Establishing robust species mixtures

by Gary Kerr, Jens Haufe, Victoria Stokes and Bill Mason

Summary:
Present policies are encouraging forest managers to develop greater resilience in forests throughout Britain. Use of mixed-species stands is one way to achieve this but there is currently a dearth of guidance on this subject available to forest managers. This paper describes a method to design robust mixtures of species at the establishment phase. It requires an estimate of top height at age 20 for the species that will be grown in the mixture and knowledge of their shade tolerance. The method has been validated against the growth and development of some Forest Research mixture experiments. The method now requires wider 'operational testing' to indicate strengths and weaknesses; forest managers are invited to try the method and feedback to the authors.

Introduction

Policies that are encouraging the development of more resilient forests have led to increasing interest about the silviculture of mixed-species stands. However, there is presently a dearth of guidance for forest managers on this subject in the modern literature – a deficit we are hoping to correct with work currently in progress in Forest Research. Some guidance on conifer/broadleaved mixtures is given in Evans (1984) and Mason (2006). In general, the advice is to: (1) grow compatible species and (2) design robust patterns of mixtures where each species is able to survive until the time of first thinning. The guidance is to use small block mosaics, strips or bands of species rather than intimate mixtures but there is limited advice on how to do this. The exception to this is that Evans (1984) suggested a rule-of-thumb stating that the anticipated yield class of the conifer should not be more than 1.5 to 2 times greater than that of the broadleaved species, which was validated for some upland conditions by Mason (2006). Evans (1984) also offers guidance on mixtures of broadleaves and makes the point that, in general, compatibility is less of an issue and mixture design is 'relatively unimportant'. More recently, guidance on the creation of new native woodlands, which by definition include a number of different species, is given in Rodwell and Patterson (1994). However, the information is limited to lists of potential species to include with scant information on how to design a robust mixture.

In conifer forests the most well-known use of species mixtures is between Sitka spruce and pine or larch on sites dominated by heather. In these situations, the effect of the mixture can be to increase the supply of nitrogen to the Sitka spruce and prevent deficiency when the trees get to 8-10 years old (Morgan et al., 1992). General guidance on mixed-species stands of conifers is sparse but Wilson (2014, 2016a, 2016b) and Wilson and Cameron (2015) have examined the subject. However, they did not cover the shade tolerance of the species to be mixed and the main aim of their work was not to provide guidance on the design of different species mixtures.

In countries where the silviculture of mixed-species stands is better developed than in Britain it's clear that there are two key factors to consider in designing a robust mixture: growth rate (specific to the site) and shade tolerance (Oliver and Larson, 1996). If two species in a mixture have the same growth rate and similar shade tolerance then they are likely to be compatible and it should be relatively easy to establish a robust mixture between them; for example, Sitka spruce and Douglas fir. However, if two species in a mixture have different growth rates their shade tolerance becomes much more important. To illustrate this let's consider Norway spruce mixed with either beech, which is shade tolerant, or birch, which is light demanding. The fact

> "There are two key factors to consider in designing a robust mixture: growth rate and shade tolerance."

X	O	X	O	X
O	X	O	X	O
X	O	X	O	X
O	X	O	X	O
X	O	X	O	X

X = Species A
O = Species B

Figure 1. An example planting design of an intimate mixture.

that there are differences in shade tolerance between beech and birch when mixed with Norway spruce does not mean that one combination will work whereas the other will not. It just means that the design and management of the mixture must take account of the differences in shade tolerance if it is to be classed as a robust mixture (the term is defined below).

Based on this understanding we have developed a method that aims to give forest managers generic advice on the design of species mixtures at establishment for stands *that will be thinned*. The advice can be applied to mixtures of two species where each makes up more than 25% of the trees that will be planted and the plan is for them both to survive for most of the rotation; it should not be used for self-thinning mixtures or mixtures established by underplanting. The method is flexible and can be adjusted to add extra species at the end of the process (Step 4 of the method below) or by accounting for natural regeneration from seed trees close to the planting area.

"The method has been designed to help forest managers design robust mixtures of two main species."

