EFI Atlantic/ IEFC
Edinburgh, May 2017

The role of alternative tree species in Scottish forestry

Dr. Scott McG. Wilson ***MICFor, MRICS***

Chartered Forester and Chartered Surveyor

Aberdeen, Scotland, UK

Topics covered in presentation

- Definition of alternative tree species.
- History of deployment and silviculture.
- Current status within Scotland's forests.
- Drivers for species diversification.
- Options for future deployment.
- Implications for silviculture and utilisation.
- Research requirements.

OVERVIEW

The Scottish forest resource - overview

- Total forest area in Scotland is ~1,450 kha.
- 33% state-owned (FC), 66% private woods.
- 75% is coniferous, 25% is broadleaved.
- Most of coniferous area is managed for timber, excepting native pinewood reserves.
- Most of broadleaved area is reserved for nature conservation and amenity, with much not managed for timber (recently woodfuel).

HISTORICAL DEVELOPMENT

Potted history of Scotland's tree species

- Prior to AD 1500, predominantly native tree species were used within Scotland (with occasional monastic walnut orchards etc.)
- From AD 1500 to 1800 we added English + European species (beech, lime, sycamore, chestnut, Norway spruce, larch, silver fir).
- From AD 1800 to 1940 we added numerous west American and east Asian tree species.

Potted history of Scotland's tree species

- From 1920 to ~1970, we tried out a wide range of PNW, European and East Asian conifers in first rotation plantation forests
- From 1970 to 2010 we narrowed down the range of conifers used to SS, SP, LP, JL, DF
- From 1990 to 2010 we concentrated on restoration of native species woodlands.
- From 2010 on – resilience through diversity

CATEGORISING SPECIES

Scotland's native tree species (pre 1500)

Conifers

Pinus sylvestris

Taxus baccata?

Juniperus communis

Hardwoods

Quercus petraea

Quercus robur?

Fraxinus excelsior

Ulmus glabra

Betula pendula

Prunus avium?

Betula pubescens

Alnus glutinosa

Populus tremula

Scotland's native tree species (pre 1500)

Conifers

Hardwoods

Corylus avellana
Prunus padus
Salix spp.
Prunus spinosa
Crataegus monog.

Scotland's introduced species (pre 1800)

Conifers

Picea abies
Larix decidua
Abies alba
Pinus nigra

Specimens of:-
Pinus spp (various)
Cedrus atlan/ liban
Cupressus semper.

Hardwoods

Fagus sylvatica
Acer pseudoplatan.
Juglans regia
Tilia cordata
Tilia x europaea
Carpinus betulus
Acer campestre
Castanea sativa
Aesculus hippo.

Scotland's introduced species (pre 1800)

Conifers

Hardwoods

Platanus x hispanica
Acer platanoides

Specimens of:-

Numerous Asian, East American and European hardwood species in collection.

Scotland's introduced species (post 1800)

Conifers

Picea sitchensis
Pinus contorta
Larix kaempferi
Pseudotsuga menz.
Tsuga heterophylla
Thuja plicata
Abies grandis
Abies procera

Hardwoods

Eucalyptus spp
Nothofagus spp

Specimens of:-

Numerous Asian, East American and European hardwood species in collection.

Scotland's introduced species (post 1800)

Conifers

Picea omorika

Sequoia semper.

Chamaecyp. laws.

Cryptomeria japon.

Abies amabilis

Pinus peuce

Pinus mugo

Araucaria aur.

Hardwoods

Scotland's conventional timber species

Conifers

Pinus sylvestris

Picea sitchensis

—— = major disease effects

~~*Pinus contorta*~~

~~*Pinus nigra*~~

~~*Larix kaempferi*~~

~~*Larix decidua*~~

~~*Larix x marschlinsii*~~

Hardwoods

Quercus petraea

Quercus robur

Acer pseudoplat.

Fagus sylvatica

Betula pendula

Prunus avium

—— = major disease effects

~~*Fraxinus excelsior*~~

~~*Ulmus glabra*~~

Scotland's alternative timber species

Conifers

Picea abies

Pseodotsuga menz.

Tsuga heterophylla

Thuja plicata

Abies grandis

Abies procera

Abies alba

Sequoia semper.

~~*Chamaecyp. laws.*~~

Hardwoods

Acer platanoides

Castanea sativa

Tilia cordata

Carpinus betulus

Juglans regia

Populus tremula

risk of *Phytophthora lateralis*

Scotland's alternative timber species

Conifers

Picea omorika

Picea orientalis

Abies amabilis

Cryptomeria japon.

Cupressocyp x leyl.

Pinus peuce

Hardwoods

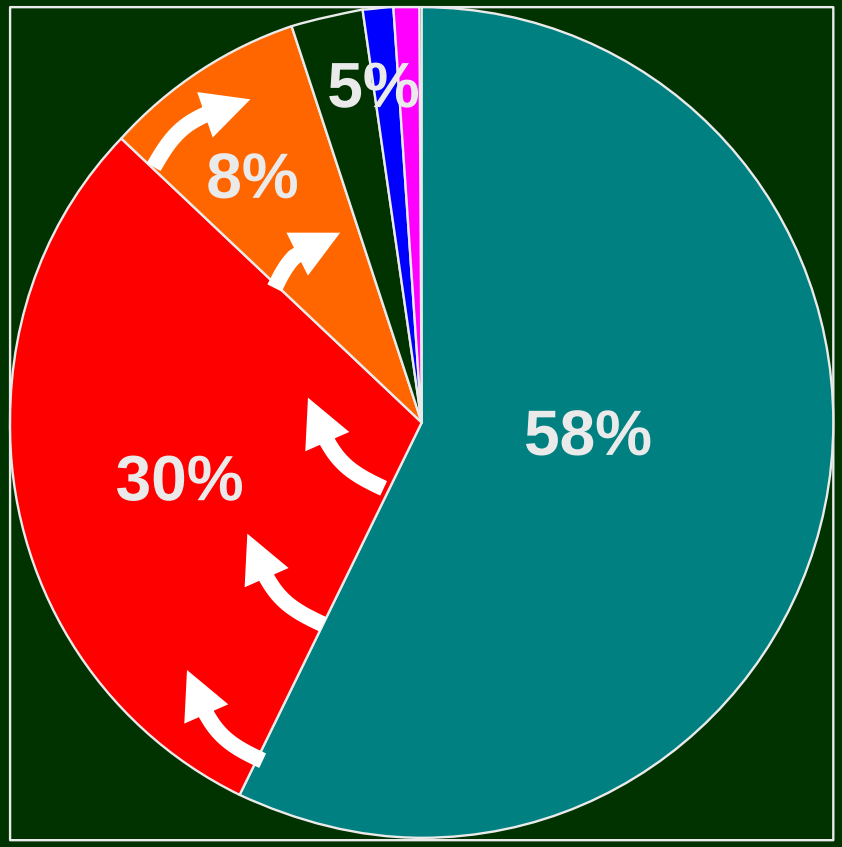
Past deployment of alternative conifers

- Policy plantings around country houses (individual specimens, avenues, groves).
- Inclusion in arboretum collections (with individual specimens or small groups).
- Inclusion in plot-scale “forest gardens”.
- Inclusion in scientific species trial series.
- Use on a small to intermediate scale within plantation forests (mainly ~1880-1970)


ARGYLL FOREST PARK
Kilmun Arboretum
RECOMMENDED WALKS
All of the recommended walks require a moderate degree of fitness and stout footwear is advisable. Elderly and less mobile visitors will find that a stroll along the forest road within the arboretum will provide an opportunity to see a wide variety of species without too much effort.
THE GREEN ROUTE (½ Hour)
A short walk from the arboretum car park and includes some of the earlier planted groups of Douglas fir, Western hemlock and Japanese cedar. Of special interest will be the group of Dawn redwood until recently (1945) only known from fossil remains.
THE RED ROUTE (¼ Hour)
This walk also starts at the arboretum car park and passes through an interesting and varied collection of tree species. Of particular interest will be the Monkey Puzzle and Southern beeches from Chile and also a collection of Eucalypts from Australia.
THE BLUE ROUTE (1½ Hours)
The upper reaches of this walk are primarily intended for the more active visitor. It initially follows the green route before turning uphill to pass through a fine collection of spruces and Silver firs. The views on a clear day from the top reaches of this path are outstanding.
Forest Road
Paths Not Waymarked
Public Road
The location of this board is shown by
In case of FIRE dial 999
Scale (Miles)
0
1/8
1/4
Sitka Spruce
Mountain Hemlock
Lodgepole Pine
Hybrid Larch
Two-Needled Pine
Three And Five Needled Pines
Corsican Pine
Mountain Pine
Spruces
Silver Firs
Red Oak
Scots Pine
Scots Pine Shelter Belt
Southern Beech
Larches
Hemlocks
Cypresses
Sub-Alpine Fir
Japanese Larch
Douglas Fir
Birch
Sycamore
Eucalypts
Ash
Alder
Beech
European Larch
Wellingtonia
Noble Fir
Redwood
Cypress Bowl
Japanese Cedar
CAR PARK
Himalayan Spruce
Maples
Alder
Cherry
(Ruin)
Church
A880
FORESTRY COMMISSION OFFICES
MAIN ENTRANCE
INQUIRIES - Please contact : Cowal Forest Office
Kilmun, Dunoon, Argyll. (Kilmun 666)
HOLY LOCH

ALTERNATIVE CONIFERS – OUR EXISTING RESOURCE

Current Scottish conifer crop by species



Source: FC Forestry Statistics 2013

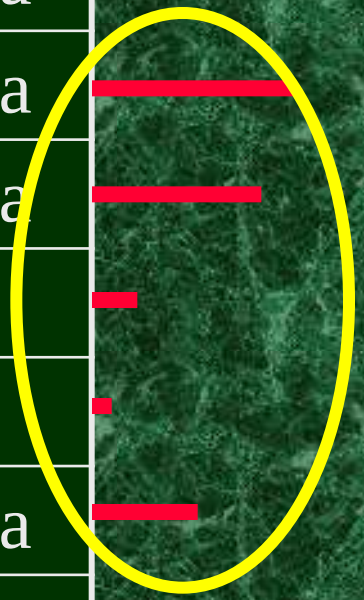
Existing resource of alternative conifers

- Estimate area of “alternative conifers” now standing in Scotland is ~ 50-55,000 ha.
- Of this, ~32,000 ha is Norway spruce.
- Douglas fir represents ~10,000 ha.
- Western hemlock, noble fir each ~1,500 ha.
- Grand fir ~1,000 ha.
- Others and mixed conifers total ~9,000ha.
- These areas are falling (until very recently?)

Existing resource of alternative conifers

- Typically small stands (larger areas of some species – Douglas fir, hemlock, grand fir)
- Typically on better sites and soils than the average for Scottish plantation forests.
- Typically mature or over-mature (50-150 years) prior to recent upsurge of planting.
- Often un/under-thinned/ neglected (ex DF).
- Spatial coincidence with alternative silvics.

1990’s	2,592ha
1980’s	5,402ha
1970’s	6,215ha
1960’s	13,569ha
1950’s	14,853ha
1940’s	6,897ha
1930’s	2,683ha
1920’s	2,235ha
1910’s	599ha
1900’s	258ha
>1860	1,395ha
<1860	59ha



“Trophy stands”

Data extracted from Forestry Commission National Inventory of Woodlands and Trees (1995)

DOUGLAS FIR

NORWAY SPRUCE

SERBIAN SPRUCE

ORIENTAL SPRUCE

LARCH SPECIES

WESTERN HEMLOCK

WESTERN RED CEDAR

JAPANESE RED CEDAR

REDWOODS

LAWSON CYPRESS

GRAND FIR


NOBLE FIR

SILVER FIRS

ALTERNATIVE PINES

FORESTRY COMMISSION

BULLETIN No. 30

Exotic Forest Trees in Great Britain

Paper prepared for the British Commonwealth Forestry Conference Australia and New Zealand 1957

LONDON: HER MAJESTY'S STATIONERY OFFICE

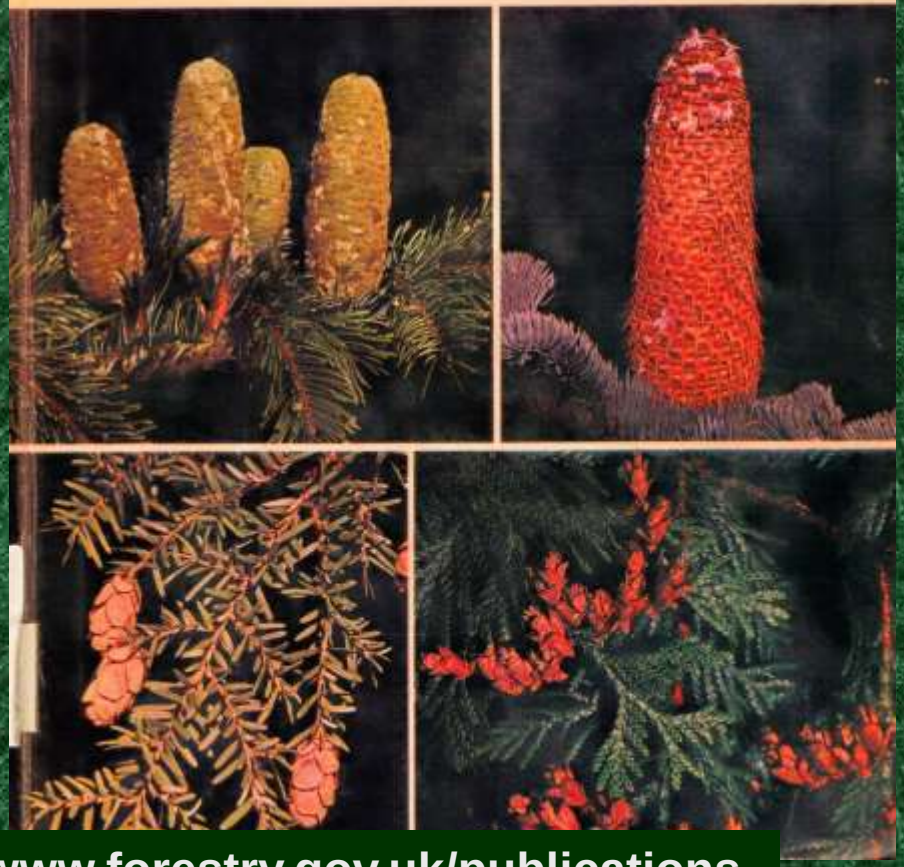
PRICE 17s. 6d. NET

HMSO £1.50 net.

Forestry Commission Bulletin **49**

The potential of Western Hemlock, Western Red Cedar, Grand Fir and Noble Fir in Britain

J R Aldhous A J Low

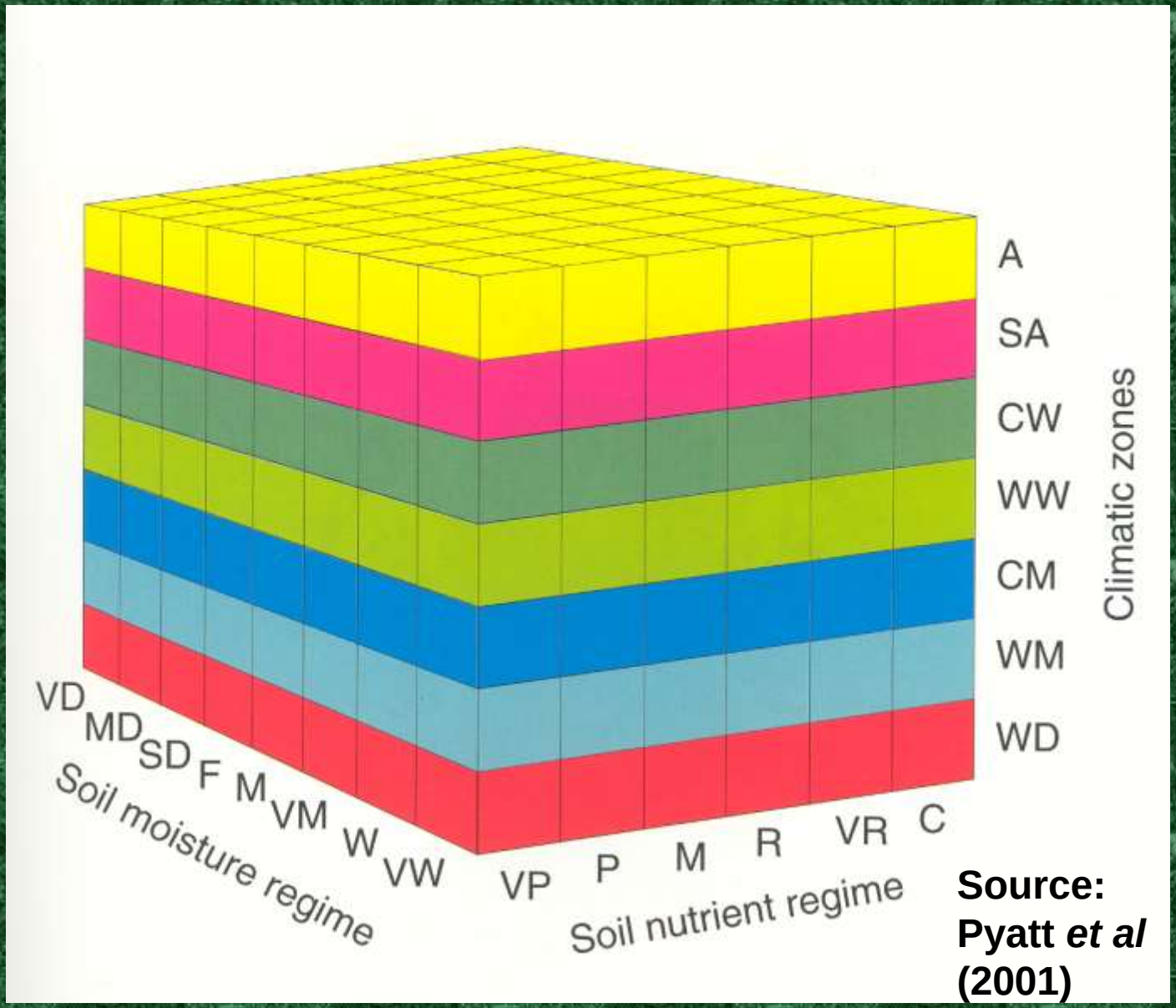


SOIL MOISTURE CLASS	DRY		MOIST		WET - MINERAL		WET - PEATY		
SOIL FERTILITY CLASS	*Hardy*	*Tender*	*Hardy*	*Tender*	*Hardy*	*Tender*	*Hardy*	*Tender*	
A	Austrian pine Corsican pine			Nordmann fir				Norway spruce	INCREASING SOIL FERTILITY
B	Japanese larch Corsican pine European larch		European larch Japanese larch Weymouth pine Western red cedar Lawson cypress	Douglas fir Silver fir spp Spruce spp Western hemlock	Western red cedar	Norway spruce		Norway spruce	
C	Japanese larch European larch Corsican pine Monterey pine		Western red cedar Lawson cypress	Spruce spp Western hemlock Silver fir spp	Western red cedar	Spruce spp	Western red cedar	Spruce spp	
D	European larch Japanese larch	Douglas fir		Spruce spp Western hemlock Noble fir					
E			European larch	Douglas fir Norway spruce					
F	Shore pine		Shore pine Mountain pine		Mountain pine Shore pine		Mountain pine Shore pine		

