Forestry Commission
231 Corstorphine Road
Edinburgh
EH12 7AT
www.forestry.gov.uk

# Transforming Even-aged Conifer Stands to Continuous Cover Management

INFORMATION NOTE

BY BILL MASON AND GARY KERR OF FOREST RESEARCH

MARCH 2004



## ABSTRACT

**This Note is a revision of the previous Forestry Commission Information Note 40 incorporating experience from a number of trials in different parts of Britain. It outlines an approach to the transformation of even-aged conifer stands in Britain. There are three stages in the process. Firstly, the potential for transforming a stand to continuous cover management is ranked using windthrow risk, soil fertility and species suitability as criteria. This ranking is then checked in the field, paying particular attention to stand structure and condition. Secondly, the manager needs to decide whether a simple or a complex stand structure is desired. Thirdly, one of four stand management options is chosen, based upon the structure desired and the age of a given stand.**

## AIM & SCOPE

1. This Note provides foresters with revised guidance on methods to increase within-stand structural diversity in even-aged forests. This process is known as *transformation*. The Note concentrates on the silvicultural aspects of the early stages of transformation. It is primarily targeted at the management of conifer and mixed species stands and expands on the general discussion of continuous cover forestry (CCF) presented in an earlier publication (Mason *et al.*, 1999). We have revised an earlier version (Mason and Kerr, 2001) in the light of experience gained in a number of operational trials of transformation to CCF in different areas of Britain. The main differences from the previous Note are in the:

- evaluation of windthrow risk in potential CCF stands;
- discussion of advance regeneration;
- presentation of stand structure;
- recent guidance on monitoring (Kerr *et al.*, 2002).

## BACKGROUND

2. CCF is an approach to management that helps increase species and structural diversity in forests and so contributes to multi-purpose objectives. For example, the United Kingdom Woodland Assurance Standard (UKWAS) requires forest managers to ‘increasingly favour’ lower impact silvicultural systems in windfirm conifer plantations (UKWAS, 2000: Section 3.4.4). The appropriate silvicultural systems for meeting this requirement are defined as ‘group selection, shelterwood or under-planting, small coupe felling systems, minimum intervention and single tree selection systems’. For the purposes of this note, CCF is considered to be synonymous with ‘alternatives to clearfelling’ (ATC).

3. We assume that managers will have decided during the Forest Design process that CCF is the best way of meeting their objectives in all or part of a given forest area. Table 4 of Mason *et al.,* (1999) summarises the advantages and disadvantages of CCF. A prerequisite for the successful adoption of CCF is a commitment to a more flexible, adaptive approach to stand management based on an understanding of woodland development over time in a given location.

## MANAGEMENT DECISIONS

4. There are three stages in the decision process:

**Stage 1: Evaluating the site and making a detailed stand appraisal**

**Evaluate both the site and the stand using criteria explained below to assess the feasibility of transformation.**

**Stage 2: Selecting the desired structure and appropriate silvicultural system**

**Decide what type of stand structure is appropriate for your management objectives.**

**Stage 3: Starting the transformation**

**Choose a thinning regime that will favour the desired stand structure, taking into account the current stage of stand development.**

## Stage 1: Site and detailed stand appraisal

### Site appraisal

5. Soils information is **essential** for areas under consideration for transformation to CCF. Do not begin the process of stand evaluation without this knowledge.

6. Once you have this information, you should then classify the potential suitability of your stands for transformation by scoring them using the criteria of windthrow risk, soil fertility and species suitability as shown below. The windthrow risk model ForestGALES (Dunham *et al.*, 2000) and the Ecological Site Classification (ESC) (Pyatt *et al.*, 2001; Ray, 2001) will be helpful guides in this process. Even if you are not familiar with these methods, you should still attempt to evaluate your sites in the same way using your own local knowledge.