Method

To use and understand the method it is important to be clear on four important terms that are defined as follows:

Intimate mixture: a mixture where each species is planted singly or in small groups in close proximity; an example is shown in Figure 1.

Compatible: two or more species that can be planted in an intimate mixture and will survive in more-or-less the proportions used at establishment until the time of first thinning.

Compatibility Score: a number used to indicate the extent to which species in a mixture should be grouped to ensure survival until the time of first thinning.

Robust mixture: a mixture of different tree species that has been designed to ensure that all species will survive in more-or-less the proportions used at establishment until the time of first thinning.

The following method has been designed to help forest managers design robust mixtures of two main species. In summary, it classes the main tree species used in Britain according to growth rate (fast, moderate or slow) and shade tolerance (light demanding, intermediate or shade tolerant), and based on a combination of these categories for the two species a 'Compatibility Score' is determined. Guidance is then given based on the Compatibility Score on how to design a robust mixture of the species, i.e. one in which both the main species will survive and thrive through to first thinning, after which the balance of the mixture can be altered when thinning.

Step 1

Estimate the General Yield Class (GYC) for each species in the mixture based on local knowledge of how they are expected to perform on the site. Then using appropriate yield models, determine the top height that each species will achieve at age 20 and use this to classify growth rate with the criteria in Table 1. Combine this information with the shade tolerance classification for the species shown in Table 2 (overleaf) and transfer the growth rate and shade tolerance for each of the two species to Step 2.

The classifications for shade tolerance in Table 2 are based on Mason et al. (1999) and other sources. For each species growth rate in Table 2 has been classified based on mean GYC for Britain, or an estimate for species not covered by the presently available yield models. These general classifications of growth rate will be inferior to site-based estimates and should only be used where there are real difficulties obtaining site-based estimates.

Step 2

Table 3 (overleaf) shows the 81 combinations that exist for three levels of growth rate and three different shade tolerance classifications for two species. The order of the species should be based on its planned presence in the mixture with the main or most important species being the 'primary species' and the other the 'secondary species'. Use Table 3 to locate the correct combination for your primary and secondary species and note the Compatibility Score for your mixture. If the mixture is planned to be 50:50 then which species is the 'primary' and which is the 'secondary' is at the discretion of the forest manager and should relate to management objectives.

Table 1. Growth rate classification.

Top height at 20 years	Growth rate
>10 m	Fast
≤ 10 m but ≥ 8 m	Moderate
< 8 m	Slow

Step 3

Using the Compatibility Score from Table 3, use the information in Table 4 to design a compatible species mixture, either as a group mixture or a line mixture depending on the context of management of the forest where the new stand will be located. For example, some line mixtures of visually contrasting species should be avoided in areas where they would be prominent in the landscape.

Table 2. Growth rate and shade tolerance classification for tree species in Britain.

Species	Growth rate*	Shade tolerance**
Conifers – main species		
Sitka spruce	Fast	Intermediate
Norway spruce	Moderate	Shade tolerant
Scots pine	Moderate	Light demanding
Lodgepole pine	Moderate	Light demanding
Corsican pine	Moderate	Light demanding
Japanese larch	Fast	Light demanding
Hybrid larch	Fast	Light demanding
European larch	Fast	Light demanding
Douglas fir	Fast	Intermediate
Grand fir	Fast	Shade tolerant
Noble fir	Moderate	Intermediate
Western hemlock	Fast	Shade tolerant
Western red cedar	Moderate	Shade tolerant
Conifers – Emerging species		
Other spruces	Moderate	Intermediate
Other pines	Moderate	Light demanding
Other firs	Moderate	Shade tolerant
Japanese red cedar	Moderate	Shade tolerant
Coast redwood	Fast	Shade tolerant
Giant redwood	Fast	Intermediate
Lawson’s cypress	Moderate	Intermediate
Leyland cypress	Fast	Intermediate
Broadleaves – main species		
Oak	Slow	Intermediate
Beech	Slow	Shade tolerant
Sycamore	Fast	Shade tolerant
Ash	Fast	Intermediate
Birch	Fast	Light demanding
Broadleaves – minor species		
Hornbeam	Slow	Shade tolerant
Sweet chestnut	Moderate	Light demanding
Alder	Moderate	Light demanding
Aspen	Fast	Light demanding
Rowan	Moderate	Light demanding
Lime	Moderate	Shade tolerant
Cherry	Fast	Light demanding

* Growth rate has been based on mean GYC for the main species in Britain or an estimate for others. However, to use the method correctly you must estimate top height at year 20 for the site and then categorise growth according to Table 1.

