Impacts of Silviculture on Conifer Timber Quality

This Guidance Note is one of a series summarising information presented at a seminar on "Improved Conifer Timber Quality through Plant Selection and Silviculture", held in February 2009 as part of FC Scotland's Timber Development Programme. It provides a broad overview of ways in which silvicultural practice can influence the timber quality of conifers grown in Scotland, together with relevant references and links to more detailed information. The presentation itself, which was delivered by Elspeth Macdonald of Forest Research, is available for download through the seminar web page.

Introduction

Silviculture is defined by UKWAS (2006) as "the techniques of tending and regenerating woodlands, and harvesting their physical products". The silvicultural decisions made by forest managers combine with site conditions and environmental factors to influence tree growth and form, and therefore timber quality.

"Timber quality" is a subjective term: the log characteristics and wood properties that are of importance depend on the intended end-use of the finished product. Maximising the output of strength graded sawn timber for the construction sector, a valuable market for commercially grown conifers, is a key objective in Scotland's productive forests. The most important quality characteristics for sawn structural timber are mechanical properties (bending stiffness and bending strength) and dimensional stability in drying.

The tree growth characteristics and wood properties that have a significant impact on the timber quality of sawn softwood include:

- Stem straightness
- Stem taper
- Log diameter
- Growth rate
- Branching/knottiness
- Grain angle
- Wood density
- Juvenile wood
- Compression wood

A detailed review of the impact of these factors on timber quality and performance, focused on Sitka spruce, can be found in Macdonald and Hubert (2002).

Choice of species

Choosing a species that is well suited to the site is an important first step in producing high quality timber. Where a species does not grow well establishment success can be poor, resulting in low stocking density and consequently many of the problems associated with wider initial spacing. With some species there are specific concerns. For example Sitka spruce planted on peatland and heathland soils can (without intervention) experience growth check as a result of nitrogen deficiency, resulting in close branch whorls in the lower stem, uneven growth and consequently a poor quality butt log. Other considerations when choosing which species to plant include prevalent pests and diseases (e.g. red band needle blight has reduced the planting of Corsican pine), the impacts of climate change on species suitability (Ray, 2008) and potential future markets.

Guidance on site assessment for species suitability can be found in the associated Guidance Note on this subject, in information relating to Ecological Site Classification (Pyatt *et al.*, 2001) and through the Establishment Management Information System (EMIS), a prototype version of which can be accessed through the FR Decision Support Services portal.

Choice of seed origin

Different seed origins of the same species can vary in vigour, form, and timber properties. For example, recent work by Forest Research assessing the utilisation potential of lodgepole pine demonstrates the importance of selecting an origin well suited to the area of establishment (Mochan and Hubert, 2005). Results showed that the South Coastal provenance of lodgepole pine had more compression wood, lower impact strength and an increase in brash fracture compared to Alaskan and inland provenances.

A recent publication by Samuel *et al.* (2007) reviews the choice of Sitka spruce seed origins for use in Britain, including a section summarising relevant timber quality studies. Guidance regarding the choice of seed origins for other conifer species is contained in Lines (1987).

Tree improvement

Selective tree breeding can deliver improvements in growth rate, stem straightness, branching, wood density and fibre properties. Lee (2004) summarises the availability of improved material for conifer species in Britain.

The Sitka spruce breeding programme in Great Britain has produced significant genetic gains in terms of growth and stem form, without a reduction in wood density when compared to unimproved material (Lee, 1999). Seed lots are commercially available from different improved production populations, allowing growers to choose, for example, between improved growth and stem form without a reduction in wood density or improved density with a smaller increase in growth and similar stem form improvement. A recent study investigated the log out-turn and timber properties of improved Sitka spruce from 3 half-sib families, compared to unimproved Queen Charlotte Islands material (Mochan *et al*. 2008). The results showed increased sawn timber volumes from improved planting stock without a deterioration in construction grade strength requirements.

Planting or natural regeneration?

The decision as to whether to use planting or natural regeneration to establish a forest stand will be influenced by many factors, not least the silvicultural system being implemented and management objectives. With regard to timber quality both planting and natural regeneration offer advantages and disadvantages (Table 1). Mason and Kerr (2004) offer guidance regarding site and stand suitability for transformation to continuous cover forest management, including the use of natural regeneration. Kerr *et al.* (2002) provide a methodology and associated software to monitor the transformation process.