**Risk of Windthrow**

7. Windfirm conifer plantations (see paragraph 2) will generally be found on sites with an old style windthrow hazard class (WHC) of 1 to 3. Stands in the lower part of WHC 4 may also be suitable, subject to further checking with ForestGALES. Stands in the upper part of WHC 4 and in WHC 5 and 6 are not recommended for transformation, particularly if they are located on wet or shallow rooting soils. However, the weaknesses in the WHC methodology (Quine *et al.*, 1995) mean that predictions of windthrow risk produced by this system are unreliable.

8. For this reason, we recommend that the risk of wind-throw in potential CCF stands be evaluated in one of two ways. In younger stands (about 20–40 years of age), ForestGALES should be used wherever possible (see paragraph 9). However, in older stands (i.e. close to or more than normal rotation age), an alternative method should be used since ForestGALES is less accurate here. More details are given in paragraph 10.

9. In **younger stands**, the prime aim of any intervention is to start to develop a more varied structure through thinning. However, since thinning can increase the risk of windthrow, particularly on exposed sites, the systematic evaluation of this risk using ForestGALES is recommended. This evaluation should be carried out using a thinning model appropriate to the stand (see Dunham *et al.*, 2000, for details). If none of the models are appropriate try a user defined model as described by Dunham *et al.* (2000). We assume that no manager will wish to incur a greater risk of wind damage than that represented by a probable return period of 1 year in 10 (equivalent to Wind Risk status 6 in ForestGALES). The wind risk in younger stands can be scored as follows:

   - Score 1 — Wind Risk status 6 expected to be reached at stand age of 80 years or more
   - Score 2 — Wind Risk status 6 expected to be reached at stand age of 40–80 years
   - Score 3 — Wind Risk status 6 expected to be reached at stand age of <40 years

10. In **older stands**, evaluation of windthrow risk will be more subjective and will require careful checking in the field. Particular emphasis should be given to past thinning history and soil type, especially rooting depth. These factors can be scored:

   - Score 1 — A well-thinned stand with basal area ≤yield tables on a deep rooting soil (e.g. brown earth, podsol, or weak/intergrade ironpan)
   - Score 2 — An underthinned stand with basal area >yield tables on a deep rooting soil
   - Score 3 — A stand with a history of very little or no thinning and/or on a shallow rooting soil (e.g. peat, gley)

11. These scores need to be interpreted with caution since topography, exposure and other local conditions will also have an influence on windthrow risk. In general terms, the older the stand, the less it has been thinned, the shallower the soil, and the more exposed the site, the lower the potential will be for transformation.

**Soil fertility and potential vegetation competition**

12. Since natural regeneration will generally be the preferred method of restocking stands being transformed, sites must be chosen where conditions for this are favourable. Achieving successful natural regeneration is often more difficult on fertile than on infertile soils because of greater vegetation competition. Soils can be ranked for potential vegetation competition by using the Ecological Site Classification (ESC) as shown in Figure 4.3 from Nixon and Worrell (1999). Soils can be scored:

   - Score 1 — Soil nutrient regime in ESC is very poor or poor
   - Score 2 — Soil nutrient regime in ESC is medium
   - Score 3 — Soil nutrient regime in ESC is rich or very rich

**Species suitability**

13. Species must be suited to the site and desirable in terms of management objectives. On many sites, other species from neighbouring stands will also regenerate. Information on species suitability/potential can be found in ESC and scored as follows:

Score 1 Species ranked as optimal in ESC
Score 2 Species ranked as suitable in ESC
Score 3 Species ranked as unsuitable in ESC

If overstorey and understorey species differ in suitability, then focus upon the species which is the object of management.