** Shade tolerance classifications are based on Mason et al. (1999) and other sources. Classifying species by shade tolerance is an inexact science and we also recognise that some species change as they grow.

Step 4

Consider whether you would like to add more species into the mixture. There are two main options: firstly, plan to accept any natural regeneration that may occur on the planting site based on observations of similar sites regenerating in the area; this has the advantage of requiring little, or no, changes to the design of the mixture. Secondly, plan to swap a proportion of one of the species for another in the designed mixture. For example, if you are planning a mixture of Sitka spruce (fast; intermediate) and oak (slow; intermediate) the Compatibility Score is 3 for these two species indicating use of a minimum group size of 121 trees or a 5:5 row mixture from Table 4. However, there would not be a problem swapping c.10% of the oak for beech (moderate; shade tolerant) because the Compatibility Score of oak and beech is ‘2’, indicating the two species are generally compatible. Another option would be to use beech as a beat-up species for the oak.

Step 5

It is worth checking the differences in top height between

Table 3. Compatibility Score for combinations of growth rate and s

Primary species		Secondary species		
growth rate	shade tolerance	growth rate	shade tolerance	Compatibility Score
fast	light demanding	fast	light demanding	1
fast	light demanding	fast	intermediate	2
fast	light demanding	fast	shade tolerant	3
fast	light demanding	moderate	light demanding	2
fast	light demanding	moderate	intermediate	2
fast	light demanding	moderate	shade tolerant	1
fast	light demanding	slow	light demanding	3
fast	light demanding	slow	intermediate	3
fast	light demanding	slow	shade tolerant	2
fast	intermediate	fast	light demanding	2
fast	intermediate	fast	intermediate	1
fast	intermediate	fast	shade tolerant	1
fast	intermediate	moderate	light demanding	4
fast	intermediate	moderate	intermediate	3
fast	intermediate	moderate	shade tolerant	2
fast	intermediate	slow	light demanding	4
fast	intermediate	slow	intermediate	3
fast	intermediate	slow	shade tolerant	2
fast	shade tolerant	fast	light demanding	3
fast	shade tolerant	fast	intermediate	2
fast	shade tolerant	fast	shade tolerant	1
fast	shade tolerant	moderate	light demanding	4
fast	shade tolerant	moderate	intermediate	3
fast	shade tolerant	moderate	shade tolerant	2
fast	shade tolerant	slow	light demanding	4
fast	shade tolerant	slow	intermediate	3
fast	shade tolerant	slow	shade tolerant	3

the two main species later in the rotation, at say 50 years. If the difference in top height between the two species is >5m then it may be worth adding one to the Compatibility Score, or being conservative when deciding on the mixture design, to ensure it is robust well beyond the time of first thinning.

A worked example of the method for the establishment of a 50:50 Norway spruce - Scots pine mixture at Gisburn in Lancashire is shown in Table 5. This worked example is based on the experience of the stand shown in Figure 2. Figures 3 to 5 show application of the method to other forest stands.

Preliminary application of the method

To check the validity of the method it has been used on the results of some Forest Research mixture experiments described by Stokes and Mason (2019) (see Table 6) and

Table 4. Guidance on designing robust species mixtures.

