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What is Continuous Cover Forestry?

INFORMATION NOTE

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SUMMARY

Continuous cover forestry involves the maintenance of a forest canopy during the regeneration phase with a consequent presumption against clearfelling in favour of alternative silvicultural systems. Although there are likely to be cost penalties from the use of continuous cover systems these can be more than offset by the provision of enhanced non-market benefits. The main constraints are the risks of windthrow and of regeneration failure through browsing or vegetation competition, plus the lack of experience of alternative silvicultural systems in British forestry. However, despite these limitations, there is potential for greater use of continuous cover forestry on selected sites throughout Britain as one means of providing more diverse forests for multi-purpose benefits.

INTRODUCTION

1. The phrase 'continuous cover forestry' has featured increasingly in discussions about the future management of British forests. For example, *The UK forestry standard* (Forestry Commission, 1998) requires managers to 'identify areas which are, or will be, managed under a continuous cover forestry system and to build them into the forest design'. 'Continuous cover' is defined as the use of 'silvicultural systems whereby the forest canopy is maintained at one or more levels without clear felling'. Clearfelling is defined in the text as the cutting-down of all trees on an area of more than 0.25 ha. The distinctive element of 'continuous cover forestry' is therefore the avoidance of clearfelling of areas much more than two tree heights wide without the retention of some mature trees. The *UKWAS certification standard* (UKWAS, 1999) requires favouring of lower impact silvicultural systems such as selection and shelterwood in windfirm conifer plantations (section 3.4.4).

2. The main silvicultural system employed in British forestry is patch clearfelling followed by planting or occasionally natural regeneration. We estimate that this system is employed in at least 90% of managed forests with an average size of clearfelled coupe of between 5 and 10 hectares, although there is appreciable regional variation.

3. The adoption of continuous cover forestry systems on any scale will require changes in silvicultural practices and management thinking in Britain. There is little British experience of using alternative silvicultural systems to patch clearfelling. Our different species and site conditions mean that regimes developed in other parts of the world must be adapted through field trials of alternative systems on suitable sites and with supporting research. Our aim in this Note is to clarify the first principles involved for those considering continuous cover forest management.

HISTORY

4. The current discussions about the potential role of continuous cover forestry are the continuation of long-standing debate about the relative merits of regular and irregular silviculture which began in Europe in the middle of the 19th century. For example, the term 'continuous cover' has links with the German term 'dauerwald' or 'continuous forest' which was discussed in the 1920s and 1930s (Helliwell, 1997) and was last seriously examined in Britain during the 1950s and early 1960s.

5. The current attraction of continuous cover forestry lies in the belief that this approach is suited to an era of multi-purpose forestry where environmental, recreational, aesthetic and other objectives are as important as timber production. In particular, continuous cover forestry is seen as a means of reducing the impact of clearfelling and the associated changes that this produces in forest landscapes and

habitats. **It does not mean abandoning stand management or timber production.** Indeed the felling of trees and the harvesting of their timber is essential in continuous cover forestry to manipulate the stand structure to promote natural regeneration and to provide revenue to offset costs of meeting multiple objectives. Key aspects are discussed in the following sections.

PRINCIPLES OF CONTINUOUS COVER FORESTRY

6. A crucial point is that continuous cover forestry describes **one approach** to forest management, and therefore it is more than a silvicultural system. Silvicultural systems (e.g. shelterwood, selection, patch clearfelling) are means of implementing the chosen management objectives. Continuous cover forestry has variously been described as a 'close-to-nature', 'holistic' or 'ecological' approach to forest management, but these terms are too vague to be practical. It is more useful to think of certain guiding principles which underpin this approach and are considered below.

Managing the forest ecosystem rather than just the trees

7. Under continuous cover, the stands in the forest are seen as the framework for an ecosystem from which timber is harvested at intervals but where other aspects such as landscape or wildlife habitat are of equal importance. The manager considers the impact of the harvest upon this framework and adjusts the quantity removed to ensure that the changes brought about do not impair the wider system. It should be noted that this principle is common to all forests managed for multi-purpose objectives. Thus the restructuring of plantation forests through the forest design process is based on a similar principle. Deciding which is a more sustainable approach will depend upon a thorough evaluation of site factors, species requirements and management objectives.

