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Monitoring the Transformation of Even-aged Stands to Continuous Cover Management

INFORMATION NOTE

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SUMMARY

The aim of transformation is to change the structure of even-aged stands from one that is regular to one that is more diverse and varied. A system of monitoring is described which will allow forest managers to record these changes and select appropriate stand interventions. The method uses fixed-area plots, located on a systematic grid over the whole area being transformed; the plots can be permanent or temporary depending on the data required by the forest manager. The main assessments are species, number and diameter of trees (≥7cm diameter at breast height), and the species and number of saplings (trees <7 cm dbh and ≥130 cm tall). Interpretation of the results of the monitoring depends on whether transformation is aiming for a *simple structure* (1 or 2 canopy strata) or a c*omplex structure* (3 or more canopy strata).

AIM AND SCOPE

1. This Information Note describes a system for monitoring the development of a stand being transformed from an even-aged structure to continuous cover management. Monitoring is essential because it produces the stand level information on species composition, diameter distribution and natural regeneration that are required to plan silvicultural interventions. Action following analysis of stand level information is often called 'adaptive management' and is a prerequisite for the successful adoption of continuous cover (Mason and Kerr, 2001).

BACKGROUND

2. A previous Note described Continuous Cover Forestry (CCF) and its importance in meeting forestry policy objectives in Britain (Mason *et al.*, 1999). A subsequent Note outlined silvicultural options for transformation (Mason and Kerr, 2001). This recommended the use of a three stage process: (i) site and stand appraisal, (ii) determining the desired stand structure to meet management objectives, and (iii) manipulating the stand to achieve the desired structure.

3. The system of monitoring outlined here produces information on which to base judgements about how a stand has developed over time. **It is therefore important to use the system before commencing, and during the process of transformation, to obtain information to control a sequence of interventions.** Information from the monitoring should be included in a written plan describing management objectives, site conditions, current and desired stand structure and species composition, planned interventions and a transformation period. The plan should be revised after each cycle of intervention and monitoring. We assume throughout that production of quality timber is an objective of management in the stands being transformed.

4. The main aim of transformation is to manipulate the current stand to develop a desired structure over time, either *simple* or *complex* (Mason and Kerr, 2001). Following from this the aims of the monitoring described here are: (i) to quantify changes in the diameter distribution and species composition of a stand over time and (ii) to ensure that regeneration fulfills set stocking requirements. Other aspects may need to be monitored and, if so, other guides should be consulted; for example, Ferris-Kaan and Patterson (1992) on vegetation, Pollard (1977) on butterflies, Mayle *et al.* (1999) on deer and Pommerening (2002) on structural indices. Current experience with long-term ecological monitoring shows that the two key factors for success are simplicity and continuity (Peterken, 2000).

DESIGN OF THE MONITORING SYSTEM

5. The main choices to make in the design of any sampling system in forests are between: (i) random or systematic sampling, (ii) fixed area or variable area plots and (iii) permanent or temporary sampling points, or a mixture of both (Husch *et al.*, 1982).

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6. Stand reactions to transformation will vary throughout an area. Random sampling is statistically ideal but can lead to plots being clustered and therefore some changes could be missed. To avoid this problem the system described here uses systematic sampling. Transects, a form of systematic sampling, have been frequently used in long-term ecological monitoring (Peterken, 2000) and in other examples of silviculture (Marquis, 1994). However, the system recommended here uses sampling points that are placed systematically over the whole area in a grid pattern.

7. This Note also recommends the use of fixed area plots which are commonly used in British forestry (Hamilton, 1975). Although it is possible to assess diameter distribution and species composition within variable area plots using a relascope (Hetherington, 1974) this Note recommends the use of fixed area plots as they allow regeneration to be assessed more easily.

8. The decision to use permanent or temporary sampling points must be made after consideration of the advantages and disadvantages of both systems (Table 1). In areas where there have been successful examples of transformation for particular species/site types, permanent plots are probably the best option from the outset. However, in other areas where the success of the transformation is less certain, temporary plots may be better for the early part of the transformation with permanent plots being installed later.