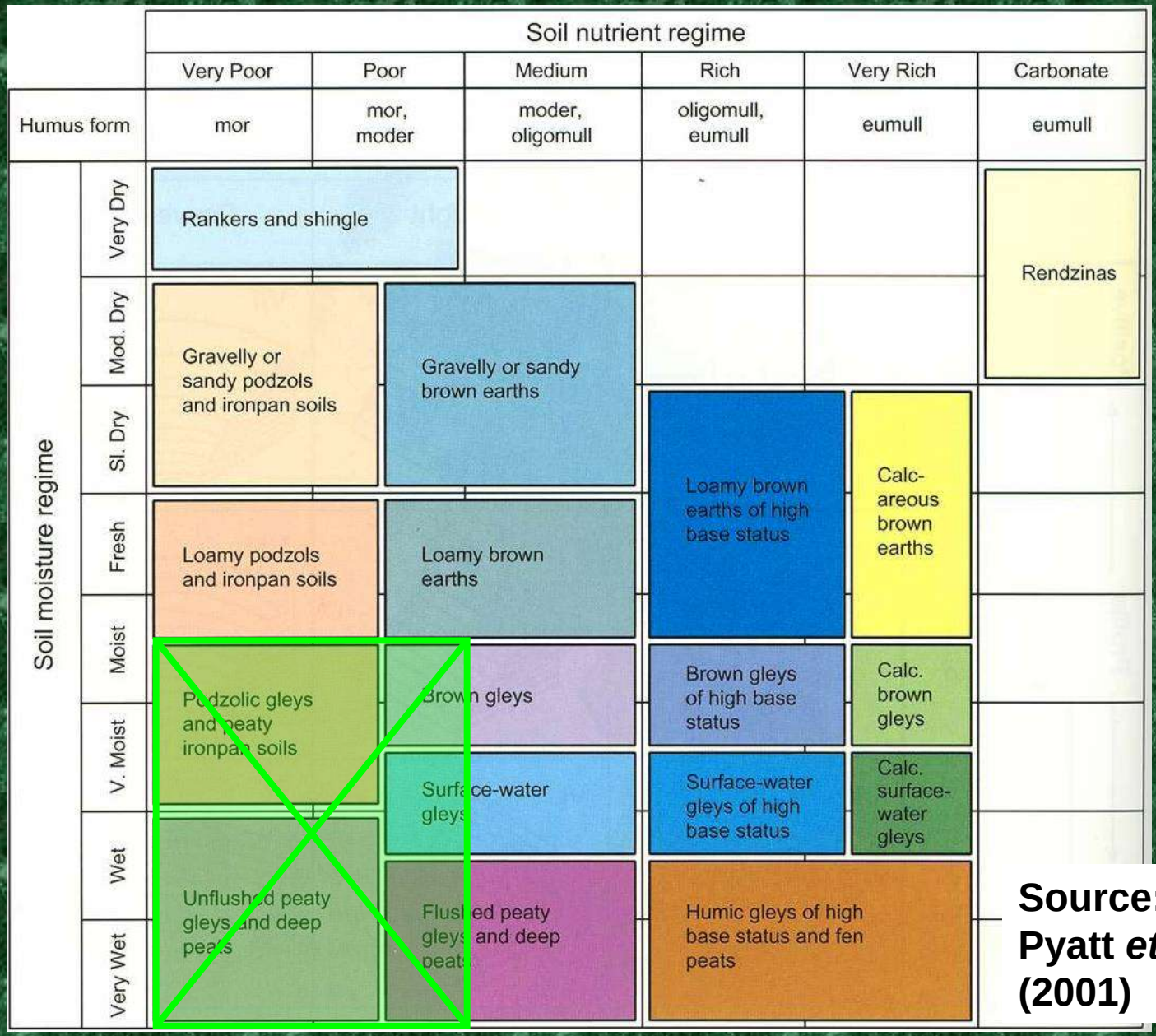
Questionable

Source: Anderson, (1950,1961)

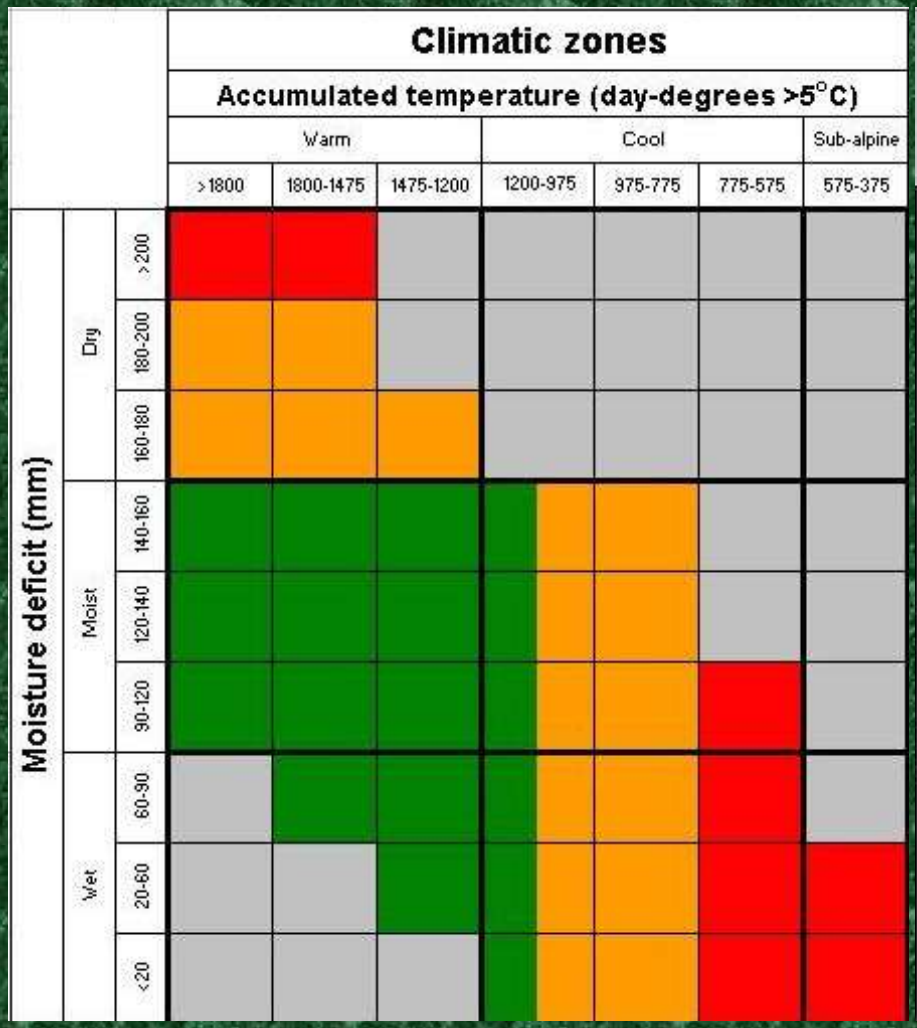
Publications available from www.forestry.gov.uk/publications

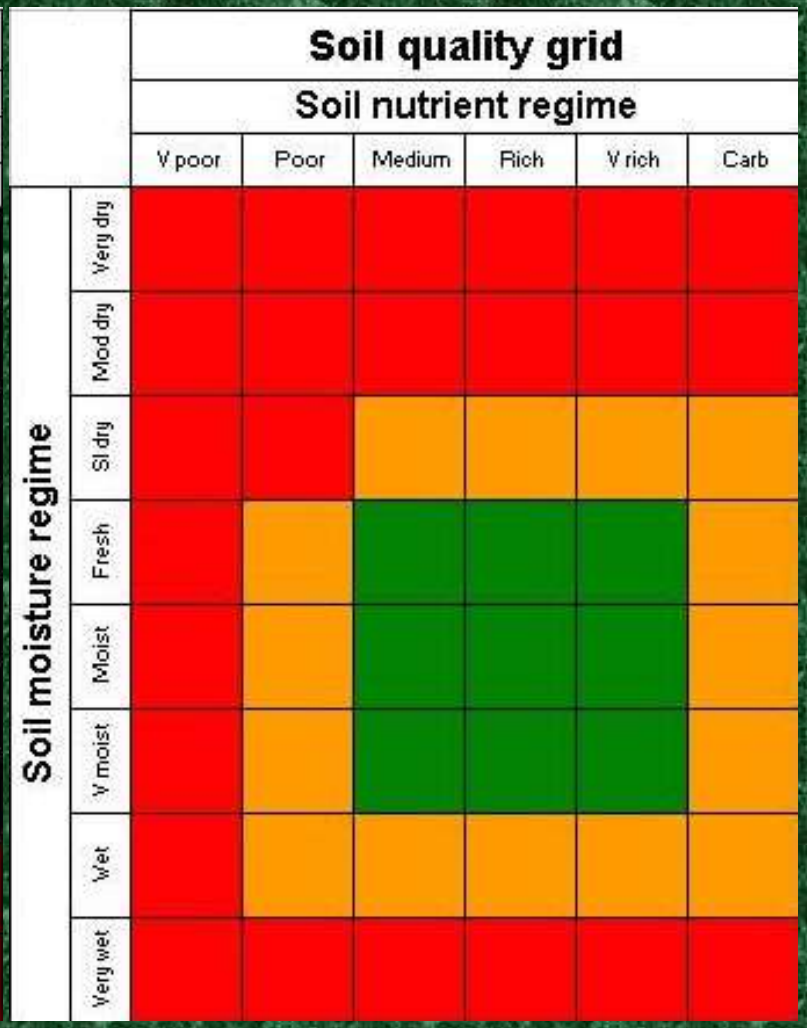


Source: Pyatt *et al* (2001)



Source: Pyatt *et al* (2001)


Climatic zones
Accumulated temperature (day-degrees >5°C)
Warm
Cool
Sub-alpine
>1800
1800-1475
1475-1200
1200-975
975-775
775-575
575-375
Moisture deficit (mm)
Dry
Moist
Wet
>200
180-200
160-180
140-160
120-140
90-120
60-90
20-60
<20


Soil quality grid
Soil nutrient regime
V poor
Poor
Medium
Rich
V rich
Carb
Soil moisture regime
Very dry
Mod dry
Sl dry
Fresh
Moist
V moist
Wet
Very wet

Attributes of alternative conifers v. SS

- Tend to require better site types than SS.
- Are more difficult to establish than SS – deer palatable, exposure sensitive, slower early growth against weed competition.
- Grow more slowly than SS other than on the best sites, where GF etc. can outgrow SS.
- Often have a longer optimal rotation length than SS – esp. DF, RC – e.g. 60-90 years.
- Timber can attract lower prices (not NS,DF)

CONIFER DIVERSIFICATION

Drivers for conifer diversification

- Reduce dependence on dominant species.
- Reduce “worst case mortality” of resource.
- Dilute “host density” within forest resource.
- Silvicultural diversification in 2nd/3rd rotn.
- Exploit new market opportunities [e.g. for durable or semi-durable RC/RSQ cladding].
- Increase/ secure additional forest services (landscape amenity, biodiversity, soil cons).

Major threats to existing conifer crops

- Drought-induced damage/ yield restriction.

  [Mainly in eastern GB areas for Sitka spruce]

- Existing pest and disease issues

  [*Dothistroma* in pine; *Phytophthora* in larch]

- Introduction of a novel insect pest.

  [*Ips typographus*, spruce budworm etc.]

- Mutation/ arrival of a fungal pathogen.

  [*Phytophthora spp*., others may well arrive]

Forestry Commission
Scotland

Research Note

Impacts of climate change on forestry in Scotland – a synopsis of spatial modelling research

Duncan Ray

January 2008

Climate change is now one of the greatest global challenges, and research is underway to establish the likely impacts on all aspects of the environment. Forestry Commission Scotland has commissioned Forest Research to determine how forests and forestry in Scotland will be affected by climate change. This Research Note provides an initial synopsis of the likely impacts, with preliminary recommendations to support development of a climate change action plan for forestry in Scotland. Climate change will create many challenges and opportunities for Scotland's forest industry. Productivity will increase in some areas and a wider selection of species will become suitable. However, there are also potential threats, including drought, increased insect and disease damage, and wind damage, hence new techniques to combat these will be necessary. There are many uncertainties associated with climate change, and its likely impact on trees, management systems and forest operations. A key basis for risk planning and management is diversification; from broadening the choice of genetic material, mixing tree species in stands, to varying management systems and the timing of operations. Scotland's aspiration to expand woodland from 17% to 25% of land area by 2050 provides an opportunity to target reforestation within habitat networks. This will reduce woodland fragmentation and thereby help improve the resilience of woodland ecosystems to climate change.