**Preliminary site ranking**

14. Windthrow risk, site fertility and species suitability can be combined to rank site potential for transformation as follows:

| | |
|---|---|
| Good | combined score of 3–4, windthrow scored 1 |
| Moderate | combined score of 5–6, windthrow scored 1 or 2 |
| Low | sites with any of the criteria scored 3 |

15. We suggest that only stands given a 'good' or 'moderate' rating in this initial evaluation should be considered for transformation, subject to detailed appraisal in the field. However, even if the current **stand** is given a 'low' rating (e.g. unsuitable species, unthinned 'older' stand), the **site** may still be suitable for transformation in the future. In such cases, management options other than clearfelling are limited, and transformation to CCF is best considered when the successor stand has closed canopy.

## Detailed stand appraisal

16. Once the initial sift has been completed, all stands with potential for transformation to CCF should be inspected in the field, paying particular attention to the following features.

**Stand structure and quality**

17. Examine the structure and composition of the candidate stands. Points to consider include:

- Are the tree species clearly suited to the site and of good form?
- The past thinning history and whether there are sufficient trees with well-developed crowns that can act as potential seed bearers. If these do not exist, are the better trees likely to develop good crowns in response to further thinning?
- Is there evidence of recent windblow to suggest that the stability may already be at risk? If windblow has occurred, is it confined to small wet areas of inherently low stability that do not compromise the rest of the stand?
- Are the stems of adequate quality? For example, stems damaged by bark stripping may be at risk of timber degrade if retained for a long time.
- Are you confident of obtaining natural regeneration of the desired species?

**Advance regeneration**

18. Advance regeneration is a general term for seedlings (woody plants <1.3 m tall) and saplings (woody plants ≥1.3 m tall and <7 cm dbh) in the understorey (see Table 3 of Kerr *et al*., 2002). Its presence shows that conditions within the stand are, or have been, favourable for seed germination and seedling growth. Not all advance regeneration will be of desirable species, and managers also need to consider whether the stocking density and sizes present on a site are acceptable. The main message is that the presence of small (i.e. <20 cm tall) seedlings, even in considerable numbers, does not guarantee regeneration success since these may be lost through browsing, insufficient light, moisture stress, or physical damage when the stand is opened up. However, the presence of adequate numbers of saplings of desired species is a more positive sign because these will have a much greater chance of surviving to maturity.

19. A decision on suitability of the regenerating species can be informed by the ESC criteria referred to above and influenced by other objectives of management. For example, Sitka spruce can be found regenerating into Scots pine stands on nutrient poor soils where it is unsuitable as a pure species. Similarly, if you want to maintain larch stands for landscape reasons, you should not accept advance regeneration of shade tolerant conifers such as western hemlock.

20. If there is no advance regeneration, try to understand what factors are responsible. These may include the age of the stand (because of low seed production and limited potential for regeneration in stands less than 30–35 years of age), the light environment within the stand, the degree of browsing pressure and vegetation competition.

These factors can change over time and may respond to appropriate management so that conditions become more favourable. **For further guidance on natural regeneration see Nixon and Worrell (1999) for conifers and Harmer and Kerr (1995) for broadleaves.**

**Ground flora**

21. The type and quantity of ground vegetation present varies with site and depends on factors such as soil, moisture availability, tree species and canopy cover. Natural regeneration will be favoured where competitive weeds such as bracken, bramble, grasses, bilberry and heather are either absent or sparse. Where such vegetation dominates the site, cultivation combined with weed control will be essential for any chance of natural regeneration. In such situations, it may be more sensible to plant, especially on moist fertile sites.

**Litter**

22. Even if there is little vegetation present, a deep litter layer (>5 cm thick) can still present a barrier to regeneration. Seed will germinate in such material but is unlikely to survive unless roots can quickly penetrate into mineral soil to access the water and nutrients required for growth. A thick layer will require disruption through scarification or similar means for regeneration to occur.

**Animals**

23. Deer, rabbits and hares will all browse advance regeneration, while squirrels, mice and birds will eat seed either in the cone or on the ground, or both. Each of these factors must be carefully assessed by observation and inspection. Current information indicates that deer densities should be less than 5–10 animals per 100 ha to minimise damage to regeneration or they must be excluded from areas by fencing. Lower densities will be necessary where the desired tree species are preferentially browsed (e.g. Douglas fir, silver firs, most broadleaves).