9. A potential problem with permanent sampling points is that if they are obviously marked, management in the plot may be different to the rest of the stand. Any estimates of stand structure will be accurate but not representative of the whole stand. Guides such as Schmid-Haas *et al.* (1993) recommend the use of permanent sampling points whose location is only known to the surveyor, which has the effect of increasing the cost of both plot installation and re-sampling. However, with the system described here sampling points will be reasonably close (every 45 m for 5.0 ha) and, even if the plots are marked, it is difficult to see how the plots could be managed differently to the rest of the matrix.

10. Permanent and temporary plots can be combined using a system known as 'sampling with partial replacement'. This allows the forest manager to react to changing variation in the area being transformed. For example: if variation increases some temporary plots could be established to supplement the existing permanent plots; if variation decreases some of the permanent plots could be abandoned. For more information on this see Ware and Cunia (1962) or Cochran (1977).

11. The system of monitoring described here was developed by simulating different sampling strategies using data from a number of stands in Germany where species, diameter and tree location had been assessed (Pommerening and Lewandowski, 1997).

Table 1

Comparison of permanent and temporary plots

Factor	Permanent plots	Temporary plots
Plot installation	Both systems can be planned and installed using the method outlined in paragraphs 18–22.	
Plot marking	Required and essential so that they can be easily relocated.	Not required.
Usefulness of data	Changes due to stand development and thinning can be separated. Variance of data will be smaller compared with temporary plots; this is important as transformation will increase the variability of the forest structure. A good option if information on stand volume increment is required.	Changes will be the result of trees removed in thinning as well as stand development but it is not possible to separate these two influences. Variances will generally be higher compared with permanent plots and there is a danger that the differences between two successive measurements will be hidden by this variability.
Costs	Generally higher for permanent plots compared with temporary plots because of the need for plot marking and subsequent location.	

The system was then field tested on two stands in Britain: at Wykeham Forest in North Yorkshire (3.2 ha, many species) and Stourhead (Western) Estate in Wiltshire (25 ha, 5 main species). At both sites the system outlined in this Note gave an adequate representation of the population in terms of dbh distribution and species proportions (Kerr *et al.*, in prep.). Both stands were mixed and were a good test of the monitoring system which should produce useful data for areas being transformed.

12. The only way to be confident of the results of your sample is to calculate the mean and variance of each of the assessments. Methods of doing this are shown in Husch *et al.* (1982) but if in doubt a statistician should be consulted. If the monitoring system described here becomes widely used then supporting software could be developed to facilitate calculation of useful statistics concerning the sample measurements.

THE MONITORING SYSTEM

13. A checklist (Appendix 1) has been compiled to summarise the important decisions for effective use of the monitoring system.

Stratification

14. The crucial first step is to divide the area being transformed into blocks that have common site factors and are to be managed as a single unit. This can only be achieved by observation in the field and must take account of the information available from earlier assessments (see paragraphs 5–21 of Mason and Kerr, 2001). The main criteria on which to divide the area are soils/topography; areas on the same soil type, e.g. podzol, brown earth, ironpan, or major topographical features should be grouped together. In many cases changes in soil type will coincide with major changes in topography, e.g. when a plateau changes to a valley side. In some areas the existing compartment structure may be appropriate, with some minor modifications; however, where soil type changes within existing compartments major changes to the division of the area will be necessary.

15. Do not subdivide simply on the basis of species even when seedlings have different light requirements (e.g. larch and western hemlock) unless the individual species are to be managed to produce different structures, i.e. *simple* or *complex*. However, if such contrasting species are included in the same block, it is important to be realistic when describing the desired species composition of the new stand in the transformation plan. It is highly unlikely that the same species balance will occur after transformation as in the original stand, and certain that other nearby species will colonise.

16. In any block, it is suggested that there is an area below which monitoring is not necessary or cost-effective. The general principle here is to attempt to combine similar areas for continuous cover management and therefore the proposed minimum is 5 ha, but in some situations (e.g. lowland mixed species stands) a lower figure may be appropriate. Each block should ideally be delineated by permanent features such as roads, rides, streams, stone walls, to ensure that future managers will be able to locate block boundaries.

17. Where blocks contain even-aged stands, monitoring will probably not be necessary until the stands are 30–40 years old because this is when seeding commences in many forest tree species and advance regeneration may become established.