Forestry Commission

Fruiting bodies of *Armillaria gallica*

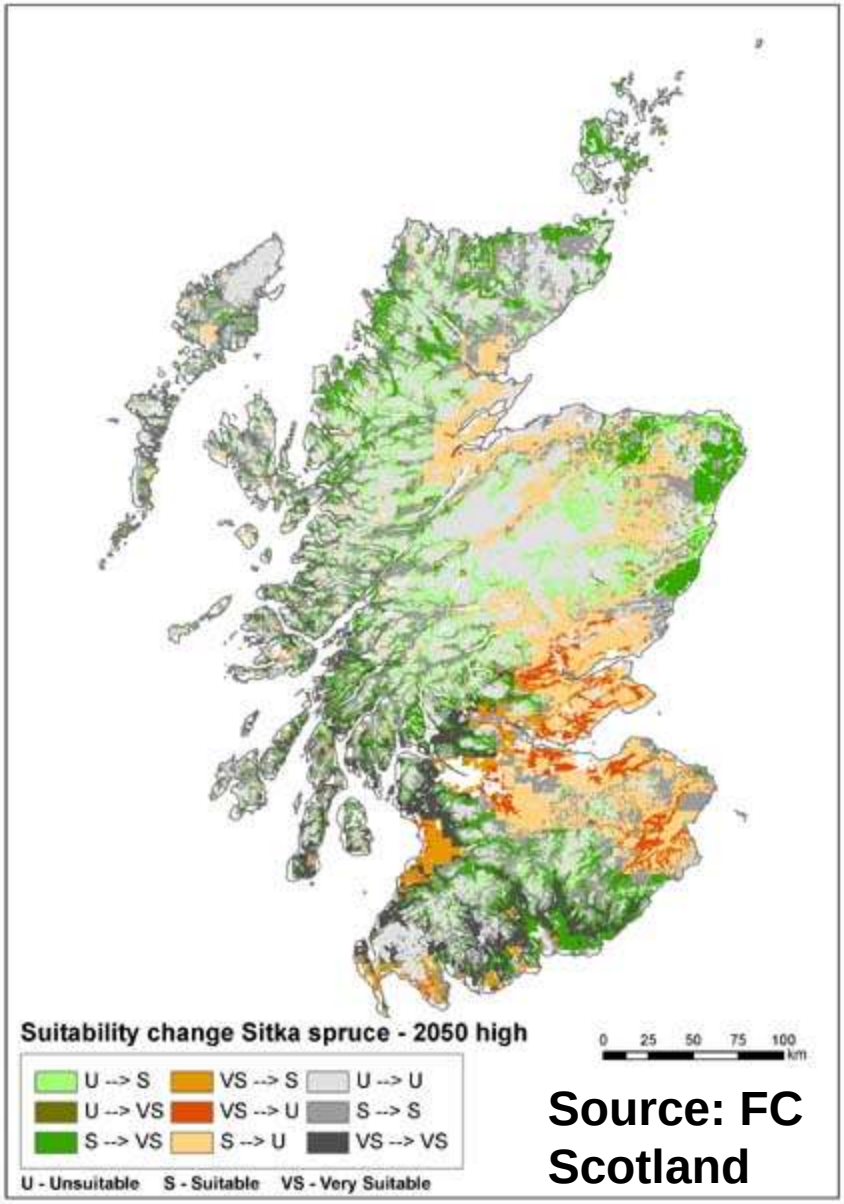
Research Note

Potential impacts of drought and disease on forestry in Scotland

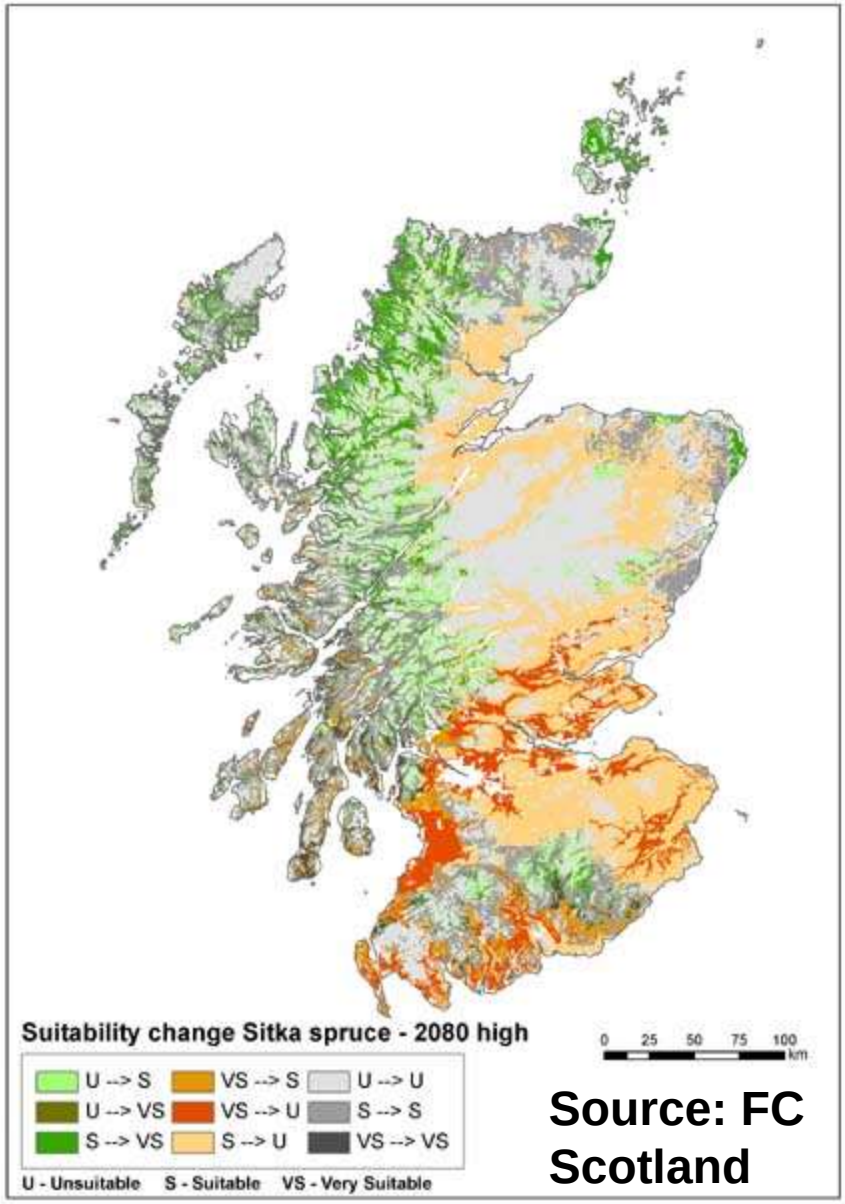
Sarah Green and Duncan Ray

September 2009

In predictions of future changes in climate, drought is expected to become a more important factor affecting the health of trees in areas of Britain, particularly in the east of the country and including areas of Scotland. Drought may cause direct physiological damage to trees as well as increase their susceptibility to a range of fungal diseases. Although a number of diseases are known to be more aggressive on trees experiencing drought stress, there are uncertainties as to which are likely to increase in frequency and severity in response to future changes in climate. This study used GIS-based modelling to develop 'drought-risk maps' to identify forest sites and tree species in Scotland most at risk by combining past and predicted climatic variables with a range of soils data. Sitka spruce, Scots pine, larch, Norway spruce, mixed broadleaves and Douglas fir were found to be major component species of drought-prone forest sites in eastern Scotland. Results from the modelling study focused a literature review of the potential risks to these species from drought-related fungal diseases. This review identified a number of diseases likely to increase in frequency and severity on drought-prone forest and woodland trees in Scotland. In addition to good silvicultural practice, it is concluded that the potential of damage to trees from pathogens must be factored into future climate change adaptation strategies.



Source: FC Scotland



Source: FC Scotland

Potential pests of Sitka spruce crops

- *Heterobasidion/ Phomes/ Armillaria* rots
- *Elatobium* (green spruce aphid)
- *Dendroctonus* (great spruce bark-beetle)
- *Hylobius* (pine weevil)

- *Ips typog*. (8-toothed spruce bark beetle)
- Spruce weevil (*Pissodes spp*)
- Spruce budworm (*Choristoneura spp*)

HOW LUCKY CAN WE EXPECT TO BE?

Forest Research - Tree spe ×

www.forestry.gov.uk/fr/treespecies

Forestry Commission | Home | Quick links | Library | Help

Forest Research | About us | Contact us | News | Research | Products/services | Events | Search

By common name

By Latin name

References

Forest Research home > Research > Tree improvement & forest genetics

Tree species and provenance

Information on over 60 tree species that are either widely grown in British forests at the present time or which could play an increasing role in the future, focusing on those species which could be expected to produce usable timber in British conditions.

Species by common name | Species by Latin name

Why choosing the correct tree species is important

The correct choice of a tree species in relation to site characteristics and local climate is an essential prerequisite for successful and sustainable forest management.

For example, planting a species like poplar on a dry site is likely to result in failure since this tree requires access to soil moisture for satisfactory growth. Similarly, planting species from warmer climates on colder sites in upland Britain can result in serious risk of death and dieback in harsh winters.

Previous generations of foresters and land owners had good access to silvicultural textbooks which described the characteristics of different species, often complemented by local trials which showed the comparative performance of different species in their region. However, such textbooks are now difficult to find, and the standardisation of species choice since the mid 1970s has led to a concentration upon a limited number of species in British forestry such as Sitka spruce, Scots and Corsican pines, various larches, Douglas fir, sessile and pedunculate oaks, beech, and silver birch.

Why considering a wider portfolio of species is important

AutoPlay | Forest Research - Tr... | Adobe Photoshop E... | 15:32

Information available from www.forestry.gov.uk/fr/treespecies

Dr. Scott McG. Wilson MICFor
Consultant Forester and Forest Ecologist

Using alternative conifer species for productive forestry in Scotland

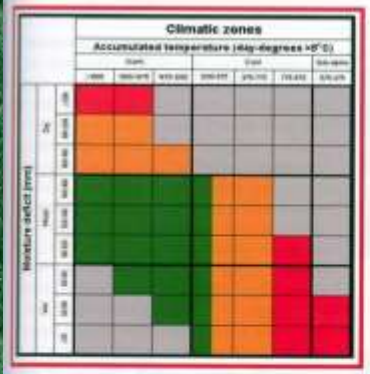
Western red cedar

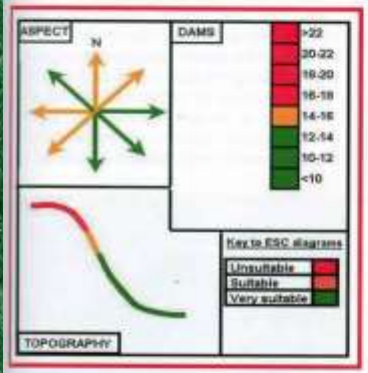
Potential for use in Scotland

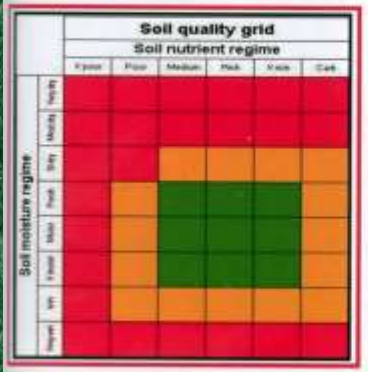
Record and potential - western red cedar (*Thuja plicata*) is an established, valuable timber species from the coastal forests of the Pacific Northwest, with the native range stretching from Alaska to California. It grows naturally together with Sitka spruce, Douglas fir, western hemlock, grand fir, Lawson cypress and coast redwood in different parts of its range, rarely forming pure stands. It is one of the longest-lived Pacific conifers, often reaching 900-1000 years. Its timber, although of low density, is highly durable, cleaves easily and was valued for boarding and cladding, roof shingles and boat-building in the American west. It was introduced to Britain in 1852 by William Lobb. Although trialed in private arboreta and forest gardens, it was never widely adopted for plantation forestry in Scotland. There were a number of small-scale plantings on private and Forestry Commission ground between 1870 and 1940, but there has been a tendency to regard the species as being too tender for widespread use in Scotland. There was continued small-scale planting after the war, including trials on peat sites. Red cedar has been planted much more extensively in SW England and Wales, where a small-scale industry, processing its timber for durable applications, has developed. It has considerable potential for expansion into Scotland under climate-change, producing a durable and attractive timber. However its processing is likely to remain a more specialist activity.

Fine stands of western red cedar - Kyloe Estate; Forest of Dean (p1916), Monaughty Forest (p1928)

Existing resource- the National Inventory of Woodlands and Trees recorded some 40ha of western red cedar in Scotland, most of that being of post-war date. However this misses a small number of older plantations on private estates (1870-1910) and Forestry Commission sites (1920-1940) that better demonstrate the potential of this species in Scotland, when grown on suitable sites. These include good stands at Darnaway Estate and the FC Monaughty Forest in Morayshire with several locations along the Great Glen (Craig Phadraig and Port Clair Forests) and Argyll (Lochgoilhead, Benmore and recently felled at Inverliever). Western red cedar has also been very successfully grown for over 100 years at the Kyloe Estate in Northumberland, just over the Border. Further south there are more extensive mature plantings - in Wales (notably at FC Gwydyr and Dyfi-Corris Forests) and in SW England (notably in the Forest of Dean and the private Dunster, Tavistock, Longleat and Stourhead Estates). While only very small amounts of home-grown timber have come onto the market in Scotland, larger volumes have been processed for cladding, boarding, fencing, glass-house framing, beehives etc in England, especially in recent years. With a small standing resource, any good regular material of >30cm dbh brought to market attracts interest, but until the recent advent of woodfuel demand, small bars were very difficult to sell.







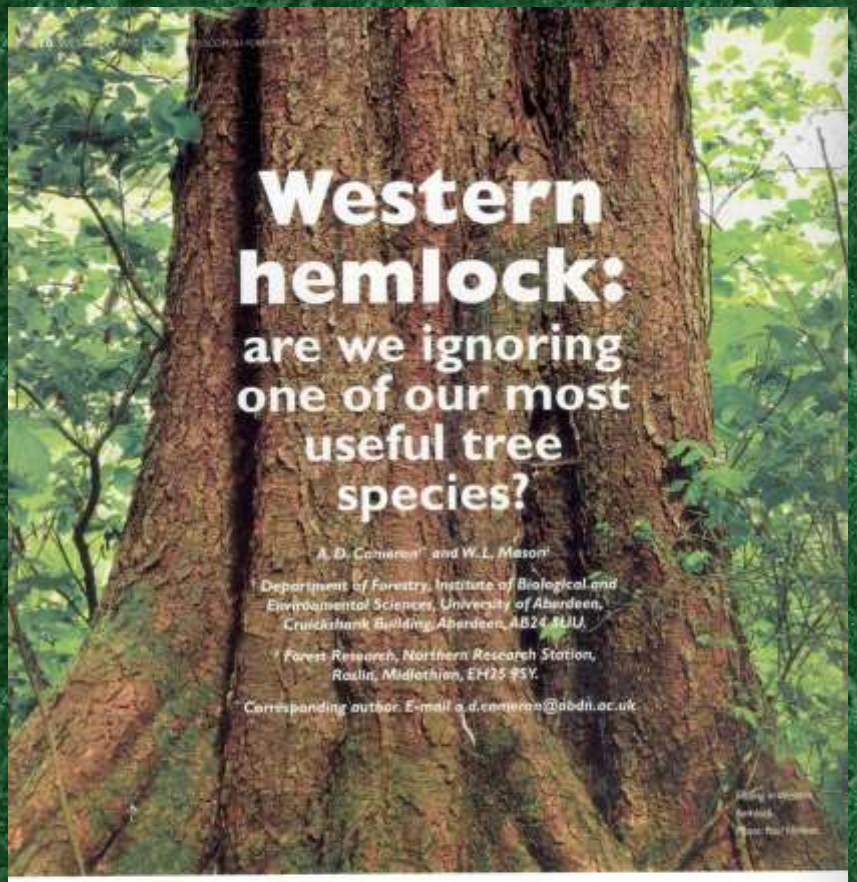
Site suitability - the limited experience to date with western red cedar in Scotland confirms that it is suitable for the warm moist climates of Galloway, Argyll, Lochaber and Wester Ross. Optimum sites are wind-sheltered and frost-free, with moist but freely-draining soils of moderate to high fertility. However western red cedar also appears to have the ability to operate well under less favourable conditions - notably the drier climates and poorer, freely-draining soils of eastern Scotland (for example the Laigh of Moray) and eastern England (for example at Thetford). There is also evidence that it will use poorly-drained gley and peat sites, as long as these are not heathery or very infertile. Growth will be less rapid on these more difficult sites, but western red cedar offers an option for a range of site conditions unsuitable for many other trees. Exposed sites above 200m are not suitable. There is known susceptibility to butt-rot/ bottle-stems and also to honey fungal decay. Frost tolerance is, at best, moderate.

Provenance- very limited study of provenance variation in western red cedar has been undertaken in Britain, and this species should be seen as a priority for future work of this kind. Imported seed origins from the coastal Washington (e.g. Olympic Mountain) and Vancouver Island (e.g. Ladysmith) areas of the native range should prove suitable. Interior origins from Montana, Idaho and inland British Columbia are best avoided for Scotland, but may have a role in south-east England. Home-collected material should be very suitable - there are three Registered Seed Stands (one in Scotland at Darnaway and two in western England). Other Scottish stands at Monaughty and Lochgoilhead could be registered in future. Nurseries currently handle limited western red cedar and contract-growing is likely to be required. Fungal disease can be a problem when raising nursery stock of this species. Western red cedar naturally regenerates well in western Britain, and this is the major method of restocking at present in SW English and Welsh growing areas.

Western red cedar

Site suitability and provenance

Wilson (2011) "Blue book" is available from www.forestry.gov.uk/scotland



Western hemlock: are we ignoring one of our most useful tree species?

A. D. Cameron[1] and W. L. Mason[2]

[1] Department of Forestry, Institute of Biological and Environmental Sciences, University of Aberdeen, Cruickshank Building, Aberdeen, AB24 3UU.

[2] Forest Research, Northern Research Station, Roslin, Midlothian, EH25 9SY.

Corresponding author. E-mail a.d.cameron@abdn.ac.uk

Summary

Recent damaging insect and fungal attacks on forest stands in Scotland have highlighted our reliance on a very limited range of commercial tree species and this has initiated discussion on the need to consider alternative species. Western hemlock (*Tsuga heterophylla* (Raf.) Sarg.) appears to have many of the attributes of a successful commercial timber-producing species. It is adaptable to a wide range of sites, has a good growth rate and desirable timber properties, regenerates freely, and to date has not succumbed to damaging biotic agents. However, western hemlock has a poor image within the forestry sector. This view may in part be based on experience of this species grown in open plantations at relatively wide spacings. In this review we suggest that the silvicultural attributes of western hemlock are better suited to mixed species stands and irregular structures rather than planted pure on open sites. When grown under appropriate conditions, the evidence suggests that the mechanical and working properties of western hemlock timber are equivalent to, or superior than, other commonly grown species.

Source: Scottish Forestry, 2013

Introduction

Forestry in Scotland is dominated by a small number of mainly shade intolerant or intermediate species such as Scots pine (*Pinus sylvestris* L.) and Sitka spruce (*Picea sitchensis* (Bong.) Carr.) that are suited to the clear-cutting system. Foresters are now under pressure to create forests that are more diverse in terms of species and stand structure to meet the multiple and changing needs of society. Furthermore, given the uncertainties associated with projected climate change combined with an increasing threat from introduced pests and diseases, it is recognised that we can no longer afford to rely on a limited number of species to supply the future needs of industry. Discussions on expanding the range of species used in forests in Scotland have highlighted the need for more shade tolerant species to be considered (e.g. Wilson, 2007), particularly as interest in developing irregular stand structures has increased. Western hemlock (*Tsuga heterophylla* (Raf.) Sarg.) has many of the attributes required to be successful in planted mixed stands and irregular stands in Britain. It is very shade tolerant and regenerates freely even under dense canopy cover. The mechanical properties of western hemlock timber make it suitable for a wide variety of end uses, such as construction and interior joinery. Notwithstanding these positive attributes, western hemlock is generally not held in high regard in Scotland, or indeed elsewhere in Britain. The capacity of western hemlock to regenerate freely has created the reputation of it being 'invasive' and has even resulted in an active policy of eradication. In addition, the timber is generally not highly valued by wood-using industries. The aim of this article is to examine the reasons behind the negative attitude towards this species, to discuss the potential of western hemlock as a quality timber-producing tree in Scotland, and to recommend the most appropriate silvicultural methods to achieve this potential.