Using natural processes as the basis for stand management

8. The approach assumes that the use of processes such as natural regeneration is more sustainable than one based upon artificial regeneration and the creation of uniform stand structures of single species. Evidence for this assumption is generally lacking. Natural regeneration is favoured as a means of achieving greater species diversity and as an assurance that the species are suited to the site.

Working within site limitations

9. Natural processes will be favoured if the species composition of the forest is appropriate to the site conditions. One would avoid using species that would require high nutrient inputs on nutrient poor sites and adopt a more conservative approach based upon a less demanding species (e.g. favouring Scots pine over Sitka spruce on dry heathland soils). Site variation within the forest would be respected as a source of diversity rather than seeking to impose uniformity by drainage or insensitive cultivation. The advent of the Ecological Site Classification (Pyatt and Suárez, 1997) offers the opportunity to develop a framework of matching species to site in a logical manner.

Creation of a diverse stand structure with a range of species

10. Many forests planted during this century are composed of trees largely in the stand initiation or stem exclusion phases (see Table 1). As a consequence the stands tend to have a regular structure with a single layer of trees in the canopy, little ground vegetation, little deadwood and few tree species. However, older stands generally have greater diversity of structure a wider range of microsites which are providing niches for more species, and a more favourable regeneration within the stand. Increasing the representation of these later stages in a forest enhances the possibility of providing recreational or wildlife benefits since many of these non-market benefits appear to be linked with the occurrence of older and larger trees.

STAND DEVELOPMENT

11. A useful conceptual model of stand development has been proposed by Oliver and Larson (1996). They postulate that the development of a regular stand of a single species can be separated as detailed in Table 1. Consideration of these stages indicates that, under a patch clearfelling system, many conifer stands managed for timber production rarely progress beyond the stem exclusion stage and are felled before advance regeneration is apparent in the understorey.

Table 1 The four stages of stand development after Oliver and Larson (1996)

Stage	Notes
Stand initiation	The period when young seedlings colonise a site after major disturbance e.g. felling, windthrow. Broadly equivalent to the 'establishment phase' defined in plantation forestry.
Stem exclusion	The existing trees dominate the site and there is no further colonisation by young trees. Some trees in lower canopy die as a result of inter-tree competition.
Understorey reinitiation	As the overstorey grows taller, herbs and advance regeneration start to colonise the forest floor. Often they make little growth because of the limited light conditions.
Old growth	Overstorey trees die in an irregular fashion and individuals of the advance regeneration grow towards the upper canopy.

The exceptions are stands of light demanding species such as pines and larches where the comparatively light shade allows other tree and shrub species to colonise the understorey before rotation age is reached. Such stands would be classed in the understorey reinitiation phase and the same is true of many regular broadleaved stands managed on longer rotations. In all these types, an approach based upon continuous cover forestry would try to maintain stand development well into the understorey reinitiation phase to foster the natural regeneration anticipated as a normal consequence of this phase.

A PRESUMPTION AGAINST CLEARFELLING IN FAVOUR OF THE USE OF ALTERNATIVE SILVICULTURAL SYSTEMS

12. Continuous cover forestry commits a forest manager to using an alternative silvicultural system to patch clearfelling. The choice of alternative system should be based upon an understanding of species requirements, site potential, climatic limitations and linked to management objectives.

13. It is convenient to distinguish between silvicultural systems according to the stand structures they produce (see Table 2). Regular stands are ones where all the trees are of similar height (but not necessarily of the same age) whereas irregular ones contain a mixture of sizes. Systems which promote regular structures require the removal of the overstorey once regeneration is established whereas in irregular systems there will always be some components of the overstorey retained in the stand. It is not our intention to discuss these systems in detail since relevant information can be found in Hart (1995) and Matthews (1989). Some 'regular' systems will involve felling the majority of trees on a site (e.g. seed tree system) and are therefore not as appropriate for continuous cover as the more intimate selection systems. Variants of these systems are described in the literature but these are generally adaptations of a basic model to particular site conditions and/or species requirements.