**Access and topography**

24. You need to consider access to the stand for harvesting and ongoing management. In general, stands placed under CCF management will require a network of within-stand racks which are linked to extraction roads so that harvesting machinery does not damage regenerating seedlings. These links need to be robust and well constructed to ensure long-term machinery access to the stands. **The layout of this extraction network must be considered before any stand management to favour CCF occurs.**

**Use the features discussed in paragraphs 16–23 to adjust the initial ranking of the site and decide on the likelihood of success with transformation. The most suitable sites will be those with little or no browsing, presence of desirable advance regeneration, a favourable stand structure, and ground flora and litter conducive to seed germination and seedling survival. If any of these conditions are not met, you must be clear on the remedial actions required, their feasibility and likely cost.**

## Stage 2: Desired structure and appropriate silvicultural system

25. Other guides, such as Yorke (1998), approach transformation by recommending a silvicultural system based largely upon the shade tolerance of the species concerned. However, we feel that the manager should first decide upon the stand structure that will best achieve management objectives. In essence, a decision must be made between:

1. A **simple** structure in which there will be 1 or 2 canopy layers.
2. A **complex** structure with 3 or more canopy layers.

Only canopy layers that contain trees (woody plants with dbh ≥7 cm) count in this classification. For example a stand with an overstorey of Douglas fir, an understorey of western hemlock and seedling regeneration of both species is a **simple** structure. Only when three distinct layers of **trees** can be identified (regardless of saplings and seedlings) is the structure a **complex** one. Note that light demanding species such as pines and larches are generally more suited to management in a simple structure.

26. Try to find stands within the forest, or on neighbouring properties, that embody the desired structure. These can be used as reference points for future management. At a landscape scale, more than one structure may be desirable to promote greater visual and habitat diversity. Only after you have decided upon the target structure for a given stand, should you choose a silvicultural system. Matthews (1989) discusses a wide range of silvicultural systems and Hart (1995) describes their recent use in Britain. Remember that a

silvicultural system is only a method of achieving management objectives and not an end in itself.

27. Figure 1 (from Kerr, 1999) illustrates the differences between the main silvicultural systems. A simple structure will be produced by the uniform or group shelterwood systems, whereas a complex structure will result from an irregular shelterwood or a selection system. The chosen system can be modified to allow for the shade tolerance of the species concerned (see Mason *et al*., 1999). For example, use of group selection with larger gap sizes (i.e. >0.2 ha) will be more suitable for light demanding species.