Background and site conditions

Western hemlock was introduced into Britain in 1851 and has become naturalised in many parts of the country. It is native to the west coast of North America, covering a latitude range from California to Alaska, and an elevation range from sea level to 2,250 m (Savill, 1991). The species will grow on a range of soil types from gleys to imrpans although best growth is on deep brown earth soils with adequate soil moisture (Burns and Honkala, 1990). Its capacity to grow on drier soils typical of eastern Britain has been acknowledged and the incidence of drought crack in stems was observed to be low compared with Abies species (Aldhous and Low, 1974). It can tolerate periods of water-logging better than Douglas fir (*Pseudotsuga menziesii* (Mirb.) Franco) and will tolerate nutrient poor soils more effectively than other high yielding conifers (Lines 1987). When compared with Sitka spruce, western hemlock has significantly lower moisture and nutritional requirements (Wood, 1955). In common with many other conifer species, calcareous soils should be avoided as it is susceptible to lime-induced chlorosis (Stroats and Winter, 2000). Planting of western hemlock in Britain has been mainly confined to fertile sites at relatively wide (≥ 2 m) spacing where growth rates of 24 $m^3 ha^{-1} year^{-1}$ are possible (Lines, 1987). Currently, there are around 1000 hectares of western hemlock in Britain.

Silviculture

Regeneration potential

In its native range, western hemlock occurs naturally in both pure and mixed stands. Forests comprising mixtures of western hemlock with either Sitka spruce or Douglas fir in the Pacific north-west of North America are recognised as the most productive natural forests in temperate regions (Burns and Honkala, 1990; Smith *et al.*, 1997), and therefore have an important role as carbon sinks. Western hemlock is known to regenerate freely even under quite dense canopies. It is probably for this reason that hemlock has a reputation of being invasive. It will also tolerate suppression in heavy shade for many years and has been reported to respond well with strong apical growth following canopy removal after periods in the shade in excess of 50 years (Burns and Honkala, 1990). Fears that western hemlock will eventually dominate the regeneration pool within mixed species stands have not been borne out by research. An investigation on the effects of partial opening of the canopy in mixed western hemlock-Sitka spruce stands in southeast Alaska showed that both species regenerated adequately provided that the reduction in basal area was sufficient to favour the spruce (Deal and Tappeiner, 2002). This supports findings from studies under British conditions that suggests limiting basal areas for successful regeneration of < 40 $m^2 ha^{-1}$ for western hemlock (Hale, 2004) and < 30 $m^2 ha^{-1}$ for Sitka spruce (Page *et al.*, 2001; Hale, 2001). By maintaining a lower basal area that favours the less shade tolerant Sitka spruce, foresters should enable successful regeneration of both species.

Western hemlock regrowth with strong apical growth even after 50 years in the shade. Photo: PCI

Competition within mixed-species stands

Concerns that western hemlock will eventually dominate mixed species stands also appear to be unfounded. Hemlock has been noted to form the sub-dominant species in mixtures with either Sitka spruce or Douglas fir (Smith *et al.*, 1997; Wierman and Oliver, 1979; Wood, 1955). Only where soil moisture and fertility are limiting can the more drought resistant western hemlock come to dominate Sitka spruce (Wood, 1955). The relative dominance of both Douglas fir and Sitka spruce over western hemlock in natural forests is attributable to

Alternative Spruces to Sitka and Norway

Part 1- Serbian spruce (*Picea omorika*)

In the first of two articles looking at alternative spruces, **Peter Savill**, **Scott Wilson**, **Bill Mason**, **Richard Jinks**, **Victoria Stokes** and **Tom Christian** focus on Serbian spruce.

The genus Picea, or the spruces, is large, with species distributed over the temperate zone of the Northern Hemisphere. It includes the most important forest tree in Britain, *Picea sitchensis* (Sitka spruce), together with *P. abies* (Norway spruce). Sitka spruce was introduced from its native Pacific coastal area of North America in 1831. It had become established as one of the chief non-native species in Britain by the early 1920s and, by the mid-1950s, it became the most widely planted tree in Britain (Streets, 1962). Norway spruce originates from northern, central and eastern Europe and was a much earlier introduction, probably before 1500 according to Mitchell (1974). Together in 2011 Sitka and Norway spruce occupied 28% of all forest area in Great Britain, or 744,000ha (Forestry Commission, 2016). To put their significance into context, other common species include the pines at 15%, oaks and birches at 9% each, larches and ash at 5% each. These two spruce species are also the most important species for the timber processing industry in Britain, accounting for over 55% of softwood timber in 2012, a figure which is projected to increase to nearly 70% by 2030 (Forestry Commission, 2014).

Figure 1. A Serbian spruce tree in Bosnia and Herzegovina. Note the characteristically very slender crown and short branches. (Photo: Tom Christian/RBGE).

According to Macdonald et al. (1957), a wide range of other spruce species have been grown in Britain at one time or another. Two of these spruces, Serbian spruce (*P. omorika*) and oriental spruce (*P. orientalis*) are among the alternative species that were considered by Read et al. (2009) and Bladon and Evans (2015) to be worth trying in Britain as the impacts of climate change become more serious, particularly in areas where Sitka spruce and Norway spruces might be subject to damage due to drought (Green et al., 2008). The potential of these two alternative spruces, along with some other spruce species, is considered in this two part article, beginning in this issue with Serbian spruce. (See April 2017 *QJF* for the concluding part of this article.)

Species Profile

Alternative Spruces to Sitka and Norway

Part 2 - Oriental or Caucasian spruce (*Picea orientalis*), and the American and Asian spruces

Peter Savill, **Scott Wilson**, **Bill Mason**, **Richard Jinks**, **Victoria Stokes** and **Tom Christian** conclude their exploration of the genus Picea.

In the first part of this article looking at possible alternative species of spruce to the commonly grown *Picea sitchensis* (Sitka spruce) and *P. abies* (Norway spruce) we considered Serbian spruce (*Picea omorika*). (Part 1 appeared in the January 2017 *QJF*)

Now we turn our attention to *Picea orientalis*, the Oriental or Caucasian spruce. In addition, we will also look at a range of other spruces that have previously been trialled in experimental plots in Britain. (For ease of reference we have repeated the tables published in Part 1.)

Distribution and ecology of Oriental or Caucasian spruce *Picea orientalis* (L.) Peterm.

Oriental spruce (*Picea orientalis*) is effectively the eastern equivalent of the European or Norway spruce, found in central Eurasia. The species is considered native to the mountains around the eastern end of the Black Sea, including the Central Greater Caucasus and the eastern ends of the Trialeti ridge on the Lesser Caucasus. These areas lie within Abkhazia, Georgia and north eastern Turkey (Farjon,

Table 1. Growth of selected sample plots of Serbian, Oriental and other spruces in different parts of Britain.

Species	Location	Age	Top height (m)	Cumulative basal area production (m^2ha^{-1})	Yield class (Local yield class) ($m^3ha^{-1}yr^{-1}$)
Serbian spruce	Bedgebury, Kent (plot 1170)	49	22.6	81.6	16
	Bedgebury, Kent (plot 1175)	49	23.1	92.1	16
	Thetford, East Anglia	49	18.5	75.7	14
	Brechfa, Carmarthenshire	45	22.0	70.8	16 (14)
	Forest of Deer, Aberdeenshire	48	14.3	103.0	8 (10)
	Newcastleton, Borders	57	18.0	87.8	10 (11)
	Glen Urquhart, Inverness	64	18.8	103.9	8 (12)
	Bennan, Galloway	73	27.0	118.3	12 (15)
Oriental spruce	Bedgebury, Kent	35	17.2	67.2	16 (18)
	Dawyck, Borders	53	19.7	93.8	10 (12)
Black spruce	Bedgebury, Kent	31	10.3	-	12
	Brechfa, Carmarthenshire	33	13.5	37.5	10 (9)
Red spruce	Bedgebury, Kent	39	16.7	48.6	16(17)
Englemann spruce	Bedgebury, Kent	32	16.7	37.2	16 (14)
Hondo spruce	Bedgebury, Kent	49	12.6	28.2	4

Pinus peuce Griseb., Macedonian or Balkan pine

Peter Savill and **Bill Mason** outline the characteristics and highlight the potential of this little used species in the UK.

Much thought is being given by foresters to possible tree species that might be used in Britain if climate change proceeds as predicted, and in the light of the threats posed by tree pests and diseases that have become so numerous since the turn of the century. Recently the Wessex Silvicultural Group has considered the matter (Bladon and Evans, 2015), as has Wilson (2011, 2014) among others. There is also an on-line network that promotes novel species known to have potential to grow well in the UK (SiviFuture, 2015). It includes nine high priority species, and 20 medium priority species. In addition, Read et al. in their 2009 publication *Combating climate change* also suggested possible species, including 15 broadleaves and 10 conifers.

Pines represent a potentially valuable group of alternative species for productive forestry in drier areas of Britain and/or on less fertile soils. However, the preferred species at present, Corsican pine, lodgepole pine and Scots pine, are susceptible to varying degrees to Dothistroma needle blight (DNB). There are about 114 species of pines in temperate, sub-tropical and tropical regions of the world, including 11 in Europe. Seventy of the world's species are in the subgenus *Pinus* (the 'yellow' or 'hard' pines). These are mostly two- or three-needled pines, and 44 species are in the subgenus *Strobus* (the 'white' or 'soft' pines), which have four or five needles. The best known North American example is Eastern white pine (*Pinus strobus*) periodically cultivated in Britain as Weymouth pine and regarded as a valuable timber tree during the period 1700-1900. *Pinus peuce* is one of only two European species in the latter group, the other being *Pinus cembra* L. (Swiss stone pine), a tree confined to the subalpine zone at elevations mainly between 1,500-2,200m. Interest in *P.peuce* arises because it appears to be immune to blister rust (see later), unlike the North American five-needled pines (Forest Research, 2015). The name 'peuce' is not a reference to a reddish or purple colour (e.g. of the developing cones), but is derived from the Greek *peuke* meaning 'pine tree'. Indeed, some older texts refer to the species as *Pinus peuke*.

Figure 1. Natural pure stand of Pinus peuce in the Mount Pelister National Park in Macedonia. The trees show the same high stocking density that is found in Britain and therefore presumably also have a high basal area.
(Photo: Dr Bojan Simovski, University of Skopje)

Silver Firs (*Abies* spp) of Europe and the Near East

Species, silviculture and utilisation potential

Peter Savill, **Scott McG. Wilson**, **Bill Mason** and **Richard Jinks** review the characteristics and potential of silver firs.

Much thought is being given by foresters to alternative tree species that might be used in Britain if climate change proceeds as predicted, and in the light of the threats posed by tree pests and diseases which have become so numerous since the turn of the century. Recently, the Wessex Silvicultural Group has considered the matter (Bladon and Evans, 2015), as has Wilson (2010, 2011). There is an on-line network that promotes novel species known to have potential to grow well in the UK (SiviFuture, 2015) including nine high priority species, and 20 medium priority species. Also Read et al. (2009) suggested a number of emerging species as a means of adapting British forests to climate change, including 15 broadleaves and 10 conifers. Prominent amongst the potential candidates are a number of silver fir species (*Abies* spp.).

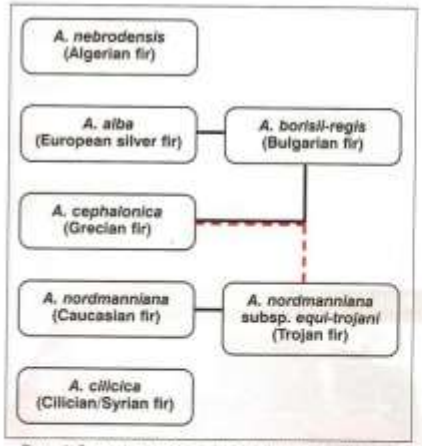


Figure 1. Suggested taxonomic inter-relationships between the Abies species of Europe and the Near East. Solid lines between species indicate firm relationships. The red dashed line between A. cephalonica and A. nordmanniana subsp. equi-trojani indicates uncertainty. Interpreted by the present authors from Kreiss (2011), Liu (1971) and other references.

According to Farjon (2010), there are 49 species of Abies that occur in temperate and boreal parts of the northern hemisphere, chiefly in mountainous regions. The main areas of occurrence are western North America (including the Pacific Northwest), eastern North America (e.g. the Appalachians), Central America, western Eurasia (including the Mediterranean basin), the Himalaya and allied montane regions and the Pacific Northeast of Asia. Common features of many, but not all Abies species, are that:

1. They are strong shade bearers and so have a potential role in continuous cover silviculture.
2. Most grow naturally in mixed-species stands.
3. Most are remarkably winter cold hardy.
4. Several species grow well on calcareous soils; an unusual attribute among conifers.

The form of *Abies* trees differs from most genera of *Pinaceae* in its exceptional uniformity. The trees typically possess a single straight stem with regularly spaced branch whorls produced at the rate of one whorl per year. The bark

The Redwoods and Red Cedar

Coast redwood (*Sequoia sempervirens*), giant redwood (*Sequoiadendron giganteum*) and western red cedar (*Thuja plicata*) – species, silviculture and utilisation potential

Scott McG. Wilson, **Bill Mason**, **Richard Jinks**, **David Gil-Moreno** and **Peter Savill** review the potential of these Pacific Northwest species.

Much thought is currently being given by foresters to alternative tree species that might be grown in Britain and Ireland if climatic change proceeds as predicted, and in the light of threats posed by novel tree pests and diseases, which have proliferated over the past decade. Recently the Wessex Silvicultural Group has considered the matter (Bladon and Evans, 2015), as have Forest Research (2016) and Wilson (2007, 2010, 2011). There is an on-line network that promotes novel species thought to have potential to grow well in the UK (SilviFuture, 2016), including nine high priority species and 20 medium priority species. Also Read et al. (2009) suggested a suite of 49 'emerging' species (24 conifers and 25 hardwoods) as a potential means of adapting British forests to climate change. Among these alternative conifer species are three productive members of the *Cupressaceae* family from western North America (a) coast redwood (*Sequoia sempervirens* (D. Don) Endl.), (b) giant redwood (*Sequoiadendron giganteum* (Lindl.) Buchholz) and (c) western red cedar (*Thuja plicata* Donn ex D. Don). These three species will be dealt with in this article. Much of the information we have used is drawn from Burns and Honkala (1990), Dallimore and Jackson (1948), Eckenwalder (2009), Farjon (1998, 2010, 2016), Macdonald et al. (1957) and Mitchell (1974).

Origin, taxonomy and introduction

All three of these species are now regarded as members of the broad family *Cupressaceae*, although the two Californian redwood species were formerly classified under *Taxodiaceae*. Other prominent forestry conifers in the *Cupressaceae* family include Lawson cypress (*Chamaecyparis lawsoniana*), Japanese red cedar (*Cryptomeria japonica*) (Savill, 2015), dawn redwood (*Metasequoia glyptostroboides*) and swamp cypress (*Taxodium distichum*). Conifer species of this type occurred commonly throughout the northern hemisphere during the Cretaceous and Tertiary periods, up to the beginning of the Quaternary glaciations 2-3 million years ago (Mai, 1989). The European and western Eurasian representatives were extinguished by the process of 'barrier compression' against east-west mountain chains (e.g. the Pyrenees, Alps, Carpathians and Caucasus) during the succeeding Pleistocene glacial episodes (Godwin, 1975; Ingrouille, 1995; West, 1970). However, the equivalent species have survived in eastern Asia and North America, where mountain chains run mainly north-south.

Coast redwood, the world's tallest tree, is a large, long-lived evergreen conifer, capable of exceeding 2,000 years in age and 110m in height. Trees with heights exceeding 60m

Cryptomeria japonica (Thunb. ex L.f.) D.Don Japanese red cedar, or Sugi

Silviculture and properties

The second in a series of articles by **Peter Savill** examining individual tree species in detail.

Japanese red cedar (or Japanese incense cedar, according to Ramsay and Macdonald (2013) or peacock pine (Edlin, 1981)) is one of several species being considered as an alternative plantation tree to various more commonly used species if climate change proceeds as predicted, or introduced diseases become more common. Other species are listed in the 'SilviFuture' database (http://www.silvifuture.org.uk/database). *Cryptomeria* is already being used to some extent by the Forestry Commission in England and Scotland and Natural Resources Wales, as well as some by private estates. Earlier accounts of the species were given by Wilson (2010) and Savill (2013).

This tree, in the *Cupressaceae*, is an endemic giant Japanese conifer related to the two sequoias of North America as well as to *Taxodium distichum* (swamp cypress) (Farjon, 2010). According to Farjon (2012), there is one species with two varieties (*Cryptomeria japonica* var. *japonica*, and *Cryptomeria japonica* var. *sinensis* Miquel in Siebold & Zuccarini). The Chinese variety is sometimes referred to as *C. fortunei*. They are distinguished by range and by the morphological differences detailed in the box below. Var. *japonica* is native only to Japan, where it occurs naturally in pure and mixed stands.