14. An important factor influencing the choice of silvicultural system is the light requirement of the species to be regenerated. A traditional distinction is drawn between light demanding, intermediate and shade tolerant species (see Table 3) on the basis of the amount of shade that seedlings can tolerate while still making effective growth. Those which are **shade tolerant** can be expected to grow in small gaps (0.05 ha or less) or under the canopy of a mature stand whereas **light-demanding** species will require very light canopies or open areas to achieve adequate growth. **Intermediate** species are those that can regenerate under a canopy, but require this to be opened up rapidly to ensure good seedling growth. Seedlings of all species can occur underneath an overstorey as 'advance regeneration', but only shade tolerant species can survive and grow for any length of time beneath a canopy. Therefore species in the shade tolerant category such as beech and Norway spruce are suitable for selection systems while those such as birch and Scots pine are favoured by seed tree systems.

Table 2 Classification of some silvicultural systems by stand structure

Regular stand structures	Irregular stand structures
Clearfelling	
Seed tree	Single stem selection
Uniform shelterwood	Group selection
Strip shelterwood	Irregular shelterwood
Coppice-with-standards	

Table 3 A classification of the main British tree species according to their seedling light requirements

Light demanding	Intermediate	Shade tolerant
European larch	Douglas fir	Western hemlock
Japanese larch	Sitka spruce	Norway spruce
Hybrid larch	Noble fir	Grand fir
Scots pine	Ash	Western red cedar
Corsican pine	Cherry	Yew
Lodgepole pine	Lime	Beech
Birch *(both silver and downy)*	Oak *(both pedunculate and sessile)*	Hornbeam
		Field maple
		Sycamore
	Rowan	
	Sweet chestnut	
	Whitebeam	
	Cherry	

This classification is inevitably relative and does not mean that all species in a given category have identical requirements. For example, there is good evidence to suggest that seedlings of Sitka spruce are less shade tolerant than those of Douglas fir and need increased light intensity for satisfactory growth much sooner than those of the latter.

ROTATION LENGTH AND YIELD CONTROL

15. Most of the silvicultural systems discussed above involve retaining a number of mature trees on site for an appreciable period after the remainder of the stand has been felled. These trees act as a seed source for regeneration, help modify the microclimate (e.g. reduction of frost damage) and provide benefits to biodiversity. Implementing a continuous cover forestry system requires rethinking the definitions of financial or technical rotation age that are integral to silviculture based upon patch clearfelling. For example, a general aim is to retain a stand into the understorey reinitiation phase with manipulation of the canopy to promote regeneration. Given that seed years are intermittent and that it can take 5–10 years for satisfactory establishment of regenerated seedlings of some species, designating a stand under continuous cover forestry management may require prolonging the rotation for some trees by at least 20 years beyond the age determined by maximum mean annual volume increment.

16. In addition, in the irregular systems, the focus is less on age than on the target diameter at which trees are considered to be marketable. In selection forests, it is quite common to find target diameters of 60–70 cm which are based on the belief that it is both possible to grow and successfully market large dimension sawlogs. In conifer stands, such target dimensions would again require an appreciable lengthening of current rotations. A number of parameters are used to guide the tending of stands managed under selection systems. Apart from the target diameter these include: the residual basal area to be left after thinning; the ideal stem size distribution on a particular site; and the actual stem size distribution recorded during a periodic inventory. Thinning of a selection stand involves the removal of stems in all size categories to bring the actual distribution closer to the ideal one (see Philip, 1994; pp. 146–149). The health and quality of the individual stems is a further guide as to which trees should be removed.

17. It is sometimes stated that stands under continuous cover management, particularly irregular stands, produce higher yields per unit area than regular, even-aged stands. There is no evidence in the literature to support this view and the safest assumption is that the yields are similar in both types of system. However, the product out-turn may vary since continental evidence suggests a higher proportion of large dimension (>50 cm) sawlogs are produced under selection systems (see Schutz, 1997).

18. There are no British yield models, and few in other countries, designed for the more complex stand structures which are one of the goals of continuous cover forestry. Existing even-aged yield models can be adapted by assuming that the average productivity of a continuous cover stand is equivalent to that expected of an even-aged stand on a given site and adjusting the model for the percentage of the stand in different size/age categories. However, this is a considerable simplification and stands being transformed to alternative systems should be monitored to check that the response is in line with expectations. This has to include an estimate of regeneration success and understorey development as well as measurement of the overstorey.