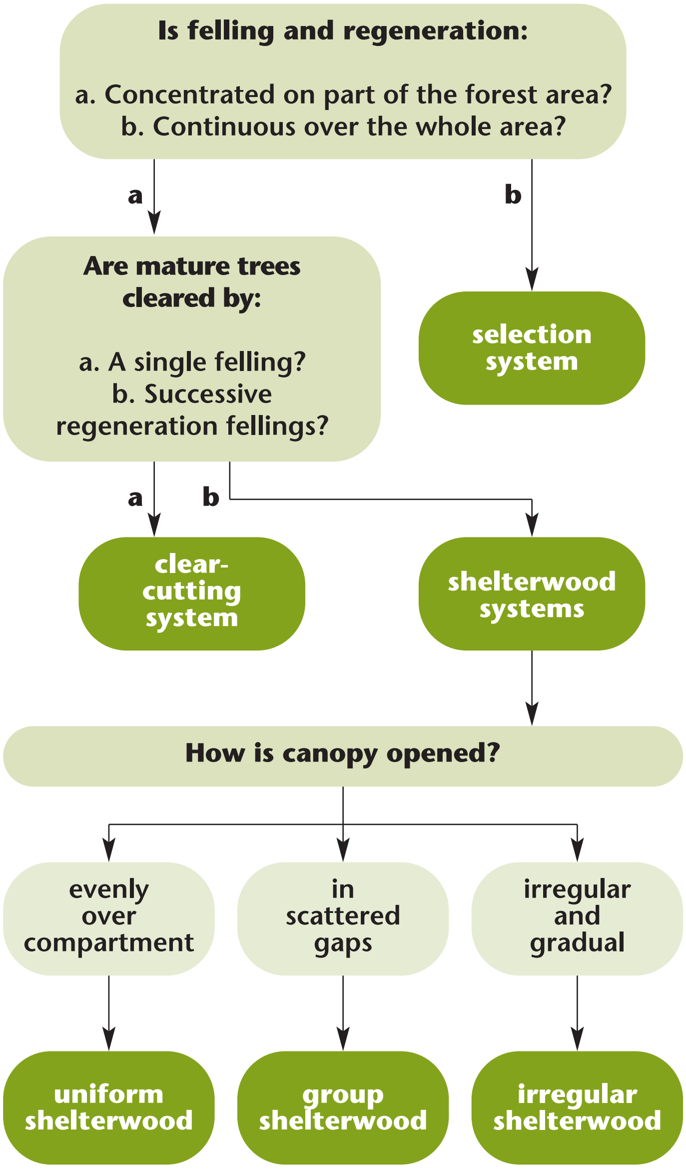


**Figure 1**

**A decision tree for classifying the main silvicultural systems, adapted from Kerr (1999). Note that selection systems can be further subdivided into group or single-tree selection depending upon the shade tolerance of the species involved.**

## Stage 3: Starting the transformation

28. Having determined your desired structure and silvicultural system, you need to decide how to begin transforming the chosen stand. The options depend on the current age of the stand and its life expectancy. **It is not always possible to complete the transformation process within the life of the existing trees in the stand.** For example, if a complex structure is desired, but the stand is within 20 years of probable windthrow then the best that can be anticipated within 30 years is for a simple structure to be developed with regeneration established and a few surviving overstorey trees. The development of a complex structure would take place through the management of the regenerated successor stand.

29. Thinning is the crucial means of developing both the crowns of the trees to provide seed for regeneration, and the structure of the stand that will produce a favourable environment for seed germination and seedling growth. Transforming even-aged stands will require much greater use of crown thinning than has been the custom in British conifer forests in recent decades.

30. The presumption is that natural regeneration will be favoured wherever possible to try to minimise establishment costs. However, underplanting can also be used, particularly if one aim is to introduce either desired species that are absent from the site or improved genotypes. For example, there is no inherent reason why the use of genetically improved Sitka spruce cannot be combined with CCF. Indeed, using a smaller number of improved plants and allowing natural regeneration to provide the matrix can reduce costs of using improved stock.

31. In the following sections we present four options depending on the type of structure aimed for and the stage of development of the stand, as shown in Table 1.

**Table 1** **Options for transformation**

| Desired type of structure | Stand age | |
|---|---|---|
| | Young (20–40 years) | Older (>40 years) |
| Simple | 1 | 3 |
| Complex | 2 | 4 |

### Option 1: Young stand aiming for a simple structure

32. The assumption here is that a shelterwood or a seed tree system is the chosen silvicultural system. Thinnings seek to favour the crown development of the eventual seed trees while ensuring that site conditions remain

conducive for natural regeneration. The target density for a shelterwood at the start of regeneration would be between 100 and 200 trees ha$^{-1}$ whereas lower target densities of 25–50 stems ha$^{-1}$ are characteristic of seed tree systems. A seed tree system will only be practical when abundant natural regeneration can be reliably expected without the beneficial effects of a retained canopy (e.g. there will be lower frost risk and reduced vegetation competition under a shelterwood).