Compatibility Score	Advice on design of robust mixture[1]
1	These are the most compatible mixtures and in theory could be planted as an intimate mix. However, in most practical situations to ensure a robust mixture small groups or line mixtures will be a better option.
2	These are quite compatible mixture combinations that require some element of design to ensure the mixture is robust. For group mixtures consider a minimum size of 49 trees (7x7 planted at 2m x 2m). For line mixtures[2] use a minimum of 3 rows for each species; i.e. for 50:50 mixture this would be 3:3 row mixtures.
3	These combinations can be robust if specific design features are used to establish the mixture. For group mixtures consider a minimum size of 121 trees (11x11 planted at 2m x 2m). For line mixtures[2] use a minimum of 5 rows for each species; i.e. for 50:50 mixture this would be 5:5 row mixtures.
4	These mixture combinations are the most incompatible. If the species are required together in the same management unit a possible way forward is to use a mosaic with each species occupying a minimum area of 0.2ha.

[1]This is guidance and should not be used as prescriptions; the guidance can be varied to suit management and operational needs.
[2] For line mixtures aim for 50:50 mixtures in most cases and then adjust the species balance by thinning.

shade tolerance.

Primary species		Secondary species			Primary species		Secondary species		
growth rate	shade tolerance	growth rate	shade tolerance	Compatibility Score	growth rate	shade tolerance	growth rate	shade tolerance	Compatibility Score
moderate	light demanding	fast	light demanding	2	slow	light demanding	fast	light demanding	3
moderate	light demanding	fast	intermediate	3	slow	light demanding	fast	intermediate	3
moderate	light demanding	fast	shade tolerant	4	slow	light demanding	fast	shade tolerant	4
moderate	light demanding	moderate	light demanding	1	slow	light demanding	moderate	light demanding	1
moderate	light demanding	moderate	intermediate	1	slow	light demanding	moderate	intermediate	2
moderate	light demanding	moderate	shade tolerant	2	slow	light demanding	moderate	shade tolerant	3
moderate	light demanding	slow	light demanding	2	slow	light demanding	slow	light demanding	1
moderate	light demanding	slow	intermediate	1	slow	light demanding	slow	intermediate	1
moderate	light demanding	slow	shade tolerant	1	slow	light demanding	slow	shade tolerant	1
moderate	intermediate	fast	light demanding	1	slow	intermediate	fast	light demanding	2
moderate	intermediate	fast	intermediate	1	slow	intermediate	fast	intermediate	3
moderate	intermediate	fast	shade tolerant	2	slow	intermediate	fast	shade tolerant	4
moderate	intermediate	moderate	light demanding	2	slow	intermediate	moderate	light demanding	2
moderate	intermediate	moderate	intermediate	1	slow	intermediate	moderate	intermediate	2
moderate	intermediate	moderate	shade tolerant	2	slow	intermediate	moderate	shade tolerant	2
moderate	intermediate	slow	light demanding	4	slow	intermediate	slow	light demanding	2
moderate	intermediate	slow	intermediate	3	slow	intermediate	slow	intermediate	1
moderate	intermediate	slow	shade tolerant	1	slow	intermediate	slow	shade tolerant	1
moderate	shade tolerant	fast	light demanding	3	slow	shade tolerant	fast	light demanding	3
moderate	shade tolerant	fast	intermediate	2	slow	shade tolerant	fast	intermediate	3
moderate	shade tolerant	fast	shade tolerant	2	slow	shade tolerant	fast	shade tolerant	3
moderate	shade tolerant	moderate	light demanding	3	slow	shade tolerant	moderate	light demanding	2
moderate	shade tolerant	moderate	intermediate	1	slow	shade tolerant	moderate	intermediate	2
moderate	shade tolerant	moderate	shade tolerant	1	slow	shade tolerant	moderate	shade tolerant	2
moderate	shade tolerant	slow	light demanding	3	slow	shade tolerant	slow	light demanding	2
moderate	shade tolerant	slow	intermediate	2	slow	shade tolerant	slow	intermediate	2
moderate	shade tolerant	slow	shade tolerant	1	slow	shade tolerant	slow	shade tolerant	1

Table 5. Worked example for a mixture of Norway spruce and Scots pine at Gisburn in Lancashire

