Encouraging Greater Use of Continuous Cover Forestry

Part 2. Wider considerations

Bill Mason concludes his look at the rationale for adopting CCF by considering the wider benefits and issues.

The term ‘Continuous Cover Forestry’ (CCF) was first used in British forestry in the early 1990s, at a time when both forest policies and wider society were increasingly requiring that forests be managed for multiple objectives. CCF is an ‘approach to forest management’ based on four principles, adapting the forest to the site, holistic management of the forest ecosystem rather than just the trees, the maintenance of forest conditions and avoidance of clear felling, and management focussed upon developing individual stems (CCFG, 2020). This approach is part of a worldwide reaction against the homogenous even-aged forests composed of few species that characterise conventional rotational forest management (RFM) and that are typically managed by clear felling and replanting (Puettmann et al., 2015).

At the beginning of the 1990s the area of British forests managed by uneven-aged silviculture was ‘extremely small’, with perhaps 15 examples known to proponents of CCF (McIver, 1992).Three decades later, awareness of CCF is widespread within British forestry, exemplified by the programme for the RFS’ 2020 Whole Society Meeting highlighting CCF as a topic for discussion on three of the five days of the meeting. Nevertheless, despite greater enthusiasm for CCF and the increased amount of information available from research and operational trials, the actual area of British forests being managed through this approach is still small. This slow rate of uptake of CCF may indicate the difficulties involved in challenging the prevailing paradigm in British forestry where patch clear felling is often considered as the default silvicultural option (Helliwell and Wilson, 2012).

This pair of articles considers challenges to the uptake of CCF in Britain (see Table 1 in Part 1 in the October issue of *QJF*) and examines how far the perceived difficulties are still valid, given information accumulated over the last 20 years about the use of CCF in research and operational trials.

The previous article concentrated upon site specific ecological challenges such as species suitability, use of mixtures, wind stability and deer management. None of the factors considered presented an insuperable challenge to wider use of CCF, except where a particular combination of current tree species, thinning history, soil conditions and wind exposure would make successful transformation problematic. In this article more general topics that can influence the uptake of CCF are discussed, ranging from climate change through financial aspects to training needs.

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CCF and adaptation to climate change

It is widely recognised that British forests lack both species and structural diversity, which makes them potentially vulnerable to the impacts of climate change, not to mention the impacts of pests and diseases (see below). Therefore, following the principles of a CCF approach to increase the structural and compositional variation of our regular forests should help managers to adapt forests to the 'climate emergency' (Anon., 2019a). For example, increasing structural and species diversity should enhance forest resistance to wind damage on sites of low and moderate wind exposure (see previous article). Indeed, a review of the potential of CCF to adapt Scottish forests to climate change found positive effects for three out of five major abiotic risks (wind damage, winter rainfall, and frost damage) and similar benefits for most minor risks (Stokes and Kerr, 2009). A comparison of different close-to-nature silvicultural systems (i.e. single stem selection, group selection and shelterwood systems) found that all systems were helpful as an adaptation measure, but that group selection was the most advantageous because the variable light environment across regeneration gaps could accommodate species of different shade tolerance (Brang et al., 2014). A CCF approach should result in less soil disturbance than occurs in RFM (e.g. limited cultivation) and therefore better maintenance of soil carbon (Forestry Commission, 2017, p.70). In addition, the emphasis upon natural regeneration, which is a feature of CCF, can increase the resilience of individual species to climate change by selecting for genotypes adapted to a changing climate (Cavers and Cottrell, 2015). The shelter of a mature CCF canopy provides a more favourable microclimate for seedling growth (e.g. less frost risk, lower wind exposure, lesser fluctuation in soil moisture) than an open clear-felled site. The sheltered environment can also be used to underplant desirable species that are difficult to establish on an open site; such measures will increase the diversity of the forest.

One consequence of the more frequent occurrence of extreme events is that silvicultural rules that have been developed in other forest types and in more stable climates may need to be adapted to these new conditions. The uncertainty over future disturbance regimes and their interaction with forest dynamics means that managers should be cautious in applying rigid silvicultural prescriptions (Puettmann et al., 2015). Careful monitoring to evaluate stand response to interventions will be needed to help foresters 'learn from the forest' and to help them deploy existing silvicultural tools in novel ways to develop more resilient forests.