CONSTRAINTS TO CONTINUOUS COVER FORESTRY

19. There are a number of factors which limit the feasibility of adopting a continuous cover forestry approach. In much of northern and western Britain on exposed sites with shallow soils, the risk of windthrow is a major limitation to the possibility of adopting one of the alternative silvicultural systems. The opening up of the tree crowns as a consequence of thinning operations to promote regeneration increases the wind loading on the retained trees substantially and these trees will be very vulnerable to blowdown or stem breakage. Therefore, it would be risky to introduce an alternative silvicultural system on sites of windthrow hazard class 4–6. Even on sites of lower windthrow risk, trees on wet or shallow rooting soils are likely to be vulnerable to wind damage. Despite the magnitude of this constraint, there are appreciable areas of upland forests where better soils and reasonable shelter would make continuous cover systems a feasibility. Paterson (1990) thought that 25% of the upland forest area was a reasonable estimate. By contrast, in lowland Britain, where the return period for catastrophic wind damage exceeds 1 in 100 years, the risk of windthrow is not a general constraint to the use of continuous cover systems.

20. We have assumed that reliable natural regeneration will be necessary if continuous cover forestry systems are to be implemented. Natural regeneration of all major trees (i.e. native and non-native) can occur in British forests provided the parent trees are of sufficient age to produce regular seed crops. The presence of advance regeneration in or near the stand is a useful indicator of the chance of success. If the trees are of suitable age (see Nixon and Worrell (1999) for conifers and Harmer and Kerr (1995) for broadleaves), but advance regeneration is not present, the failure may be due to a host of reasons including lack of seed, vegetation competition and predation. Do not attempt to promote natural regeneration until the limiting factor has been identified and remedial action taken.

21. Trees need to be old enough before they start to seed regularly and for the potential for regeneration to occur. Depending upon species, the beginning of regular seeding is between 20 and 40 years of age, the younger age being characteristic of pioneer light-demanding species such as the pines, and the latter of shade-tolerant species such as Norway spruce. There is also variation in the frequency of good seed years which, for example, may be every 3 years in birch and Scots pine and 5–8 years in beech.

22. Soil conditions are important for a number of reasons. Deep rooting soils are beneficial to tree stability which is a key consideration with any alternative silvicultural system. Fertile soils (‘medium’ to ‘very rich’ in Ecological Site Classification terms) have the potential for vigorous weed growth. On such sites it is important to encourage advance regeneration first and then develop it through progressive opening up of the canopy, so ensuring that small seedlings are not swamped by weeds. In contrast, on less fertile sites (‘very poor’ to ‘poor’), vegetation competition is less intense and a regeneration ‘window’ for successful seedling establishment can persist for 2–3 years after a canopy is opened up. For this reason, many examples of the successful use of alternative silvicultural systems tend to be on less fertile sites.

23. Young seedlings are very vulnerable to browsing damage and, in areas with high deer densities, it is unrealistic to expect regeneration without reducing the populations below 5–10 animals per 100 ha and/or fencing the zones to be regenerated.

COSTS

24. There are few examples of continuous cover forestry systems in operation in Britain and it is not possible to provide definitive costings on the implications of changing to this type of management from conventional patch clearfelling systems. Some research is underway at the present time which may help to clarify this aspect. There is general agreement that some cost penalties are involved, either because trees are being maintained beyond financial rotation or because the costs of management per unit area are higher than with conventional systems. However, the increased costs may be offset by benefits in terms of ability to meet landscape, recreation or conservation objectives. In addition, the costs associated with replanting can be avoided provided that natural regeneration is sufficiently profuse and reliable. A further claim sometimes made for the irregular systems is that an all sized stand structure ensures some resilience against the effect of a catastrophic gale since there are always smaller trees to colonise the available growing space.