Step	Design of the mixture
1	The aim is to produce a mixed stand of Norway spruce (NS) and Scots pine (SP) in which NS is the primary species. Local experience suggests GYC12 for NS (data from the experiment gives a top height at 20 years of 7.9m) and GYC 8 for SP (data from the experiment gives a top height at 20 years of 7.0m). Using Table 1 indicates the growth rate for NS and SP are both 'slow'. Table 2 shows the shade tolerance of each species: NS is 'shade tolerant' and SP is 'light demanding'.
2	From Table 3 the option of 'slow; shade tolerant – slow; light demanding' gives a Compatibility Score of 2.
3	Based on Table 4 it is decided to use a 3 row: 3 row line mixture as there are no landscape implications at the site.
4	Birch would be a welcome addition to the mixture and will be accepted if it occurs as natural regeneration.
5	The top heights at 50 years are forecast to be 20.8m (NS) and 17.3m (SP) so there is no need to adjust the design of the mixture to factor in differential growth after 50 years. Any differences that do occur and the possibility of differing rotation lengths can be taken into account during thinning.

also a summary of work in Ireland described by Keane et al. (2018). These preliminary checks indicated that the Compatibility Scores of a range of mixtures and planting designs were broadly consistent with the observed growth in Britain and Ireland. The method now needs wider

Figure 2. A 3 row : 3 row mixture of Norway spruce and Scots pine at Gisburn, Lancashire. This stand is the basis of the worked example in Table 5.

Figure 3. A mixture of 3 rows sycamore and 1 row hybrid spruce (a hybrid of Sitka spruce and white spruce). The sycamore is fast; shade tolerant, and the hybrid spruce is moderate; intermediate, with a compatibility score of 3. The shading effect of the hybrid spruce on the outer rows of sycamore can clearly be seen and demonstrates the need for bigger groups / more rows of each species.

'operational testing' to indicate strengths and weaknesses, and forest managers are invited to feedback their thoughts and experiences to the authors.

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References

Aldhous, J.R. & Low, A.J. (1974) *The potential of western hemlock, western red cedar, grand fir and noble for in Britain*. Forestry Commission Bulletin 49. HMSO, London.

Evans, J. (1984) *The silviculture of broadleaved woodland*. Forestry Commission Bulletin 64. HMSO, London.

Keane, M., Mason, B. & Pfeifer, A. (2018) *Species mixtures in Irish Forests*. COFORD, Department of Agriculture Food and the Marine, Dublin.

Mason, B., Kerr, G. & Simpson, J. (1999) *What is Continuous Cover Forestry?* Forestry Commission Information Note 29. Forestry Commission, Edinburgh.

Mason, B. (2006) *Managing Mixed Stands of Conifers and Broadleaves in Upland Forest in Britain*. Forestry Commission Information Note 83. Forestry Commission, Edinburgh.

Mason, W.L. (2014) Long-term development of nursing mixtures of Sitka spruce and larch species in an experiment in northern Scotland. *Forest Systems*, **23**(3):590-597.

Figure 4. A small group (18 trees) mixture of Sitka spruce and Scots pine. Using the method Sitka spruce is fast; intermediate, and Scots pine is moderate; light demanding, giving a compatibility score of 4. The Sitka has totally dominated the Scots pine indicating the mixture is not robust (but would be a useful nursing mixture).

Figure 5. An intimate mixture of Sitka spruce and Japanese larch at six years-old showing the initial superior height growth of larch. Using the method Sitka spruce is fast; intermediate, and Japanese larch is fast; light demanding, giving a compatibility score of 2. An intimate mixture is not a robust design as, with time, the Sitka spruce will begin to dominate the mixture.

Mason, W.L. & Baldwin, E. (1995) Performance of pedunculate oak after 40 years in mixture with European larch and Norway spruce in southern Scotland. *Scottish Forestry*, **49**(1):5-13.

Mason, W.L. & Connolly, T. (2014) Mixtures with spruce species can be more productive than monocultures: evidence from the Gisburn experiment in Britain. *Forestry*, **87**(2):209-217.