Table 1: Advantages and disadvantages of planting and natural regeneration with regard to conifer timber quality

	Advantages	Disadvantages
Planting	1. Opportunity to select species 2. Volume and quality gains from selectively bred planting stock 3. Control over stocking 4. Minimal variation in age class structure resulting in more uniform growth and timber properties	1. Possible stem form problems associated with nursery practice and early instability (toppling) 2. High establishment costs 3. If establishment success not uniform – may get patchy stocking resulting in future timber quality problems
Natural Regeneration	1. Improved stability – possibly better stem form 2. Potentially high stocking and large number of trees for selection in thinning 3. Potentially low cost 4. Fits well with Continuous Cover Forestry	1. No opportunity for improvement in growth or timber quality through use of selectively bred material 2. Difficult to control species mix – may have a lot of low value species (e.g. hemlock, grand fir) 3. Costs of respacing/pre-commercial thinning

Spacing

Trees planted at wider initial spacing tend to have increased stem taper, bigger knots, reduced average density, higher grain angle, a larger juvenile core and poorer stem straightness, resulting in sawn timber with inferior mechanical properties and dimensional stability. Wider spacing also means that there are fewer trees to select amongst when thinning, and at very wide spacing there is the risk that the biological capacity of the site may not be fully utilised. However, at wider spacing establishments costs are lower, tree stability is improved and a merchantable volume is achieved earlier.

Current spacing guidance for commercial conifer species is based largely on work by Brazier and Mobbs (1993), who recommended 2500 stems/ha as the maximum planting spacing for Sitka spruce to obtain commercially acceptable yields of timber grading to strength class C16. Recent results from a Sitka spruce early respacing trial at Baronscourt in Northern Ireland support these conclusions (Moore *et al.*, 2009).

Commercial conifer plantations in Europe and north America are generally established with initial spacing of 1500 – 3000 stems/ha. In Scotland the required stocking densities for the Woodland Creation Grant under the Scotland Rural Development Programme (SRDP) are:

- Spruce – 2500 stems/ha
- Scots pine – 3000 stems/ha
- Larch, Douglas fir – 2000 stems/ha

Thinning

Thinning is a key silvicultural tool used to improve stands by removing poor stems of poor form and concentrating increment on superior trees. Depending on stand characteristics and market conditions it can also provide an early economic return. Compared to no-thin regimes, thinning will result in:

- An improvement in stem form and branching through selection
- A lower proportion of juvenile wood
- More uniform growth

Timing of thinning is important when considering timber quality. Early thinning or respacing prior to canopy closure can result in:

- Retention of deep living crown → large knots in logs
- Increased stem taper
- Possible reduction in stem straightness

Increasing use of Continuous Cover Forestry systems will result in changes to thinning practice. In particular there will be greater use of crown thinning in the early stages of stand development (Mason and Kerr, 2004). The impact of these changes in thinning practice on log quality and timber properties have been considered by Macdonald *et al.* (2009).

Pruning

Pruning is the removal of branches from the lower part of the stem in order to improve timber quality. It is usually carried out to limit the extent and size of knots, producing a small knotty core and maximising the amount of clear timber formed. Marking and recording of final crop trees is essential to ensure that the pruned individuals can be appropriately marketed when they are harvested.

Pruning is rarely practised in conifer crops in the UK. Operational costs are high, the investment period is long (generally 25-30 years between pruning and harvesting) and there is no established market for pruned material.

Financial support for pruning is now available in Scotland however, under the "Improving the Economic Value of Forests" option of SRDP. Guidance and grant support for pruning is also available in Ireland (Phillips, 2004). Where pruning is practised the greatest return will be achieved where it is focused on species that already attract a higher price for better quality timber such as Douglas fir, larch or Scots pine.

Rotation Length

The average age of felling for commercial conifer stands managed under clearfell systems is currently in the order of 40-60 years. Where trees are grown on a longer rotation there is an opportunity to produce high quality timber, provided stem form and branching in the stand are acceptable. Regular selective thinning will concentrate increment on final crop trees of good form and maintain an even growth rate. Logs produced from larger diameter, older trees will have a lower proportion of juvenile wood, resulting in a greater volume of mature wood with more desirable wood properties in terms of mechanical performance and drying stability. There is also the potential to produce a significant amount of knot-free timber in the valuable sawlog part of the stem, once branches have self-pruned.

A recent study by Napier University CTE examined the properties of timber from an 83 year old stand of Sitka spruce (Ridley-Ellis *et al.*, 2008). Sawn timber cut from the outer part of the log had improved timber properties, in terms of mechanical performance and drying distortion, compared to those cut closer to the pith. The economic impact of lengthening rotations in even aged stands, together with a lack of price premium for higher timber grades, mean that longer rotations are not likely to be an attractive option in current market conditions. However, this study highlights the potential gains that could be made in timber cut from trees retained to older ages in continuous cover forestry systems and the importance of cutting patterns in determining the properties of sawn timber.

Conclusions

- No single action will ensure good timber quality: the final product must be considered at all stages
- Suiting the species/seed origin to the site is a key decision
- Selectively bred planting stock can offer significant gains in volume and timber properties
- Spacing, selective thinning, pruning and rotation length can be used to manipulate the quality of the final crop

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