Applying CCF in mixed broadleaved woodlands in the forest of Weibicht on the outskirts of Weimar, Germany. Photo taken about a year after thinning – extraction rack running up the centre of the photo. (Photo: WLM)

CCF stands and vulnerability to pests and disease

Just as the greater within-stand heterogeneity provided by CCF can help adaptation to climate change, so managing for diversity in species composition and structure is a sensible way of reducing the impact of pests and diseases (Waring and O'Hara, 2005). For instance, the greater structural diversity of CCF stands can reduce the impact of a generalist insect pest associated with RFM, e.g. much lower *Hylobius* damage found on Sitka spruce seedlings growing under a canopy of mature spruce trees compared with seedlings on a restocking site (Mason, 2015). Lower numbers of bark beetles were present in stands managed through shelterwood or group selection systems (Williams et al., 2017). However, the limited effect of shelterwood or group selection systems on green spruce aphid abundance in pure spruce stands (Straw et al., 2020) indicates that CCF should promote both structural and species diversity to counteract pest impacts. Greater species diversity is an important mechanism providing enhanced resistance to pests and diseases (Jactel et al., 2017), particularly when the species differ in important functional characteristics,

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such as an element of broadleaved species in conifer stands. A general review found that both CCF and greater use of mixed stands were management approaches that should increase natural control of important insect pests characteristic of clear felling regimes (Klapwijk et al., 2016).

Evidence for the impacts of different silvicultural systems upon fungal pathogens is scarce, and previous reviews have indicated that wider use of CCF seems unlikely to reduce the risk posed by pathogens such as *Heterobasidion annosum* or Dothistroma needle blight (Stokes and Kerr, 2009). However, if a CCF approach is used to increase species diversity in a forest (e.g. through enrichment planting in gaps), this should increase resilience to tree diseases, especially if the admixed species have different traits (Roberts et al., 2020). First principles suggest that the regular thinning regimes required to implement CCF should moderate risks by removing trees in poor health, while favouring regular cohorts of natural regeneration as part of CCF could select genotypes that have lower susceptibility to prevailing pathogens (Cavers and Cottrell, 2015).

Shelterwood systems can be used as a means of beginning the transformation from RFM to CCF. A group shelterwood being applied in Clocaenog forest, north Wales – note the natural regeneration developing well with adequate light.

Economics of CCF

A comment often made is that implementing CCF management can be more demanding and hence more costly than continuing with the practices of conventional RFM. To some extent, this reflects the likely 'installation cost' associated with introducing any new system, but with experience the initial costs come down and the benefits of the new approach become apparent. Theoretical considerations suggest that there are two main areas where a CCF regime has financial advantages over RFM, namely: a saving on establishment costs by using natural regeneration rather than planting; and the production of more trees of large dimensions and with high quality timber from stands managed using irregular systems (Schütz et al., 2012).

Standard restocking costs may reach almost £3000 ha^{-1} (Bladon et al., 2019) and can amount to at least 20-30% of the revenues generated by clear felling (e.g. McMahon et al., 2016). By contrast, CCF relies upon natural regeneration which, although it can take longer to establish, when successful incurs few of the costs involved in purchasing plants, planting or site cultivation. The main establishment expenditure is the need for respacing of regeneration before canopy closure if the stocking densities are too high. The importance of successful natural regeneration for the economics of CCF was highlighted by Davies and Kerr (2015) who showed that the net present value (NPV) accrued when transforming British Sitka spruce stands to CCF was at least equivalent to that obtained under RFM, provided successful regeneration occurred. Similar results were found in a landscape scale simulation study in Finland where CCF had a higher NPV than RFM at discount rates greater than 1%, because of both a greater proportion of sawlog production in CCF and lower costs of regeneration (Peura et al., 2018).