Morgan, J.L., Campbell, J.M. & Malcolm, D.C. (1992) Nitrogen relations of mixed-species stands on oligotrophic soils. In: M.G.R. Cannell, D.C. Malcolm & P.A. Robertson, eds. *The ecology of mixed species stands of trees*. Special Publication Series of the British Ecological Society Number 11. Blackwell, Oxford. p.65-85.

Oliver, C.D. & Larson, B.C. (1996) *Forest Stand Dynamics* (Updated Edition). John Wiley & Sons, New York.

Rodwell, J. & Patterson, G. (1994) *Designing New Native Woodlands*. Forestry Commission Bulletin 112. HMSO, London.

Stokes, V. & Mason, B. (2019) A review of research on species mixtures with potential for use in British forests. Forest Research report to Forest

Table 6. Application of method to common mixture types in Britain.

Mixture	Reference	Compatibility Score (CS)	Summary of results	Do results validate CS?
Scots pine: birch	Mason (2006)	2	Scots pine will dominate birch at 30 years if planted as 3:1 or 1:1 mixtures planted as groups of 25 trees.	Yes
Sitka spruce: birch	Mason (2006)	2	Birch unlikely to survive in intimate mixture with Sitka spruce to 30 years.	Yes
Oak: European larch	Mason and Baldwin (1995)	2	Species quite compatible up to 40 years after which European larch will dominate.	Yes
Oak: Norway spruce	Mason and Baldwin (1995)	2	Species quite compatible up to 40 years then Norway spruce dominates.	Yes
Sitka spruce: Douglas fir	Wilson (2014)	1	Study of comparative height-age relationships confirms compatibility.	Yes
Sitka spruce: Grand fir[1]	Wilson (2014)	1	Study of comparative height-age relationships confirms compatibility.	Yes
Sitka spruce: Western hemlock[1]	Wilson (2014)	1	Study of comparative height-age relationships confirms 'quite compatible'.	Not quite
Sitka spruce: Noble fir[1]	Wilson (2014)	2	Study of comparative height-age relationships confirms 'quite compatible'.	Yes
Sitka spruce: Western red cedar[1]	Wilson (2014)	2	Study of comparative height-age relationships confirms 'quite compatible'.	Yes
Alder: Norway spruce: Oak: Scots pine (most combinations of)	Mason and Connolly (2014)	1 or 2	Gisburn experiment confirms compatibility.	Yes
Sitka spruce: Scots pine or Scots pine: Sitka spruce	Mason and Connolly (2014)	3 or 4	Results show Sitka spruce dominating mixture (18 tree plots) after 20 years (see Figure 4).	Yes
Sitka spruce: Japanese larch	Mason (2014)	2	Results show Sitka spruce dominating mixture (planted as 3 tree plots) from 20 to 41 years.	Yes

[1] Compatibility also confirmed in Aldhous and Low (1974).

Enterprise England. Forest Research, Northern Research Station, Penicuik, Edinburgh (unpublished).

Wilson, S.McG. (2014) *The potential for use of rotational mixtures with Sitka spruce in British upland forests*. Technical Report to the Scottish Forestry Trust. Scottish Forestry Trust, Edinburgh.

Wilson, S.McG. & Cameron, A.D. (2015) Alternative models for productive upland forestry. Model 2: Sitka spruce mixtures with alternative conifers. *Scottish Forestry*, **69**(1):26-32.

Wilson, S.McG. (2016a) Selection of tree species for future forestry in Scotland: Nativeness, diversity and resilience. *Scottish Forestry*, **70**(1):5-14.

Wilson, S.McG. (2016b) Making sense of mixtures. *Forestry & Timber News*, February 2016, p14-15.

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Hemery, G.E. (2001) Growing Walnut in Mixed Stands. *QJF*, **95**(1):31-36.

Mason, W.L. (2006) Transformation of conifer plantations to mixed forests: initial guidance from an experiment in Wykeham forest, North Yorkshire by. *QJF*, **101**(1):31-42.

Spencer, J.W. & Field, A. (2019) Forest Resilience in British Forests, Woods & Plantations - 4. Forestry practice and 21st century challenges. *QJF*, **113**(3):169-177.

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