33. Thinning practice can be based upon that used in conventional even-aged stands but with some modifications. Firstly, early thinning intensity should be slightly heavier (10–20%) than current recommendations (e.g. Edwards and Christie, 1981) to develop the crowns of the eventual seed trees. Secondly, crown thinning should be used to promote these seed trees rather than conventional intermediate or low thinning. Thirdly, it may be helpful to mark the potential seed trees so that there is continuity in the pattern of thinning. Natural regeneration will not start to occur until around 40 years because of a lack of adequate seeding. Therefore opening up the stand to enhance growth of advance regeneration may well be delayed until some 10–20 years beyond normal rotation age. You will need to consider the potential windthrow risk to the retained trees after the stand has been opened up to promote regeneration.

34. The choice of the most suitable variant of these silvicultural systems will depend on the appearance and pattern of natural regeneration, e.g. if it is abundant and regularly distributed, then a uniform shelterwood may be appropriate, however, if it is sporadic and in groups then a group shelterwood may be more appropriate. **The main principle during this phase is that felling releases advance regeneration and does not take place in anticipation of regeneration.** If natural regeneration is not successful, you may need to plant using the overstorey to shelter the newly planted trees.

**Option 2: Young stand aiming for a complex structure**

35. A group selection or irregular shelterwood system is assumed, since most species grown in Britain are insufficiently shade tolerant to justify a single stem selection system (e.g. Mason *et al.*, 1999). The aim is to develop greater structural diversity within the stand first by selecting 40–80 trees of desirable species ha$^{-1}$ using the criteria of stem stability, good form and vigour, and appropriate spacing (Schütz, 2001). Individual trees with a tree height:diameter ratio of $<80$ are likely to be more stable than those with higher ratios (Mason, 2002). These 'Frame' trees should be favoured in all thinnings using a crown thinning regime. This process needs to be implemented by the third thinning at the latest to ensure that the favoured trees have a chance to respond.

36. A residual basal area is selected for the stand, which on current knowledge should be about 18–25 m$^2$ ha$^{-1}$ for larches and pines and 25–35 m$^2$ ha$^{-1}$ for spruces and Douglas fir. The choice within this range depends upon the site and the balance between the overstorey and any regeneration. If there is little, or no, regeneration, then higher values should be chosen to provide suitable conditions for seedlings to establish. If there is sufficient regeneration which needs to be released, then lower values would be favoured. The aim at each thinning is to remove sufficient trees so that the chosen residual basal area is achieved. A thinning cycle is selected based mainly on the current increment of the stand to maintain the basal area within a suitable range (Hamilton and Christie, 1971). No more than 20% of the basal area should be removed at any thinning to guard against the risk of windthrow. This can be very important when dealing with stands that are overstocked because of limited past thinning. In such situations, two thinnings in short succession should be chosen in preference to one heavier intervention.

37. As the stand develops over time, natural regeneration should begin to colonise the understorey. This may not be appreciable until normal rotation age or later. Later thinnings can progressively open up gaps to favour areas of established regeneration. Because of the variable light climate within the stand, some of these seedlings will start to grow towards the canopy and, following further regeneration, a 2–3 storied structure will develop. At least 50 years may be required for this to occur, when the stand can be considered to have completed its transformation and ready to be managed using methods such as the 'reverse-J' structure traditionally identified with classical selection systems. More information on this can be found in Yorke (1998), and Kerr (2001, 2002a and b). If natural regeneration is not initially successful, group planting could be used to create the desired structure, although ultimately a complex structure is probably only cost-effective with natural regeneration.

**Option 3: Older stand aiming for a simple structure**

38. These stands are managed in accordance with Option 1 described above, the main difference being that in Option 3 the window for regeneration is shorter, especially if the risk of windthrow at the site is scored

2 or 3. As a consequence, there is little opportunity for favouring the crowns of the trees to be retained and improving their potential stability. This will result in more seed trees being retained than in Option 1 and possibly in a longer regeneration period being used. Strip shelterwood systems can be particularly useful in this situation provided the sections are worked from leeward to windward. If natural regeneration is secured then the stand can be managed in accordance with Option 1, i.e. by selecting the silvicultural system according to the appearance and pattern of natural regeneration. If no natural regeneration is obtained, planting will have to be considered and transformation may have to be suspended until the next rotation.