An additional factor that influences the financial outturn from CCF is the crown thinning regime used to develop structural diversity and favour better quality stems (Susse et al., 2011). This results in the removal of any dominant or co-dominant competitors to the favoured stems and so produces more sawlogs earlier in the stand development cycle. For example, thinning to favour future frame trees (trees that maintain the long-term stability of a stand) had a higher sawlog outturn and lower cost m^{-3} than the low thinning typically used in RFM (Mason, 2015). However, there is little consistent evidence of premium prices being achieved in Britain for the large dimension sawlogs produced through CCF management, with any benefit

Gap creation and enrichment planting in broadleaved woodlands managed by CCF on the Morton estate, Nottinghamshire.

being species specific. Thus, in south-west England there was a price premium for large diameter Douglas fir logs of good quality, but not for large Sitka spruce or western hemlock (Poore and Kerr, 2009). Davies and Kerr (2015) also found little change in the ranking of different transformation options in Sitka spruce, even when sawlogs attracted a substantial premium.

Timber quality of trees produced from CCF stands

The limited research on this topic in Britain has mainly tried to evaluate the effects of CCF upon the timber quality of conifers, which reflects their much greater importance for the domestic processing sector. Modelling the potential impacts of transformation to CCF upon Sitka spruce found that CCF had the potential to produce high quality timber, partly because of crown thinning favouring better quality stems and because of reduced proportions of juvenile wood in overstorey trees retained to greater ages and larger sizes (Macdonald et al., 2010). Careful and sustained silvicultural input over time was essential to ensure that this potential for improving timber quality through CCF was realised. Aspects to avoid included the dramatic opening up of gaps, which could result in edge trees with heavy branching and increased variation in timber properties. Sitka spruce trees that developed in dense thickets of natural regeneration have much less variation in juvenile and mature wood properties than trees respaced at an early age (Cameron et al., 2015), suggesting that the timing and degree of respacing will affect eventual sawlog quality. Taken overall, given that regular thinning is a critical component of CCF, it is likely that the sawlog quality produced will be at least equivalent to that found under RFM, without considering any negative impacts of delayed or no thinning in even-aged conifer stands.

Training in CCF and related research

As highlighted by both Wilson (2013) and Puettmann et al. (2015), successful introduction of CCF requires the training of foresters and forest workers in the silvicultural techniques that are important for success. Experience suggests that two areas of training need are in operational thinning of stands being managed for CCF and in the fostering of natural regeneration. Currently, relevant in-service training courses are available to staff in the state forest services, and also to the wider sector through the CCFG, through Forest Research, and through specialist consultants (e.g. http://www.selectfor.com/courses/courses.html). Lessons from operational trials can also provide guidance on effective ways of introducing CCF into normal management. For instance, thinning regimes must be compatible with the use of mechanised harvesting machinery and will require operators to be confident in identifying the trees to be removed in crown thinning. This can be achieved by having a forester mark all future frame trees together with a sample marking of the whole stand, and for the desired pattern of thinning to be implemented by the operator using feller selection. The use of enumerated training stands (aka ‘marteloscopes’; Pommerening et al., 2015) can be a valuable aid to show the potential effect of different patterns and intensities of thinning upon stand development and financial outturn. Close cooperation between machine operator and forester, plus long-term continuity of work for the harvesting contractor provides the consolidation necessary to achieve confidence in irregular silviculture, as exemplified in some trial sites on the public forest estate (e.g. Browning, 2019).

In parallel with increasing interest about using CCF in British forests, the research evidence about different aspects of this approach has also been accumulating. For example, recent years have seen reports from several long-term trials into the transformation of even-aged stands to irregular forests such as those at Glentress (Kerr et al., 2010; Mackintosh et al., 2013), Faskally (Cameron and Prentice, 2016) and Tavistock (Kerr et al., 2017). These have highlighted the considerable time (decades) required to complete the transformation to an irregular structure plus the tendency for the regeneration to be dominated by species that are either shade tolerant or of intermediate tolerance. Studies of wider environmental aspects have shown that the greater structural diversity provided by CCF stands can benefit woodland birds in Sitka spruce (Calladine et al., 2015) and Scots pine forests (Calladine et al., 2017), as well as in lowland broadleaved woodland (Alder et al., 2018). A review of two decades of research of trialling CCF in Sitka spruce stands in Britain showed good understanding of factors influencing natural regeneration success, and reasonable knowledge of operational aspects, but poorer information on stand tending, especially on issues relating to the formation of mixtures and the interaction of CCF thinning regimes with stand stability (Mason, 2015).