ADVANTAGES AND DISADVANTAGES OF CONTINUOUS COVER FORESTRY

25. The advantages and disadvantages of continuous cover forestry, given present knowledge, are summarised in Table 4.

26. There are clearly potential benefits and appreciable risks in embarking on the transformation of regular stands to continuous cover forestry. The benefits are greater the more that a stand or a forest is being managed for non-timber objectives. The long time before the success of transformation can be determined should borne in mind. For example, one of the best known areas of continuous cover management lies in Glentress Forest near Peebles in Scotland where Professor Mark Anderson of Edinburgh University initiated a trial of a group selection system in first rotation conifer stands in the late 1950s. It has taken some 30 to 40 years for the diversity of structure to become apparent and for it to be possible to start to judge the success of this trial. Not all organisations or owners will be prepared to take such a long-term view.

IMPLEMENTATION

27. We anticipate that an increasing number of owners will be interested in undertaking trials of alternative silvicultural systems in the years ahead and we would strongly advise anybody in this position to start on a trial basis to begin with. The following simple check list is a guide to anyone considering the continuous cover forestry approach.

- Are the stands in question of windthrow hazard class 3 or less and without sign of wind instability?
- Are the tree species present adapted to the site and of suitable genetic quality?
- Are the soils freely draining?
- Are the stands involved in the stem exclusion or very early understorey reinitiation phases?
- Is the forest floor under the stands bare or with very little vegetation?
- Is there evidence of advance regeneration of a desirable species? If not, do you know why not?
- Are deer, rabbits, sheep or other browsing animals under control?

Table 4 **Advantages and disadvantages of continuous cover forestry**

Advantages	Disadvantages
Less visual impact than clearfelling.	More complex stand management requiring skilled personnel.
Increased within-stand structural and species diversity.	Yield prediction/regulation is more difficult.
Greater structural diversity with potential benefits for wildlife.	Greater harvesting costs because of small dispersed felling sites.
Less disturbance of forest ecosystem and greater shelter for regenerating seedlings.	More site damage on heavy soils because of less brash to provide brash-mats.
Reduced restocking costs (assuming natural regeneration is successful).	Dependent upon natural regeneration to be cost-effective. Therefore less suited to more fertile sites (weed competition) and/or where there is heavy browsing pressure.
Production of large diameter, high quality sawlogs.	Risks of wind damage when transforming regular stands, particularly on unstable sites.
Structural diversity provides resilience against windthrow (at the stand level).	Time required to determine success.

- Is the site suitable for laying out a system of racks for machine access for harvesting?

- Are you prepared to wait at least 20 years to know whether you have succeeded?

- Have you access to a qualified professional forester who can handle the management and monitoring of these stands for you?

- Are you prepared to forgo the income from some mature trees in the stand?

- Are there other stands on the property to provide income in case of failure?

If the answer to any of these questions is in the negative, then we would advise reconsidering the proposal, possibly by looking for more suitable sites or by obtaining further advice. Further information can be obtained from the references, and from the organisation listed in paragraph 30.

28. Any trial area should have a **short** management plan outlining the objectives, the silvicultural system(s) proposed and the desired stand structure and species composition, and listing the intended operations. This plan should be reviewed at 5-year and revised at 10-year intervals in the light of the results obtained.

CONCLUSIONS

29. Continuous cover forestry is an approach to management that fits well with current requirements to manage forests for multiple objectives. The silvicultural systems required to implement such an approach demand species that are adapted to sites and stands that are not subject to regular disturbances such as gales. There are many sites in Britain which do not fulfil these requirements and, given present knowledge, it would be folly to try to introduce such systems in these areas. However, where suitable conditions exist, we believe that a continuous cover approach will have an increasing role to play in the future management of British forests. The transition from the present reliance upon a single silvicultural system to a situation where a mix of systems are used in forest management requires the evaluation of the more promising systems and the development of the knowledge and skills essential for this type of change to occur. Achieving this type of change will demand time and patience, a readiness to learn from the experience of others and a willingness to manage trials and demonstrations for the long term. Success will not be achieved overnight, but the potential benefits from combining a mixture of systems at a landscape scale should produce more diverse forests to meet the demands of multi-purpose forestry.

FURTHER INFORMATION

30. There is an active research programme into alternative silvicultural systems and further details can be obtained from the authors on request.

The Continuous Cover Forestry Group hold regular meetings and workshops on these themes. For more details please contact the Membership Secretary:

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