Dallimore and Jackson (1948) describe *Cryptomeria* as a very variable tree with a clean tapering, trunk rising above well-defined buttresses. Farjon (2012) says that the trees are monoecious, evergreen, up to 50 to 65m tall and up to 300cm in diameter, with a conical crown and a characteristically straight, slender trunk (Figures 1 and 3-6). The bark is reddish brown to dark gray, fibrous, peeling off in long shreds (Figure 1). Branches are whorled, horizontally spreading or slightly pendulous; branchlets are usually pendulous, those of the first year green and glabrous. Winter buds are small. Cones are brownish, globular, and solitary 1.5 to 2cm in diameter (Figure 2). A peculiarity of the species is that the growing shoot is sometimes prolonged from the apex of the cone due to abnormal development of dormant buds. The 0.5 to 1.5cm long leaves are spirally arranged.

Key to the varieties (Fu et al., 1999, from Farjon, 2012)

1a.	Leaves ± straight at least in proximal 1/2, often recurved apically on leader branchlets, arising at 35-45° to axis on leader branchlets, 45-55° on fertile branchlets, rigid and hard; most pollen cones longer than their subtending leaf; cone scales 20-30, each bearing 2-5 seeds; distal projections of bracts and cone scales 2-3.5mm.	1a. var. japonica
1b.	Leaves usually strongly incurved throughout, arising at 15-30° to axis on leader branchlets, 30-40° on fertile branchlets, rigid but relatively soft; most pollen cones shorter than their subtending leaf; cone scales ca. 20, each bearing 2 seeds; distal projections of bracts and cone scales 1-2mm.	1b var sinensis

Opportunities for conifer diversification

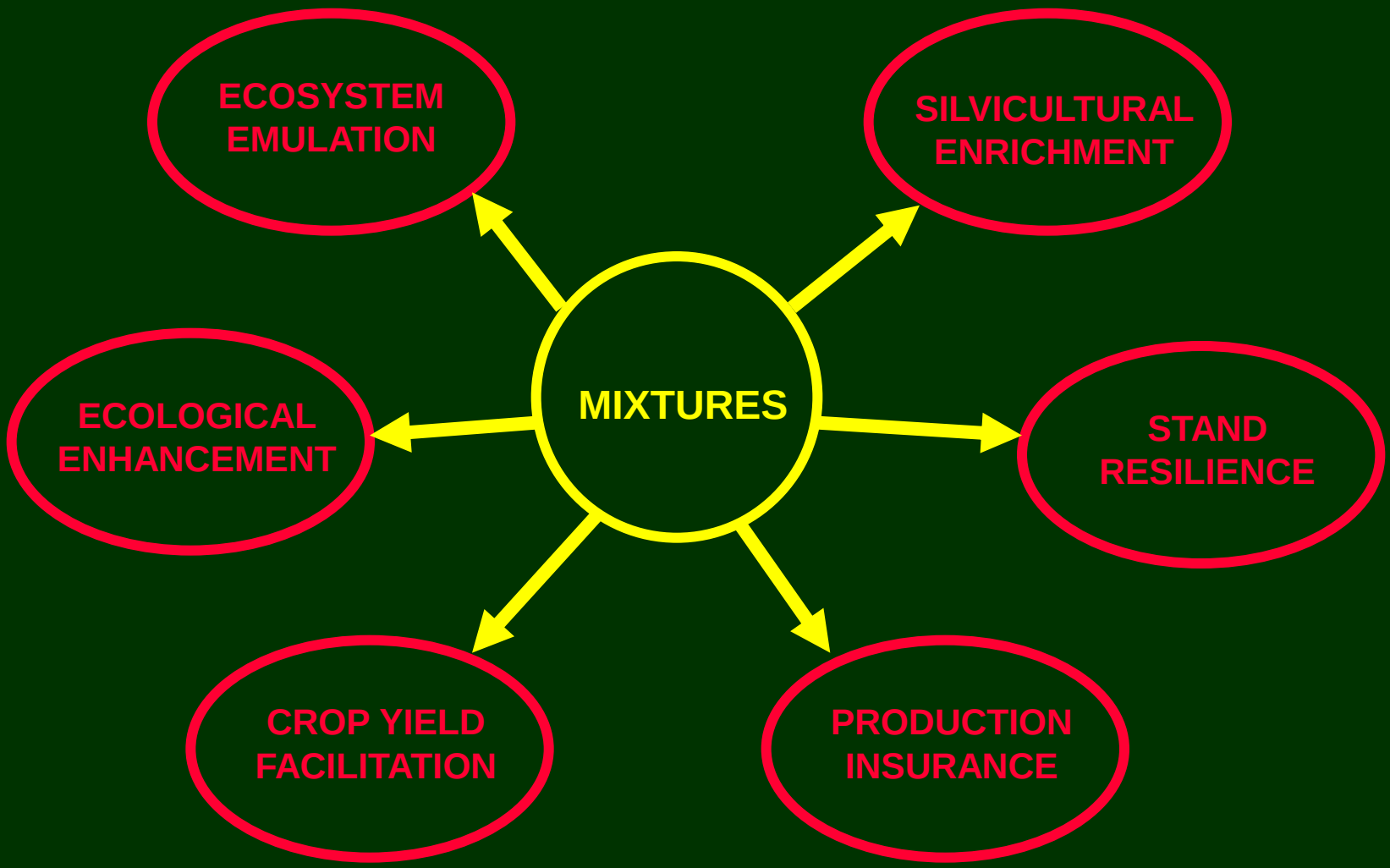
- New planting or restocking situations.
- Most alternatives are shade-tolerant/ later-successional => really need top/side shelter.
- Most alternatives are deer palatable and hence fencing is almost always required.
- Longer/ more expensive plant supply cycle => need to move toward contract growing.
- Need for better early tending, cleaning – no scope for “limited intervention” forestry.

Deployment of alternative conifers

- Single species new plantations or restocks – but need to consider species requirements.
- Establishment/ restocking with mixtures (e.g. SS/WH, SS/DF, SS/PSF, SS/NF).
- Preparatory underplanting/ interplanting of Sitka spruce, pine or larch stands with shade bearing alternative conifers (WH, RC, SF).
- Use within continuous-cover forestry (CCF) systems with Sitka spruce or other altcons.

MIXTURES

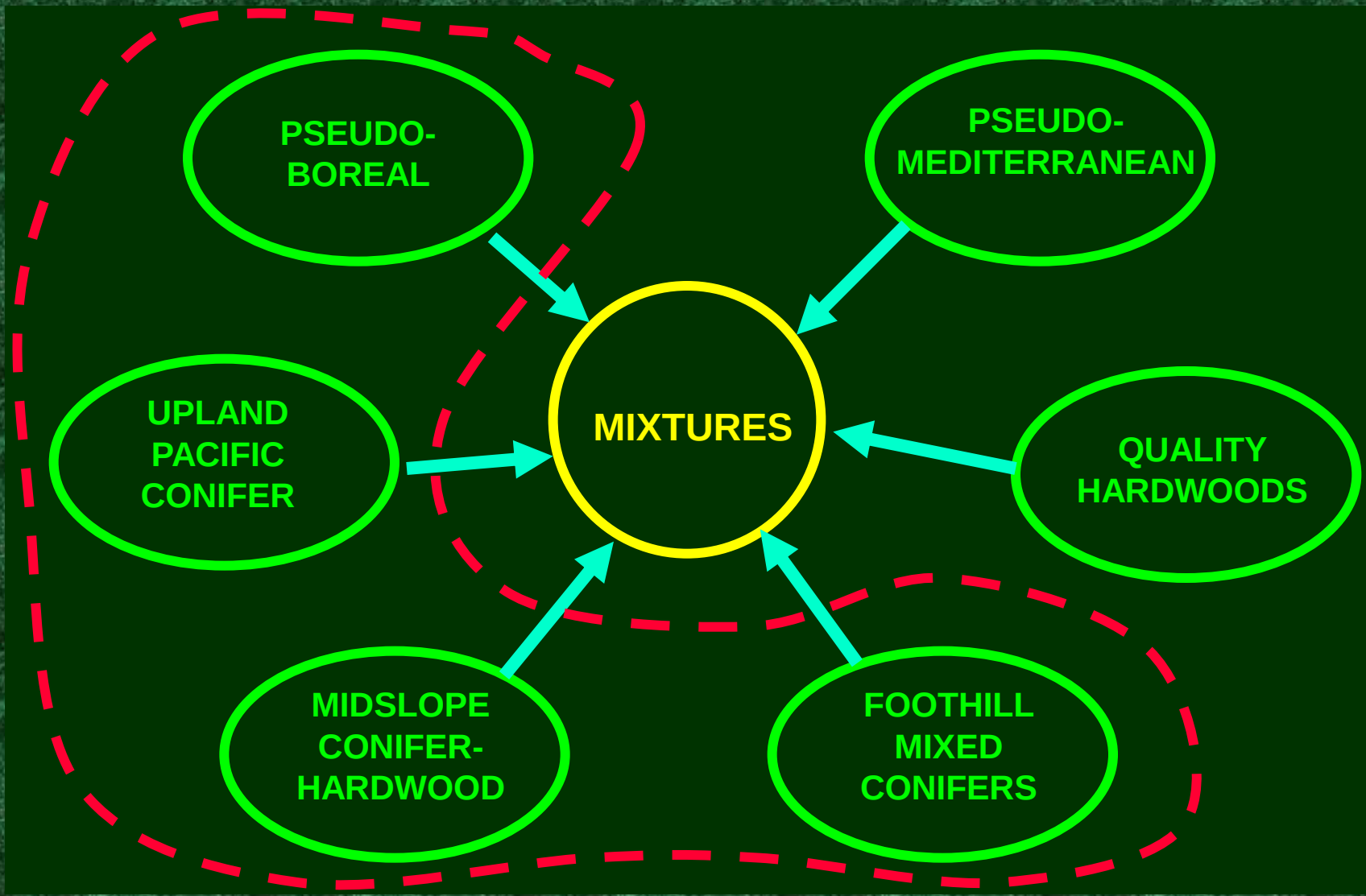
Objectives/ advantages of mixtures



Fundamental types of mixture

- Nursing mixture – the nurse species is generally suppressed or removed during first half of planned rotation (SS/LP)
- Rotational mixture – original established mixture persists until clear-felling of whole stand at a compromise rotation age.
- Permanent mixture – original established mixture persists in perpetuity (e.g. CCF)

Species composition of mixtures



Composition of mixtures for Britain

- ‘Pseudo-boreal’ – normally Scots pine/ birch/ aspen (NVC W17-19) but may add species such as Macedonian pine, Serbian and Norway spruces.
- ‘Upland Pacific conifer’ – simpler mixtures of Sitka spruce and other Pacific conifers including hemlock, silver firs, noble fir, (Douglas fir?).
- ‘Midslope conifer-hardwood’ – modelled on European forests – e.g. Norway/ Oriental spruces, silver firs, beech, oak, sycamore (+DF, RC?).

Composition of mixtures for Britain

- ‘Foothill conifers’ – richer mixtures on better sites with Douglas fir, red cedar, redwoods, grand fir usually managed under CCF systems..
- ‘Quality hardwoods’ – dominated by timber hardwoods – oak, ash, sycamore, elm, maple etc. – but can have a minority of valuable conifers.
- ‘Pseudo-Mediterranean’ – for coastal sand and dry lowland sites – dominated by pines (SP, CP, MAP, RAP) but can add in cedars, silver firs, evgn. oaks.

Dr. Scott McG. Wilson MICFor

Consultant Forester and Forest Ecologist

The potential for use of rotational mixtures with Sitka spruce in British upland forests

Technical Report to SFT - November 2014

Available from www.scottishforestrytrust.org.uk

Source: Scottish Forestry, 2015

Alternative models for productive upland forestry
Model 2: Sitka spruce mixtures with alternative conifers

by Scott McG. Wilson[1] and *Andrew D. Cameron[2]*

[1]*Chartered Forester and Rural Surveyor, 3 Thorngrove Crescent, Aberdeen AB15 7FH*
[2]*Department of Forestry, Institute of Biological and Environmental Sciences, University of Aberdeen, Cruickshank Building, Aberdeen AB24 3UU*
[*]*Correspondding author. E-mail: scottmcgwilson@hotmail.com*

Summary

Upland forestry in Britain is currently dominated by two management models - (a) even-aged medium-rotation plantations of predominantly Sitka spruce (*Picea sitchensis* [Bong.] Carr.) and (b) conservation or ecological restoration of native woodland with minimal production outputs. To meet emerging objectives and address current challenges to sustainable operation, a wider range of upland forestry management models should be considered. Emerging objectives include mitigation of climate change by enhanced carbon sequestration and increased production of woodfuel biomass, alongside ecological restoration and enhanced rural development forestry benefits. Key challenges include impacts of predicted climate change, incidence of novel pests and diseases in existing stands and the need to ensure a sustainable long-term relationship between forest productivity and site, soil and freshwater resources. Deployment of mixed-species stands comprising Sitka spruce and one or more alternative productive conifers, potentially capable of completing the rotation, offers the opportunity to enhance inherent stand resilience while retaining the option of a final crop of the species that is currently preferred by many processors. A recent scoping study has evaluated the principal advantages and challenges associated with this alternative model, considering Norway spruce (*Picea abies* L.), Douglas fir (*Pseudotsuga menziesii* [Mirb.] Franco), western hemlock (*Tsuga heterophylla* [Raf.] Sarg.), silver firs (*Abies* spp.) and western red cedar (*Thuja plicata* Don ex D. Don) as the most likely "companion conifers" to Sitka spruce. Key requirements for research and development are discussed, which would be essential to support wider and more confident operational adoption.

Context

Upland forestry (above 300m asl, but lower in hyper-oceanic districts) is pursued across large parts of Scotland, Ireland and Wales and more restricted areas of England (e.g. Dartmoor, the North York Moors, Cumbria and Northumberland). These upland areas of the British Isles currently represent a major proportion of the available production forestry resource, although characterised by site types with multiple environmental challenges including high elevation and wind exposure, low thermal sum/ growing season accumulated temperature, high rainfall, poorly drained and infertile soils. These factors, together with weak road infrastructure and remoteness from sources of labour inputs and industrial processing outlets, restrict the range of tree species and management models considered. Since the 1960s, only two major forest management models have been operated on any scale within these areas - (a) even-aged medium-rotation plantations of predominantly near-monocultures of Sitka spruce (*Picea sitchensis* [Bong.] Carr.) and (b) conservation or ecological restoration of native species woodland with minimal production outputs. While periodic attempts at greater integration and diversification have been made, progress has been limited and these remain two very distinct paradigms.

Several current challenges have emerged to this position, together suggesting that new management models may be required. On the positive side, there is policy prioritisation of a wider range of "ecosystem services", most pertinently climate change mitigation through increased carbon sequestration in both peatland and forests and increased fossil fuel substitution through production of woodfuel biomass. These services are expected to be realised within a context of emphases on landscape amenity, biodiversity conservation, ecosystem restoration and rural economic development benefits from upland forest management. On the negative side are heightened challenges to the "natural capital" from which these services derive, including adverse climate impacts, novel pests and diseases affecting existing tree species choices and the specialisation of the UK timber processing sector, favouring a narrow range of commercial "whitewood" conifer species. One approach to these challenges is to develop upland production forestry models based on deployment of mixed-species stands combining existing preferred species with alternative tree species (Mason, 2006a, 2012a&b; Mason and Perks, 2011) in order to enhance inherent resilience while retaining economic timber potential. This paper deals with mixed-species stands combining Sitka spruce (as the preferred upland conifer) with a range of alternative conifer species with proven timber production potential, and the ability to complete a

Conifer mixtures in Britain (ex SS/LP)

- Saw some popularity in the period 1950-1970, with some surviving examples.
- Largely neglected as an approach since 1970 due to emphasis on pure SS crops.
- Remaining examples scattered, small and generally silviculturally rather neglected.
- Lack of operational experience/ skills.
- BUT – significant potential for the future.