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Access to documented and monitored demonstration sites

A central recommendation of Wilson’s review (2013) of alternative silvicultural systems was that a network of around 40-50 sites should be established across Britain to demonstrate aspects of CCF to interested foresters and other stakeholders. This would cover a range of forest ownerships and all sites would be enumerated using a common protocol by 2020. Unfortunately, little progress has been made towards achieving this target although valuable long-term results have been reported from a few individual sites (see above). Visit reports in forestry journals suggest some type of CCF approach has been implemented at a wide range of sites, but seemingly with little monitoring, and with little accessible information on any results obtained. The lack of monitoring is the greatest concern, given that there is guidance available on methods that can be used to assess stand development over time and at a reasonable cost (Kerr et al., 2002), with supporting software. Without good knowledge of how reference stands have developed over time in response to intervention, it is difficult for interested foresters to evaluate the potential for implementing CCF in their forests and select an appropriate silvicultural system.

Excellent informal links have developed between site managers as a result of field visits sponsored by the CCFG and other forestry societies, but the paucity of documented results from many sites means that evidence of the effectiveness of a CCF approach is too often anecdotal. The lack of information about the location of sites being managed through CCF also means that it is difficult for interested foresters or members of the wider public to visit stands being managed in alternative ways to RFM. The issue of providing demonstrations of best practice in forest management is not confined to CCF, and initiatives such as the Royal Scottish Forestry Society’s ‘Monitor Woods’ (see http://www.rsfs.org.uk/rsfs2018/doing/doing-mws) may serve as a vehicle for supporting an integrated network of CCF demonstration sites.

Financial support for CCF management

As shown in the previous article and in the preceding paragraphs, CCF is supported in high level policy documents such as the UK Forestry Standard (Forestry Commission, 2017) as a desirable strategy for adapting woodlands to climate change. However, successful delivery arguably requires a supporting package of grant-in-aid to encourage uptake among private woodland owners (Wilson, 2013). A problem is that forestry grant schemes have traditionally been geared to supporting activities associated with tree planting including inputs such as site cultivation and fencing. Such activities are relatively easy to monitor with success or failure normally being evident within a five-year timespan. By contrast, activities associated with CCF, such as developing structure through thinning or promoting natural regeneration can require a decade or more for successful completion, which can make oversight of CCF management plans problematic. This problem appears to be a long-standing one, since one reason for the decline in the use of shelterwood systems in the management of pinewoods in north-east Scotland following the Second World War was that the Dedication and Approved Woodland schemes of that era could not accommodate natural regeneration prescriptions (pers. comm., D.B. Paterson, Forest Research, retired).

As a result, financial support for forest managers interested in introducing a CCF approach can seem both limited and complicated to obtain (Brown and Pakenham, 2016). For example, in Scotland the support available to support CCF is only available for five years and amounts to £30 ha^{-1} (Anon., 2016), although additional capital funding could be available to provide improved access to allow thinning (e.g. on steep terrain). Examination of equivalent websites in England and Wales suggests there are, at present, no specific grants available for supporting CCF. There is an apparent lack of consistency here, since in Wales, previous grant schemes such as Better Woodlands for Wales provided preferential support for a CCF approach (pers. comm. Philippe Morgan, SelectFor). In contrast, a pilot grant scheme was recently introduced in Ireland to support the transformation of even-aged forests to CCF management (Anon., 2019b). This provides for three staged payments of 750€ ha^{-1} over a 12-year period to support a range of activities associated with CCF such as improvement thinnings and promotion of natural regeneration, all under the supervision of an approved forester skilled in CCF.

Discussion

The main proposition of these two articles is that CCF is both theoretically and practically a very desirable and attractive management approach for many forests in Britain. Provided the soils allow good rooting and the site is not subject to extreme wind exposure, stands of all major species can be thinned to develop a more diverse structure and provide a mixed species composition. Natural regeneration can be promoted and will save on restocking costs, provided that vegetation competition and browsing pressure are kept under control. When the regeneration is managed by selective respacing and regular interventions

Stands in Erdmannshausen forest near Bremen in Germany where over a century ago managers began to transform poor quality even-aged Scots pine stands through enrichment with European silver fir, beech and other species. This is now a classic example of the diverse and attractive forests that can be created through CCF.