**Option 4: Older stand aiming for a complex structure**

39. The aim is the same as Option 2, but the likelihood of any of the 'Frame' trees surviving to the completion of the transformation phase is low given windthrow risk and a lack of stand differentiation. There is also the danger that the 'Frame' trees reach such large diameters as to be unmarketable. While the target basal areas and the thinning procedures remain the same as in Option 2, the response of the trees in the stand will be much less. In these older stands, the main aim should be to establish groups of regeneration under an irregular overstorey while the older trees are progressively felled or wind-blown. The variable growth of regenerating seedlings in the understorey will create irregularity in the successor stand which can be exploited to complete the transformation using the procedures outlined in Option 2.

**Felling of small groups**

40. This method aims to transform a conifer stand over a period of time (conversion period) by felling groups of 0.1 to 0.5 ha and replanting with the desired species and taking advantage of natural regeneration when, and if, it appears. The method is considered in detail in Yorke (1998) and has been used since 1952 at the Edinburgh University/Forestry Commission demonstration forest at Glentress in south Scotland (see Wilson *et al*., 1999). The advantages of the system are that it is predictable, is not reliant on natural regeneration, and allows the introduction of species/genotypes not present in the existing stand. It is a useful means of initiating transformation in older stands of high visual amenity. However, the disadvantage is the high cost associated with restocking and managing extensive areas of small groups. When applied on fertile sites, the felling of the groups can result in rapid vegetation colonisation so that managers are faced with the problem of restocking many small and dispersed clearfell sites. Where groups are created in this way, it is important to ensure that the ratio of group diameter to height of surrounding trees is not less than 1.5–2.0 if satisfactory growth of young trees is to be achieved.

## MANAGEMENT PLANNING

41. All areas being transformed to CCF should have a succinct management plan outlining the objectives, current and desired stand structure and species composition, proposed silvicultural system(s), and the interventions planned in the next 10 years. These proposals should be reviewed at 5 year intervals.

42. We recommend that all silvicultural interventions are planned on the basis of stand level information on species composition, diameter distribution and natural regeneration collected using the monitoring system described in Kerr *et al*. (2002). Information from monitoring should be appended to the management plan and used as a basis for any revision.

## WIDER APPLICATION

43. We believe that the principles presented in this Note are capable of being applied to other woodland types in Britain (e.g. various types of broadleaved woodland). However, the details would require adjustment to the sites and species concerned. For further details, please contact the authors.

## SOURCES OF ADVICE


| | |
|---|---|
| Bill Mason | Gary Kerr |
| Forest Research | Forest Research |
| Northern Research Station | Alice Holt Research Station |
| Roslin | Farnham |
| Midlothian | Surrey |
| EH25 9SY | GU10 4LH |
| 0131 445 2176 | 01420 22255 |
| bill.mason@forestry.gsi.gov.uk | gary.kerr@forestry.gsi.gov.uk |


## FURTHER INFORMATION

The Continuous Cover Forestry Group produces a Newsletter, organises field meetings, training courses and seminars. Contact with the Group can be achieved via the authors, both of whom are active members, or by writing to the membership secretary whose name can be found on the CCFG website (www.ccfg.co.uk).

## ACKNOWLEDGEMENTS

We would like to thank the many people who commented on early drafts of this revised note including: Colin Edwards, Ralph Harmer, Chris Marrow, Helen McKay, Chris Nixon, Richard Thompson, Crispin Thorn, Sophie Hale, Barry Gardiner, Chris Jones, Steve Murphy, Craig Sinclair, Paul Cody and Peter Weston.