NS/ SS mixture, Archiestown, Moray

DF/ SS mixture, Balnacoul, Moray

WH/ SS mixture, St. Gwynno, Wales

GF/ SS mixture, Kirkhill, Aberdeen

NF/ SS mixture, Penllyn, Wales

GF/ SS mixture, Wales

RC/ SS mixture, Stromeferry, Highland

ENRICHMENT

Forestry Commission

Silvicultural Guide

Successful underplanting

by

Gary Kerr and Jens Haufe

Version 1.0 October 2016

Table 2 Shade tolerance of main and emerging species in Britain

Light demanding	Intermediate	Shade tolerant
Main species		
European larch	Douglas-fir	Grand fir
Japanese larch	Noble fir	Norway spruce
Hybrid larch	Sitka spruce	Western hemlock
Corsican pine		Western red cedar
Scots pine		Yew
Lodgepole pine		
Silver birch	Ash	Beech
Downy birch	Cherry	Field maple
	Sessile oak	Hornbeam
	Pedunculate oak	Sycamore
	Rowan	Small-leaved lime
	Sweet chestnut	Wych elm
	Whitebeam	
Emerging species*		
Cedar of Lebanon	Atlas cedar	Coast redwood
Maritime pine	Leyland cypress	European silver fir
Radiata pine	Macedonian pine	Japanese red cedar
Wellingtonia	Oriental spruce	Lawson's cypress
	Serbian spruce	Caucasian silver fir
	Weymouth pine	Pacific silver fir
Common alder	Big leaf maple	
Grey alder	Norway maple	
Italian alder	Silver maple	
Red alder	Red oak	
Aspen		
London plane		
Common walnut		
Black walnut		

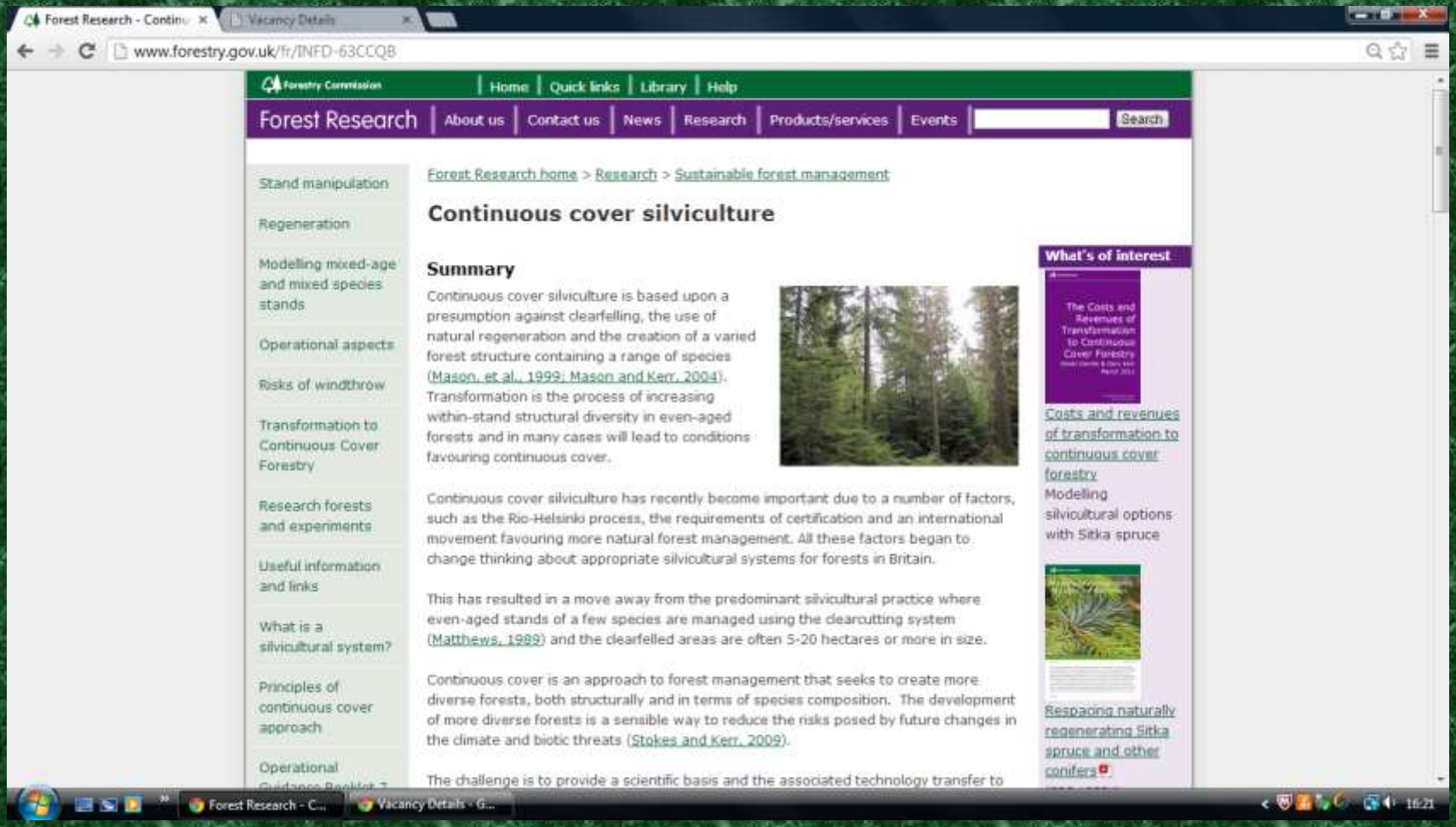
* A group of species that have been identified as possible candidates for more extensive planting but where knowledge and understanding is incomplete; for more information see http://www.forestry.gov.uk/fr/treespecies.

Publications available from www.forestry.gov.uk/publications

CONTINUOUS-COVER FORESTRY

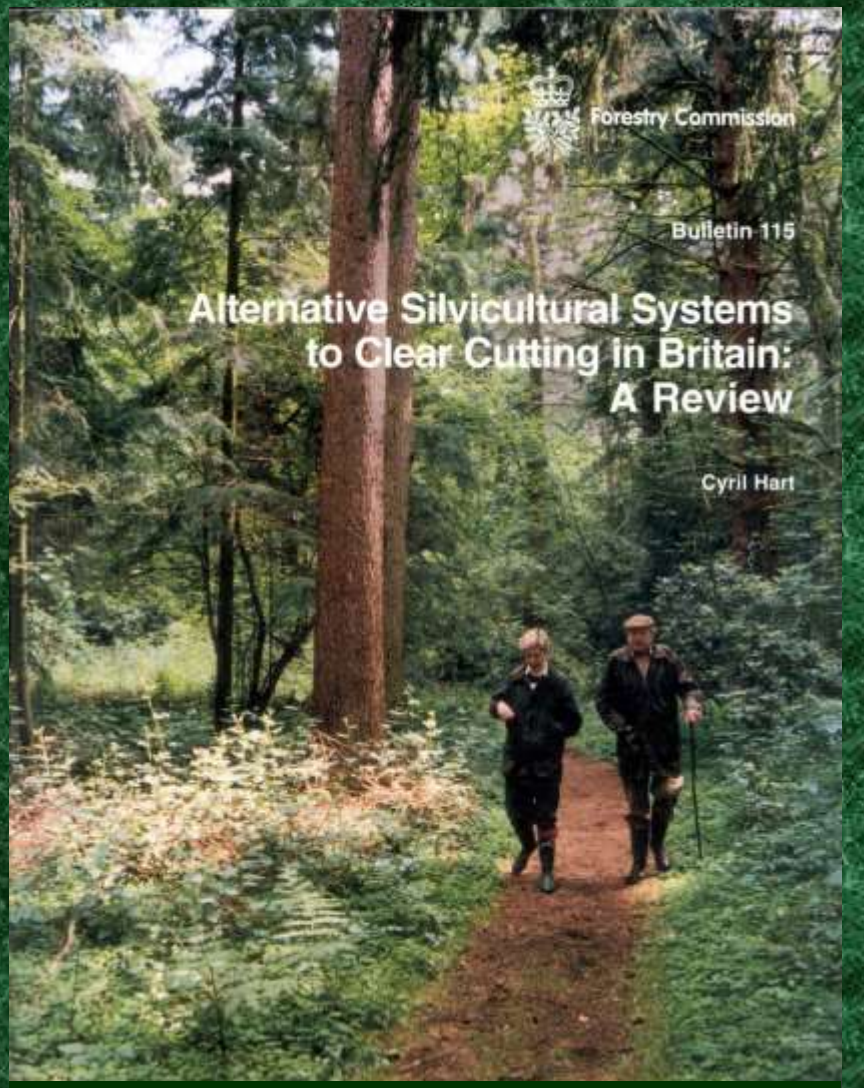
CCF in Scotland – small but growing

- Clearfell-replant remains dominant in both Scottish forestry culture and practice.
- Alternative silvicultural systems speak for <15% of the resource, better developed examples for 3-5% of the resource at most.
- Adoption is expanding in response to policy drivers, but still remains variable/ hesitant.
- Main barriers are wind exposure, costs, lack of familiarity/ skills, unsuitable machinery.



Information available from www.forestry.gov.uk/fr

See also: Continuous-Cover Forestry Group [www.ccfg.org.uk]



Publication available from www.forestry.gov.uk/publications

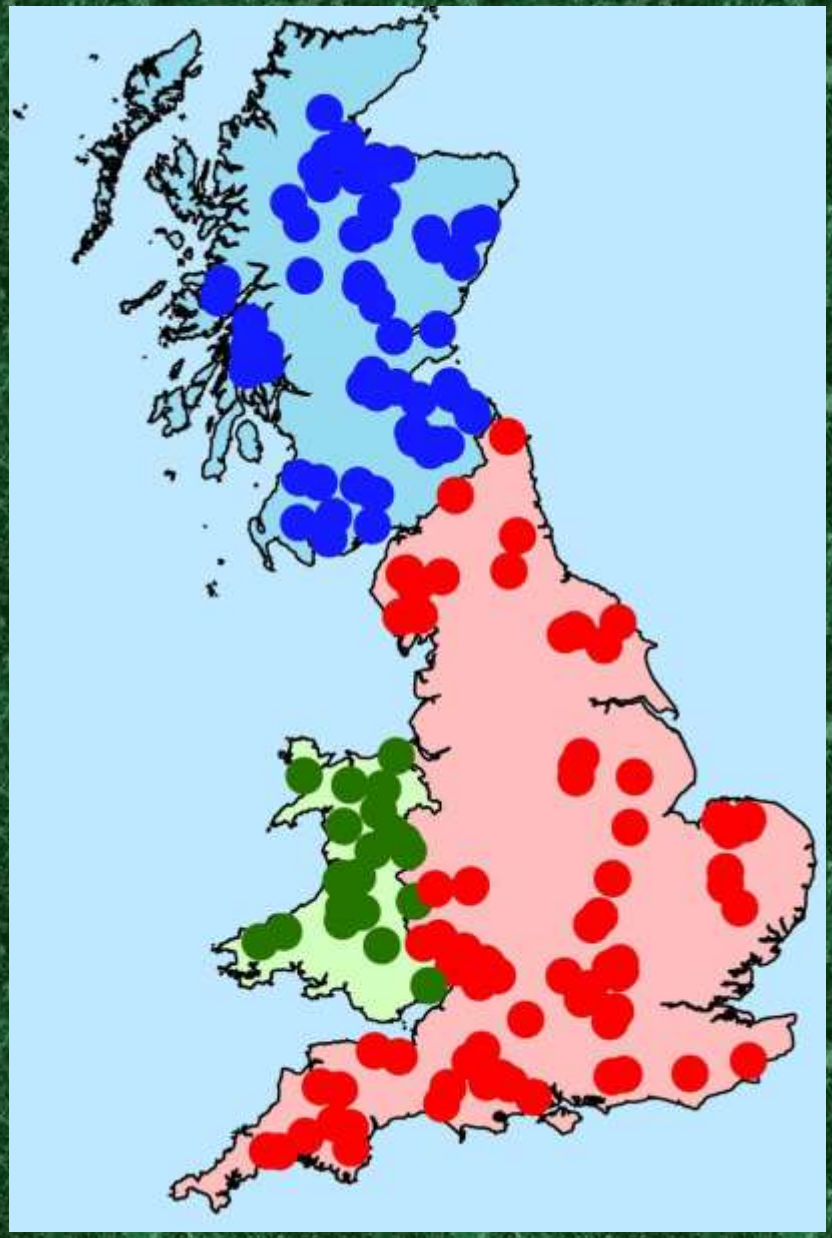
Dr. Scott McG. Wilson MICFor

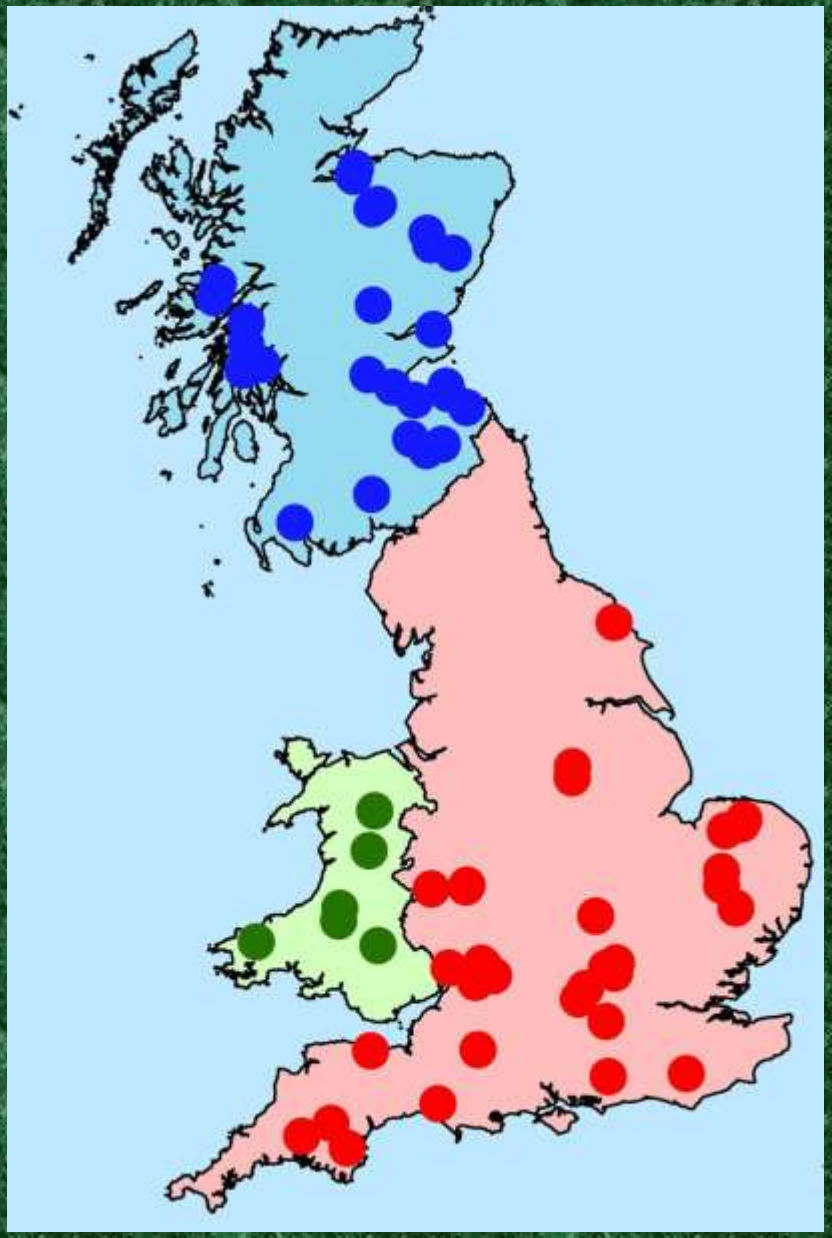
Consultant Forester and Forest Ecologist

Progress of adoption of alternative silvicultural systems in Britain: an independent review

Technical Report - March 2013

Available from www.scottishforestrytrust.org.uk





Upland examples of alternative silvics.

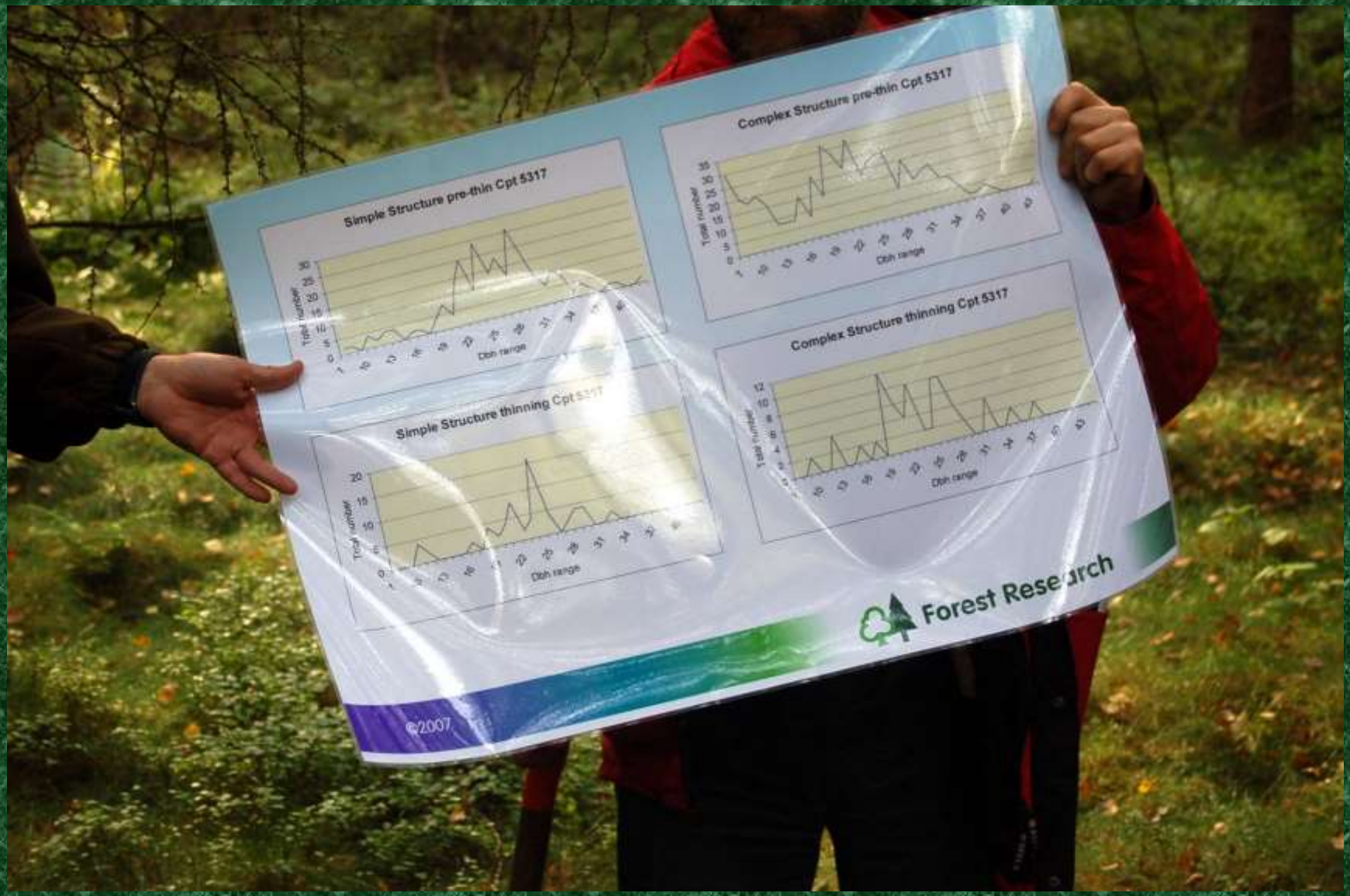
Species diversification

- Glentress
- Wykeham
- Corrour

Structural development in pure Sitka crops

- Cefn Llwyd
- Cwm Berwyn
- Clocaenog
- Fernworthy


1
2
3
FELLING PROPOSALS MAP
North York Moors Forest District


Simple Structure pre-thin Cpt 5317
Complex Structure pre-thin Cpt 5317
Simple Structure thinning Cpt 5317
Complex Structure thinning Cpt 5317
Tree number
Dbh range
Forest Research
©2007

SPECULATIONS ON THE FUTURE RESOURCE

Suggested 2087 conifer proportions?