in the overstorey, the stem quality of the trees in the resulting stands should be good, and with an individual stability that enhances stand resistance to windthrow. There are several well described silvicultural systems that can be used to implement a CCF approach, and the use of varying gap sizes should allow foresters to ensure that both light demanding and more shade tolerant species are recruited into the future stand. The irregularity and diversity that is a feature of CCF allows managers to work with natural processes of stand development, and to develop forests that should be both more resistant to the impacts of climate change and more resilient to those extreme events that occur. Arguably, the mixed stands that can develop as a result of implementing a CCF approach represent a more sustainable and less risky diversification option than planting plots of alternative species in patch clear felling regime. Forests managed by CCF provide many attributes liked by visitors (e.g. the presence of large trees and species growing in mixed stands), while forests managed by RFM have features like the unattractive visual appearance of recently clear felled areas and their associated harvest residues (Edwards et al., 2012).

The evidence presented in these articles suggests that there are a few measures that could be implemented to increase uptake of CCF:

1. Time frame, consistent financial support and good data.
It is clear from various experiments and operational trials that it will take a decade or more to see encouraging results from the introduction of CCF into the management of a specific forest or woodland. This lengthy transition period may well be a reason why uptake in Britain has been comparatively slow. Given that forest policies explicitly favour the structural and species diversification provided by CCF as a means of increasing forest resilience, then the provision of financial subsidies that provide long-term support for the approach would seem sensible. These subsidies could be used to support the operations required to develop an irregular structure, plus any necessary infrastructure development within the forest and/or for the regular provision of sound monitoring data to inform future management. An important point is that the support measures should be flexible and capable of adaptation to the development of individual forests. The financial support could also be complemented by the provision of accurate data showing the areas being managed through different silvicultural systems.

2. Network of demonstration sites.
Being able to visit forests with a history of CCF management and with good data on stand development over time is an excellent means of explaining this approach to interested foresters and other stakeholders. There are two informal networks in existence: the ‘National Network’ sites established by the then Forest Enterprise in forests across upland Britain the early 2000s, and the plots of the Irregular Silviculture Network located primarily in lowland Britain (Morgan and Poore, 2017). However, results from these networks are not widely available and information on the site locations is hard to come by, although some sites (e.g. Clocaenog, Craigvinean) are visited regularly by the CCFG and other forestry groups. Creating a more integrated network of demonstration sites, possibly with some central funding for coordination, would allow the sharing of knowledge that will be essential to support wider uptake of CCF (e.g. Lawrence, 2017). For example the network could be supported by an online platform, containing relevant site information and visual representations of stand development over time. (Charlie Taylor suggested this idea of creating a virtual resource to support a revitalised network of CCF demonstration sites.)

3. Enhancing silvicultural awareness and training.
Applying CCF successfully requires foresters who can think ‘outside the box’ imposed by the patch clear felling regimes that are too often the default option in British forestry. This requires an ability to diagnose site and stand characteristics, and to perceive where and when a CCF approach will work. Some of these skills can be obtained by visiting demonstration sites but others may require in-service training, including visits to forests in other countries with a longer tradition of using CCF. This requirement for training not only applies to foresters, but to harvesting operators who must work out how to implement new thinning regimes, and to wildlife rangers who need to ensure that browsing animals do not prevent successful natural regeneration. The training needs to be followed up by consolidation in the workplace and the availability of help and advice from more experienced silviculturists.

4. A continuing need for supporting research.
Given the premise that the use of CCF should be considerably expanded across British forests, there is an increasing need to be able to predict the impact of this change upon a range of ecosystem services such as carbon storage, water quality, and timber production.

Achieving this will require more sophisticated growth models that are capable of accommodating the complexity posed by mixed species stands and irregular structures – a prototype of what will be needed is provided by the MosesGB project (see https://www.forestresearch.gov.uk/research/modelling-mixed-age-and-mixed-species-stands/). In addition, improved techniques of monitoring the development of demonstration stands using 'drones' or similar technology could be helpful in both providing more accessible information and reducing the cost of data collection.

If these measures were put in place as part of a sustained programme for increasing the use of CCF in British forestry, over the next decades we could begin to see real progress towards developing a more varied and productive forest resource that was resilient to the impacts of climate change while providing a wide range of ecosystem services.

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