natural Heritage

SECTION 7 – woodlands and freshwater

Archer, N, et al. (2015), *Rainfall infiltration and soil hydrological characteristics below ancient forest, planted forest and grassland in a temperate northern climate*, Ecohydrology 10.1002

Hilderbrand G, et al. (2004), *Importance of salmon to wildlife: implications for integrated management*, Ursus 15(1)

Parrott J, Holbrook J. (2006), *Natural heritage trends: riparian woodlands in Scotland*. Scottish Natural Heritage

Parrott J, Mackenzie N. (2000), *Restoring and managing riparian woodlands*. Scottish Native Woods

Tree Planters Guide to the Galaxy issue no. 1 (1989), *The Loch Garry Tree Group*

SECTION 8 – agro-forestry and non timber forest products

Bishop R, Church M, Rowley-Conwy P. (2015), *Firewood, food and human niche construction: the potential role of Mesolithic hunter-gatherers in actively structuring Scotland's woodlands*, Quaternary Science Reviews 108

Emery M, Martin S, Dyke A. (2006), *Wild harvests from Scottish woodlands: social, cultural and economic values of contemporary non-timber forest products*, Forestry Commission

FCS (2019), *The Scottish Government's Policy on Non-timber Forest Products*, Forestry Commission Scotland

Griggs H. (2007), Fraochan *"That which grows amongst the heather"*, BSc. dissertation, Napier Uni.

Saunders M et al. (2016), *Can silvo-pastoral agroforestry systems contribute to Scotland's emission reduction targets?*, James Hutton Institute

Sinclair F. (2001), *Project Blaeberry*, Millennium Forest for Scotland Trust

Whitfield P. (2003), *Practical experiments with agroforestry in Moray Forest District – progress report April 2003*, Forestry Commission Scotland

SECTION 9 – shelterbelts and hedges

Gardiner B, Palmer H, Hislop M. (2006), *The principles of using woods for shelter*, Forestry Commission Info Note

SECTION 10 – home-grown timber – markets and uses

Davies I. and Wood J. (2010), *External timber cladding : design, installation and performance*, Arcamedia

SECTION 12 woodland ecology

Birks H. (1972), *Studies in the vegetational history of Scotland. III. A radiocarbon-dated pollen diagram from Loch Maree, Ross and Cromarty*, The New Phytologist Vol. 71, No. 4

Blake J. (1966), *Trees in a treeless island* : Scottish Forestry. 20/1

Graveland L, Drent R. (1997), *Calcium availability limits breeding success of passerines on poor soils*, Journal of Animal Ecology 66

Lang F, et al. (2016), *Phosphorus in forest ecosystems: new insights from an ecosystem nutrition perspective*, J. Plant Nutr. Soil Sci.

Merryweather J. *Mycorrhiza – a brief introduction*, Blue-Skye Publications website http://www.slef.org.uk/merrys weathers-mycorrhiza-page.asp

Miles J, in Jenkins D. (ed) (1986), *What are the effects of trees on soils?* : Trees and wildlife in the Scottish Uplands NERC/ITE, (ITE Symposium,17)

Pace M, Cole J, Carpenter S, Kitchell J. (1999), *Trophic cascades revealed in diverse ecosystems*, Trends Ecol.Evol. vol.14 no.12

Pinnegar J, Engelhard G. (2008), *The 'Shifting Baseline' Phenomenon: a global perspective*, Rev.Fish.Biol. Fisheries 18

Plassard C, Dell B. (2010), *Phosphorus nutrition of mycorrhizal Trees*, Tree Physiology 30

Moar N. (1969), *A Radio-carbon dated pollen diagram from north-west Scotland*: New Phytol 68

Moir A, et al. (2010), *Dendrochronological evidence for a lower water-table on peatland around 3200-3000 BC from subfossil pine in Northern Scotland,* The Holocene 1-12

Schaberg P, Miller E, Eager C. (2010) , *Assessing the threat that anthropogenic calcium depletion poses to forest health and productivity, Advances in threat assessment and their application to forest and rangeland management*, USDA, Ed J.Pye

Tipping R. (1993), *The History of the Scottish Forests revisited Parts 1 and 2*, Reforesting Scotland Journal Nos. 8 and 9

Vera F, (2010), *The Shifting Baseline Syndrome in Restoration Ecology*, in Restoration and History – the search for a usable environmental past, Edited Marcus Hall.

Wilson B, Campbell A. (1996), *An assessment of the effects of native woodland expansion on soils in the Highlands of Scotland*, Scottish Forestry Vol 50, No.4

FURTHER READING

Sections 2, 3 and 6 draw on the following three authoritative books which cover native woodland history from pre-history to the present day.

Smout T, MacDonald A, Watson F. (2005,2007), *A history of the native woodlands of Scotland 1500-1920*, Edin. Uni Press ISBN 978 0 7486 3294 7

Smout T, Ed. (2003,2005), *People and woods in Scotland*, Edin. Uni Press ISBN 0 7486 1701 9

Wilson S. McG, (2015), *The native woodlands of Scotland – Ecology, conservation and management*, Edin. Uni Press ISBN 978 0 7486 9284 2

MOORCO experiment, set up by John Miles, James Hutton Institute, see: https://www.hutton.ac.uk/research/groups/ecological%20sciences/research%20facilities/moorco/publications

Reforesting Scotland Journal https://www.reforestingscotland.org/publications/journal/ covering all aspects of social and environmental forestry and reforestation.

The Scrubbers Bulletin: www.msag.org.uk for all aspects of mountain woodlands.

https://mycorrhizas.info for detailed info on all aspects of mycorrhiza

Wohlleben P, (2016), *The Hidden Life of Trees*, Greystone Books Ltd, ISBN 978-1-77164-248-4

Croft Woodlands Project 2019

ISBN 978-1-5272-4061-2