Sitka spruce 35% (down from 55-60%)

Pines 25% (down from 30%)

Larches 5% (down from 8%)

Other spruces 7.5%

Douglas fir 5%

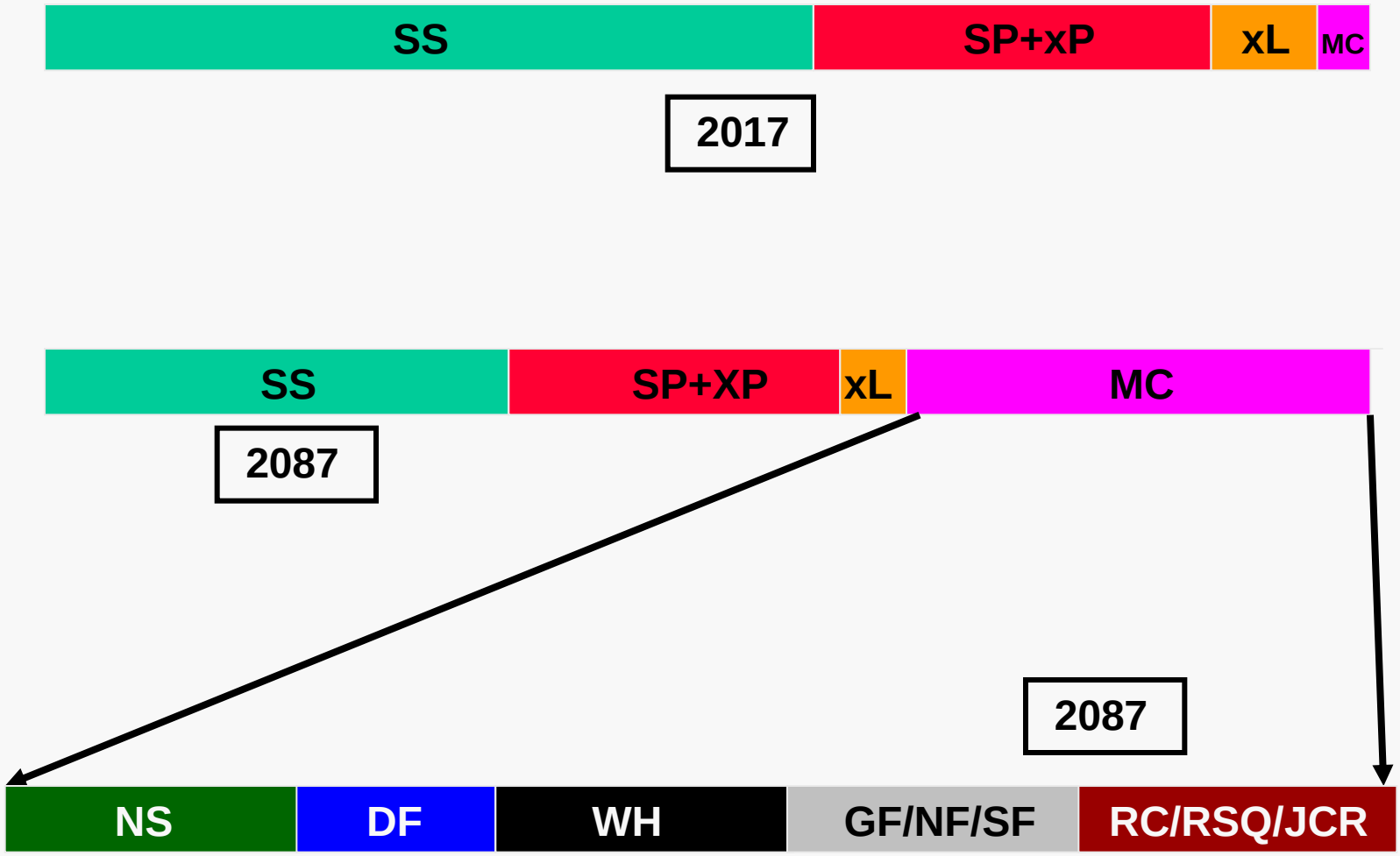
Abies firs 7.5%

Western hemlock 7.5%

Redwoods and red cedar 7.5%

35% (up from <5%)

Suggested 2087 conifer proportions?



MARKETING AND PROCESSING

Implications for conifer marketing

- Move away from "Scandinavian-style" of spruce forestry towards "mixed Continental/ PNW-style"
- More species, but smaller volumes of each – i.e. need "portfolio marketing" or "niche marketing".
- Alternative species are readily marketed in BC etc but UK markets/ prices will need development.
- Non-whitewood supplies (e.g. RC) will rise as a proportion of the total UK timber assortment.
- Diameter class/ rotation lengths will drift upwards (e.g. 60-90cm, 60-90 years) (but less in uplands).

Forest Research

Timber Properties of Minor Conifer Species

A report to the Forestry Commission

James Ramsay and Elspeth Macdonald

The Research Agency of the Forestry Commission

Species	SG	MoE	MoR	Side Hardness	Number of samples	Sizes	Region	Reference	Natural durability class
		kN/mm²	N/mm²	N					
Pacific silver fir *Abies amabilis*	0.36	11.3	69			Small clears	Canada	Wood Handbook	
European silver fir *Abies alba*	0.40	9.8	79	2850	15 trees	Small clears	UK	Lavers, 2002	4
European silver fir *Abies alba*	0.38	8.8	77	2490	28 joists	Structural	Yugoslavia	Lavers, 2002	
Scots pine *Pinus sylvestris*	0.46	10.0	89	2980	61 trees	Small clears	UK	Lavers, 2002	3 to 4
Lodgepole pine *Pinus contorta*	0.40	10.9	76			Small clears	Canada	Wood Handbook	3 to 4
Lodgepole pine *Pinus contorta*	0.42	8.1	79	2940	26 trees	Small clears	UK	Lavers, 2002	
Maritime pine *Pinus pinaster* - UK	0.43	8.9	77	2670	7 trees	Small clears	UK	Lavers, 2002	
- Atlantic	0.52	10.0	38		351 joists	Structural	Spain	Fernandez-Golfin, 1996	
- Mediteranean	0.53	9.1	36		176 joists	Structural	Spain	Fernandez-Golfin, 1996	
Macedonian pine *Pinus peuce*	0.36	4.8	52			Small clears	UK	Lines, 1985	
Western red cedar *Thuja plicata*	0.32	7.7	52	1600		Small clears	U.S.	Wood Handbook	
Western red cedar *Thuja plicata*	0.33	7.0	65	2000	10 trees	Small clears	UK	Lavers, 2002	3
Western hemlock *Tsuga heterophylla*	0.38	8.0	76	2580	15 trees	Small clears	UK	Lavers, 2002	4
Western hemlock *Tsuga heterophylla*	0.45	11.3	78	2400		Small clears	U.S.	Wood Handbook	
Western hemlock *Tsuga heterophylla*	0.41	12.3	81			Small clears	Canada	Wood Handbook	
Leyland cypress *Cupressocyparis leylandii*	0.40	5.9	77	2980	3 trees	Small clears	UK	Lavers, 2002	

Western red cedar - *Thuja plicata*

Data are presented from both the US and from 10 trees grown in the UK. This species is used extensively in external applications, particularly cladding.

Western hemlock - *Tsuga heterophylla*

The values presented for UK data (small clears from 15 trees) suggest that western hemlock grown in the UK has a lower wood density and lower stiffness than material grown in the US and Canada. However, from the available data it is impossible to determine whether this difference is due to differences in sample age (e.g. greater proportion of juvenile wood in the UK sample than in the N. American samples), or if there is an actual difference in wood properties when samples of a similar age are compared. The timber from this species is used in construction and external applications.

Leyland cypress - *Cupressocyparis leylandii*

These values are based on a small clears testing from a very small number of trees. The high MoR value and low MoE value may not be representative. There is some evidence to suggest that the heartwood is moderately durable.

Atlas cedar - *Cedrus atlantica*

This species is being used extensively to re-forest large areas of Italy. The relatively high MoE and MoR values presented here are encouraging but are based on small clears on a sample of only 6 trees so caution should be used in their interpretation. This is the primary source of construction timber across Morocco.

Publication available from www.forestry.gov.uk/publications

Forestry Commission

Research Note

Timber properties of noble fir, Norway spruce, western red cedar and western hemlock grown in Great Britain

David Gil-Moreno, Dan Ridley-Ellis and Paul McLean December 2016

The softwood processing sector in Great Britain has been built around the use of a very small number of timber-producing species – predominantly Sitka spruce. The recent increase in outbreaks of host-specific tree pests and diseases has led to an interest in diversification, through planting a wider range of tree species, to mitigate any risk to the softwood resource. However, there is a lack of evidence about how this diversification will impact on the future merchantability of timber. This Research Note investigates the structural timber properties of noble fir, Norway spruce, western red cedar and western hemlock grown in Great Britain and compares the results with published values for British-grown Sitka spruce. The study was carried out using timber from even-aged plantations growing in a range of latitudes representative of productive conifer forests. Twenty-seven trees per species were felled, processed into structural-sized battens, kiln dried and destructively tested in a laboratory according to current European standards. Characteristic values of mechanical properties and density were determined and indicative yields for different strength classes were calculated. The results showed that all of the species investigated can produce structural timber, but that western red cedar has the least desirable properties for this purpose. Some further work is under way in order to investigate the effect of rotation length on the timber properties of these species.

FCRN026

Figure 4 Processing of a log of Norway spruce in Aberfoyle.

Figure 5 Destructive test of a Norway spruce specimen at Edinburgh Napier University.

(CEN, 2016c) and compared to the requirements of the most common strength classes EN 338:2016 (CEN, 2016a) shown in Table 2. In simple terms, a timber population tested in this way is allocated to a strength class if its characteristic (here 5th percentile) values of bending strength and density equal or exceed the values for that strength class and its characteristic mean bending stiffness equals or exceeds 95% of the value for that strength class. The mean and 5th percentile of a generic population are demonstrated in Figure 6. Timber cannot be allocated to a strength class unless the requirements are met for all three properties, so in the case where one property does not allow allocation of a higher strength class it becomes limiting. Therefore the strength class is determined by

Figure 6 Population statistics associated with timber grades. 95% of values are above the 5th percentile. A timber grade provides a mean value of stiffness and a 5th percentile value for strength and density. Grading removes the unfavorable pieces to increase the mean and/or 5th percentile.

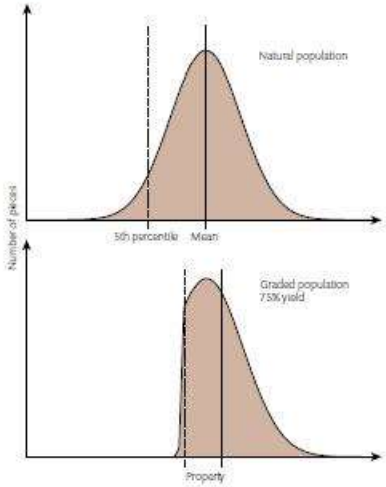


Table 2 Characteristic values for strength classes C14 to C24 (CEN, 2016a). Strength and stiffness values apply to bending.

Wood property	Characteristic property values for each strength class					
	14	16	18	20	22	24
5th percentile strength (N mm^{-2})	14	16	18	20	22	24
Mean stiffness (kN mm^{-2})	7	8	9	9.5	10	11
5th percentile density (kg m^{-3})	290	310	320	330	340	350

Market potential of alternative spp

Dimension-lumber/ structural whitewood

Alternative spruces, western hemlock, silver fir.

Non-load bearing / pallet/ massive timber etc.

Alternative spruces, western hemlock, Macedonian pine, *Abies* firs, birch/ aspen.

Special purpose/ cladding timbers.

Western red cedar, western hemlock.

[but may require a distinct processing model]

Market potential of alternative spp

Particle board

All alternative species have potential.

[but darker species may require new lines?]

Pulp and paper.

All alternative species have potential.

[but RC and WH may require a chemical mill?]

Biomass/ woodfuel.

All alternative species should be suitable.