## REFERENCES

DUNHAM, R. A., GARDINER, B. A., QUINE, C.P. AND SUÁREZ J. C. (2000).
*ForestGALES – A PC based wind risk model for British forests.*
Forestry Commission, Edinburgh.

EDWARDS, P. N. and CHRISTIE, J. M. (1981).
*Yield models for forest management.*
Forestry Commission Booklet 48.
HMSO, London.

HAMILTON, G. J. AND CHRISTIE, J. M. (1971).
*Forest management tables (metric).*
Forestry Commission Booklet 34.
HMSO, London.

HARMER, R. AND KERR, G. (1995).
*Natural regeneration of broadleaved trees.*
Research Information Note 275.
Forestry Commission, Edinburgh.

HART, C. (1995).
*Alternative silvicultural systems to clear cutting in Britain: a review.*
Forestry Commission Bulletin 115.
HMSO, London.

KERR, G. (1999).
The use of silvicultural systems to enhance the biological diversity of plantation forests in Britain. *Forestry* **72**, 191–205.

KERR, G. (2001).
*An improved spreadsheet to calculate target diameter distributions in uneven-aged silviculture.*
Continuous Cover Forestry Group Newsletter 19. August 2001.

KERR, G. (2002a).
The potential for the sustainable management of semi-natural woodlands in southern England using uneven-aged silviculture. *Forestry* **75**, 227–243.

KERR, G. (2002b).
Uneven-aged silviculture: putting ideas into practice. *Quarterly Journal of Forestry* **96** (2), 111–116.

KERR, G., MASON, B., BOSWELL, R., AND POMMERENING, A. (2002).
*Monitoring the transformation of even-aged stands to Continuous Cover Management.*
Forestry Commission Information Note 45.
Forestry Commission, Edinburgh.

MASON, B., KERR, G. AND SIMPSON, J. (1999).
*What is continuous cover forestry?*
Forestry Commission Information Note 29.
Forestry Commission, Edinburgh.

MASON, W. L. (2002).
Are irregular stands more windfirm? *Forestry* **75**, 347–355.

MATTHEWS, J. D. (1989).
*Silvicultural systems.*
Clarendon Press, Oxford.

NIXON, C. AND WORRELL, R. (1999).
*The potential for the natural regeneration of conifers in Britain.*
Forestry Commission Bulletin 120.
Forestry Commission, Edinburgh.

PYATT, D. G., RAY, D. AND FLETCHER, J. (2001).
*Ecological Site Classification for forestry in Great Britain.*
Forestry Commission Bulletin 124.
Forestry Commission, Edinburgh.

RAY, D. (2001).
*Ecological Site Classification: a PC-based decision support system for British forests.*
Forestry Commission, Edinburgh.

SCHÜTZ, J-P. (2001).
Opportunities and strategies of transforming regular forests into irregular ones. *Forest Ecology and Management* **151**, 87–94.

UKWAS (2000).
*Certification standard for the UK Woodland Assurance Scheme.*
UKWAS Steering Group, Edinburgh.

WILSON, E. R., WHITNEY McIVER, H. AND MALCOLM, D. C. (1999).
Transformation to an irregular structure of an upland conifer forest. *Forestry Chronicle* **75**, 407–412.

YORKE, D. M. B. (1998).
*Continuous cover silviculture: an alternative to clear felling.*
Continuous Cover Forestry Group.
Tyddyn Bach, Llanegryn, Tywyn, Gwynedd LL37 9UF.

Enquiries relating to this publication should be addressed to:

Bill Mason
Forest Research
Northern Research Station
Roslin
Midlothian
EH25 9SY

Tel: 0131 445 2176
Fax: 0131 445 5124

Email: bill.mason@forestry.gsi.gov.uk

ISSN 1460-3802
ISBN 0-85538-620-7





FCIN040/FC(KMA)/NVSPT-2K/MAR04