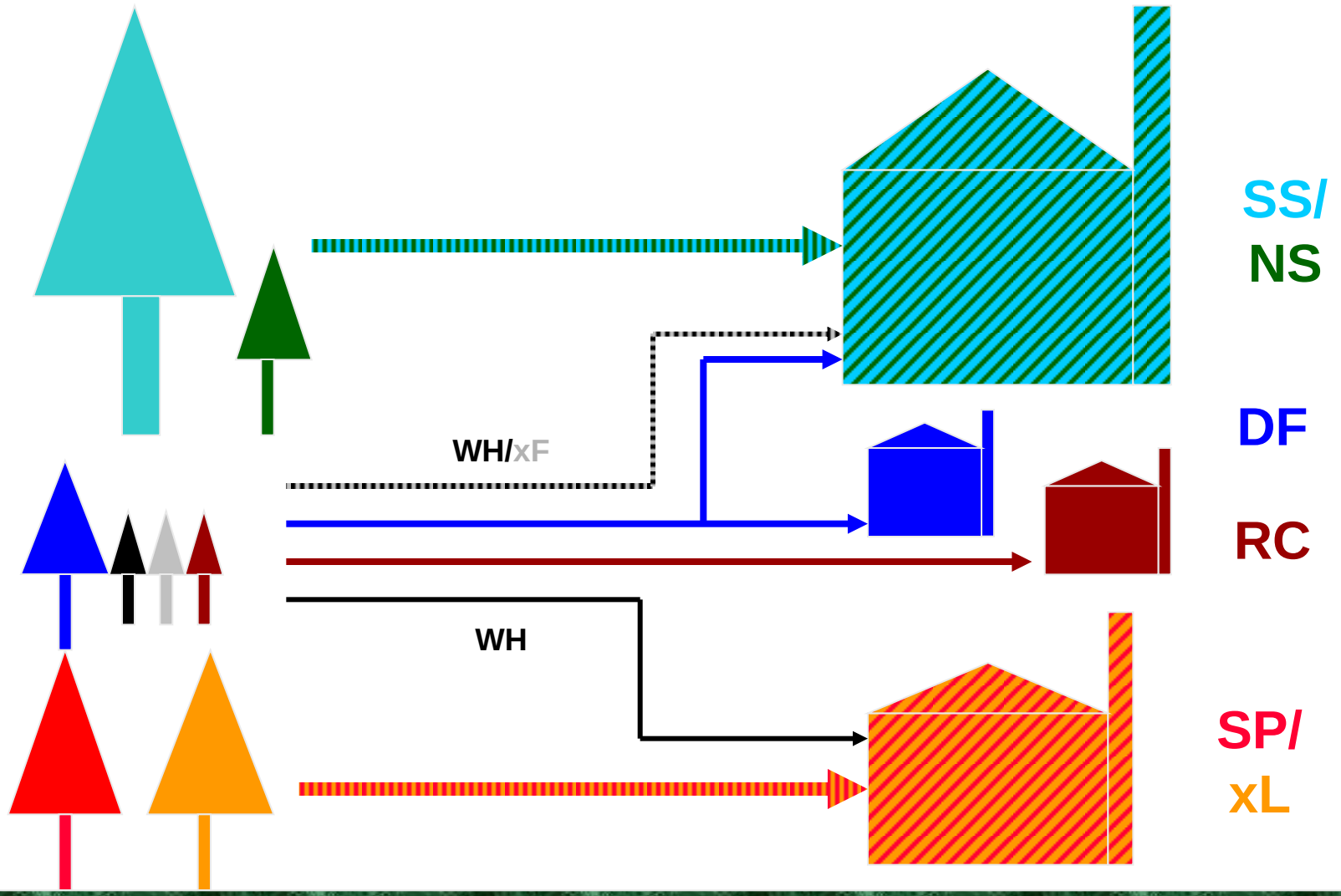

Wood-Mizer


The Birnam Institute

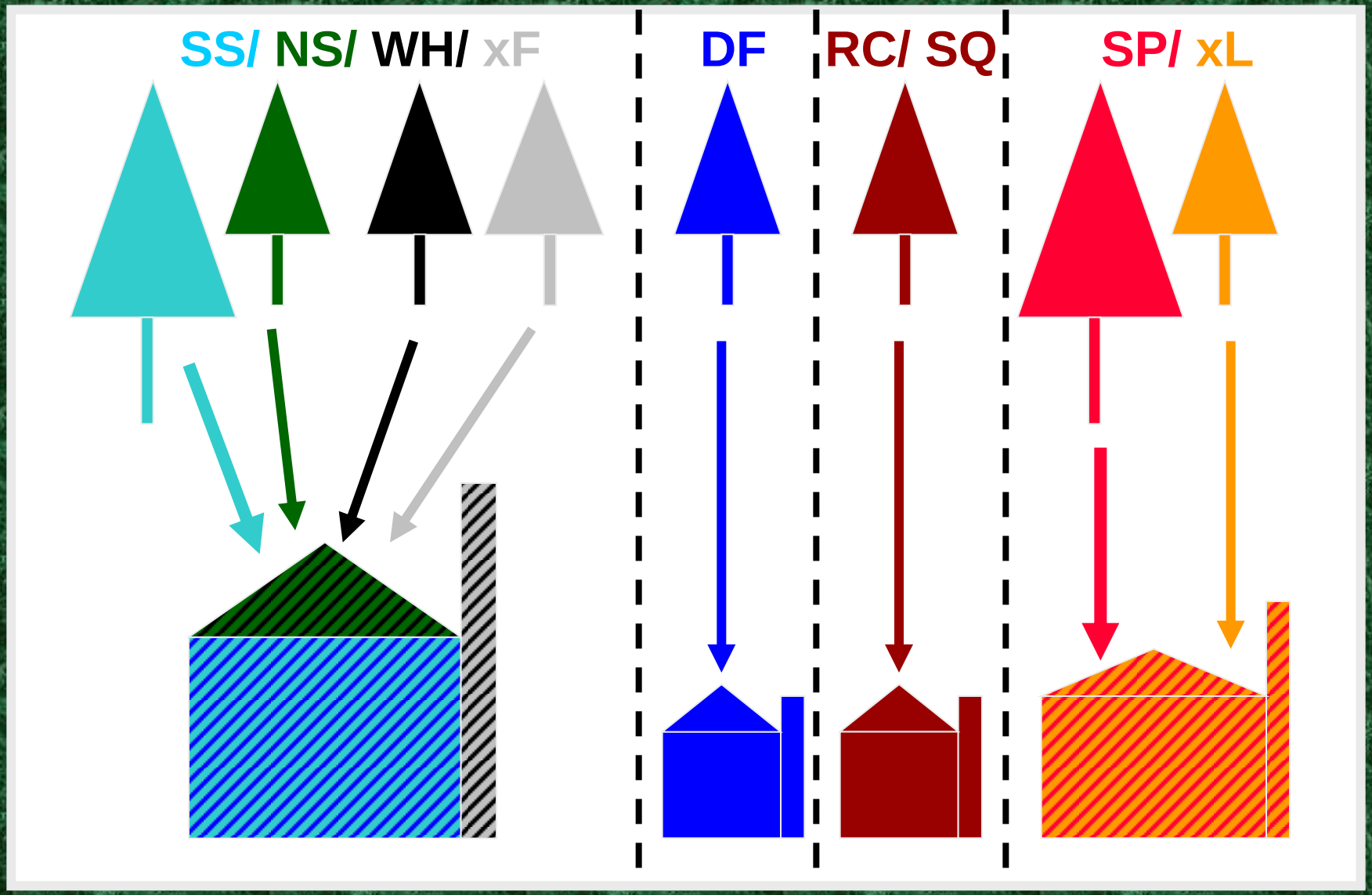
Implications for conifer processing

- Shift away from a “primacy of efficiency” paradigm towards “optimising diversity” – trade off some efficiency for reduced risks.
- Batch processing (optimised by species) partially replaces “continuous SS flow”.
- Technological flexibility in processing (e.g. rapid retooling, stress grading curves etc.)
- More local/ estate-scale processing, higher value-added, vertical integration etc.

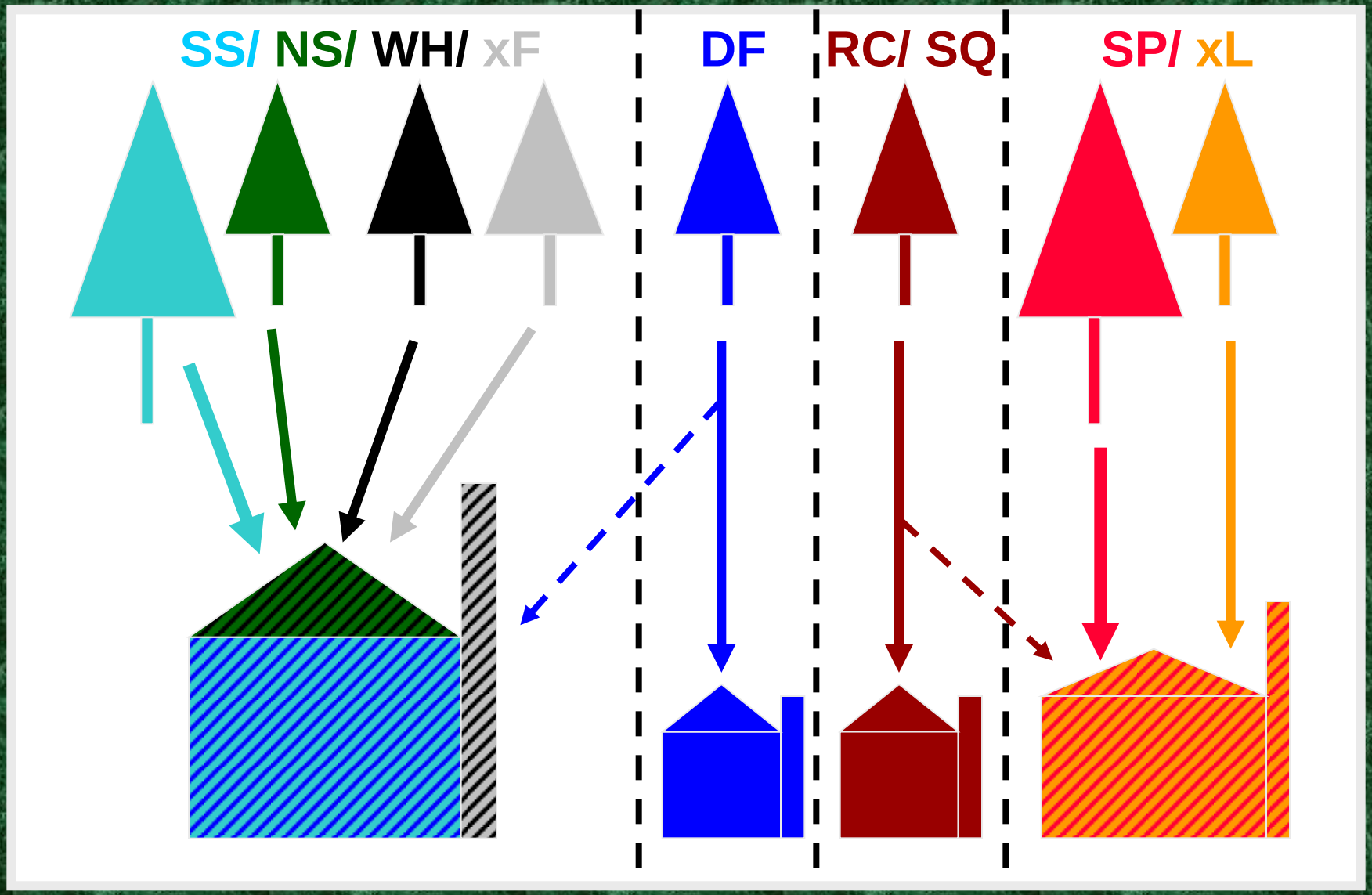
Alternative processing strategies - now



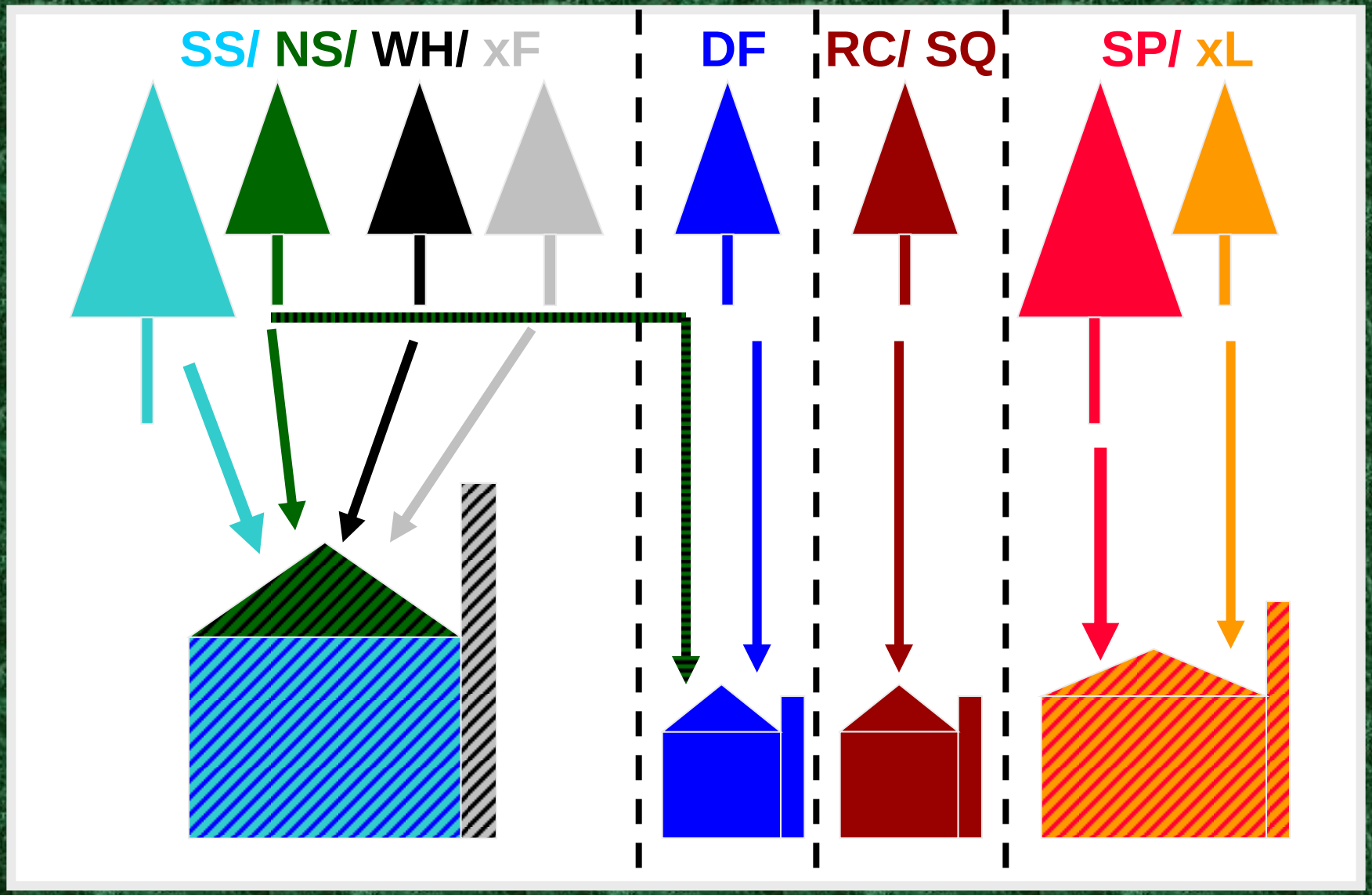
Alternative processing strategies - 2087



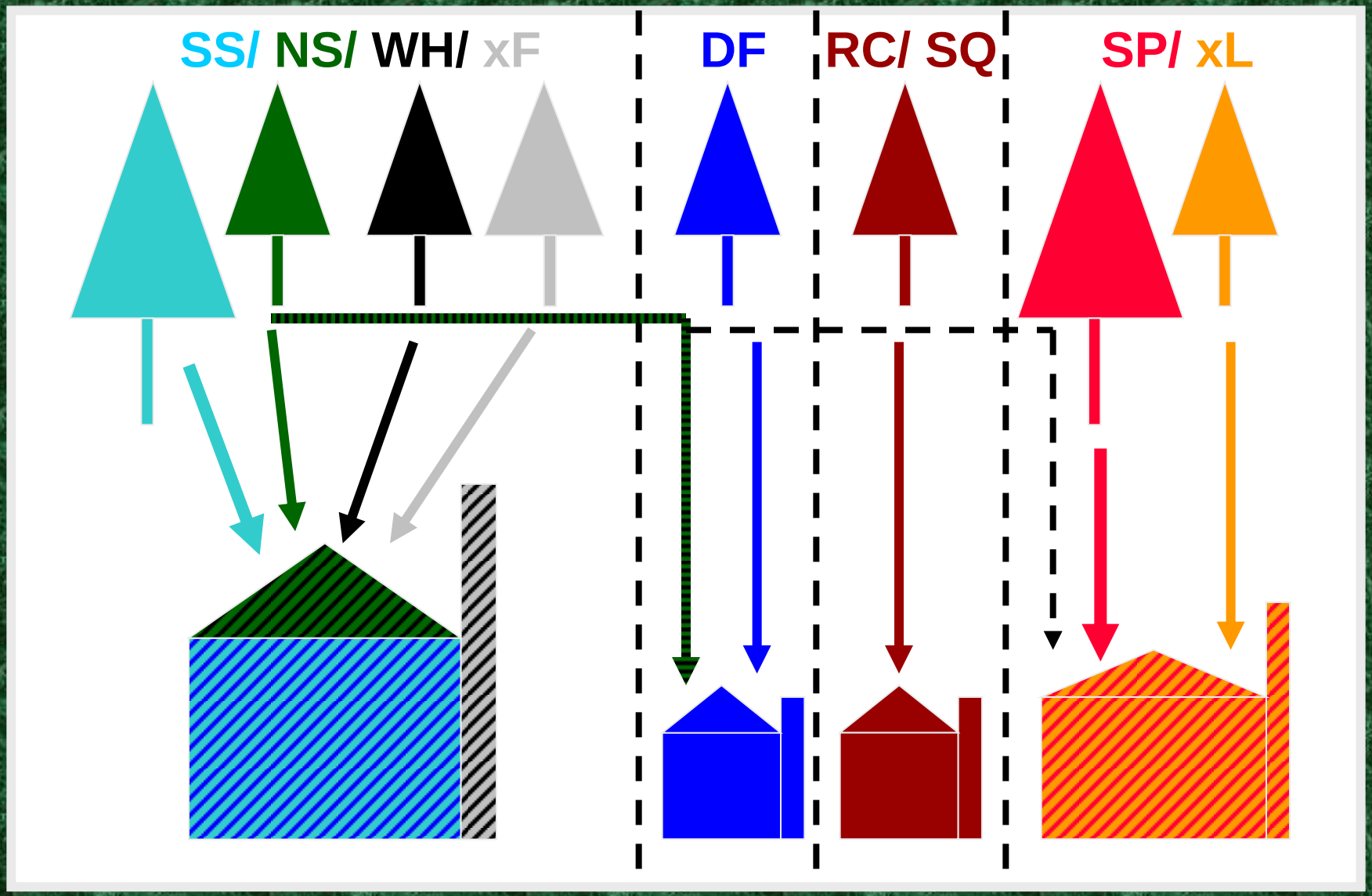
Alternative processing strategies - 2087



Alternative processing strategies - 2087



Alternative processing strategies - 2087



CHALLENGES AND RESEARCH PRIORITIES

Challenges for conifer diversification

- Exposed steep sites and infertile, wet soils.
- Current “fleet” of trials and experiments weighted to more favourable conditions.
- Issues with availability/ adoption of more flexible/ lighter-weight harvesting kit.
- Skill shortages – esp classical silvicultural/ site expertise and motor-manual working.
- Specialisation of sawmilling fleet for large throughput of medium diameter spruce.

Challenges for conifer diversification

- Overall move away from post-1980 “search for simplicity and efficiency” paradigm towards one “accepting and re-embracing complexity” in our forestry management.
- Prioritises more experienced, long-service silvicultural foresters managing relatively compact estate or “beat” scale holdings.
- May shift the balance away from “max IT” back towards a more “intuitive” forestry.

Research and development needs

- Continued species and silvicultural trials to develop the best alternatives for uplands.
- Silvicultural demonstration forests with more aggressive diversification work and more intensive enumeration/ monitoring.
- Developing high-tech “batch processing” and “rapid retooling” saw-milling strategies.
- Productive new native woodland options for upland sites (downy birch-aspen-alders)