Number of plots and plot size

18. In order to reflect the diameter distribution of the block accurately it is important that a minimum number of trees are sampled throughout the area. For areas of up to 5 ha, **sample at least 60 trees** using 25 plots. For areas above 5 ha, **sample at least 75 trees** using a minimum of 25 plots and a maximum of 35 plots depending on area, using one extra plot for each additional 2 ha above 5 ha. For example, for 9 ha use 25+2=27 plots, for 17 ha use 25+6=31 plots, and for 25 ha and above use 25+10=35 plots. The area of the plot must be selected to ensure the target number of trees is achieved with the number of plots for the area (Table 2), allowing for the fact that in the medium term, tree numbers will decline due to thinning.

Spacing between plot centres

19. The spacing between plot centres within a block can be calculated using the following formula:

$$S = 100 \times \sqrt{\frac{A}{n}}$$

Where: S = spacing between plot centres in metres; A = area of the block in hectares; n = number of plots required.

Table 2

Plot sizes for monitoring transformation to continuous cover

Stand density (trees ha^{-1})	Recom-mended plot area (ha)	Circular plot radius[1] (m)	Square plot side[1] length (m)
>300	0.01	5.6	10.0
150–300[2]	0.02	8.0	14.1
<150[2]	0.05	12.6	22.4

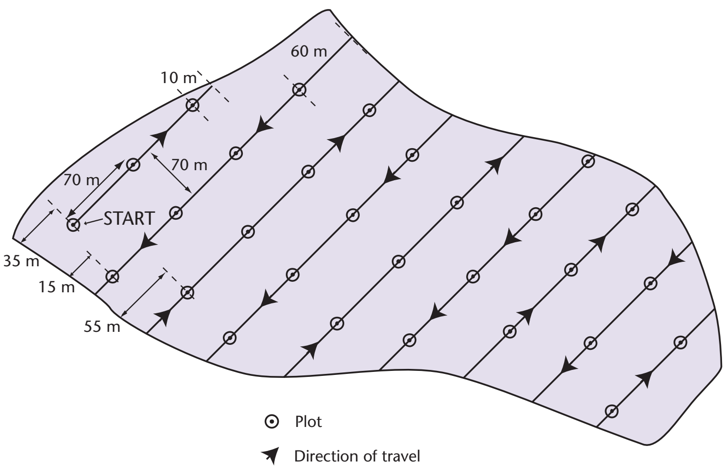
[1]Distances must be corrected for slope (see pages 132–134 of Hamilton, 1975).
[2]See paragraph 25 for guidance on assessment of regeneration in these large plots.

Plot location

20. Figure 1 shows an example of a block of 13.9 ha where *S* = 70 m. The first plot centre is located by choosing a convenient point on the boundary of the stand, and then pace into the stand a distance *S*/2, in this case 35 m. Plot centres are established at intervals of 70 m along a bearing and continued on parallel bearings 70 m from the first. From then on plot centres should be located by pacing, with regular checks to ensure the paced distance is approximately *S*. If *S* is consistently under-paced the whole area will not be covered. In long, thin areas, for example a stratum stretching around a contour, it would be important to prevent sampling on a single line. To avoid this, the distance between the sample points could be adjusted to ensure two lines were used or, with an appropriate increase in *S*, they could be zigzagged over the area.

Figure 1

Location of 29 plots in a 13.9 ha block



21. If a plot falls near a boundary it should only be rejected if the edge of the plot falls outside the area of the block. Edges can be important environments for regeneration and this must be reflected in the sample. However, if a plot falls on a ride, or a similar non-wooded area within the block, it should be recorded as such and not included in the assessments.

Plot installation

22. A simple and efficient procedure for installing circular plots is to: (i) locate and mark the centre of the plot with a ranging pole (and mark permanently if appropriate); (ii) measure 6–12 radii and mark the plot boundary with brightly coloured plot markers; it will be helpful if these are near to boundary trees. Once the plot is marked it is much easier to make the measurements required and where necessary check them. Experience has shown that where there is regeneration to be assessed in the plot, investment in (ii) above saves time while the plot is being assessed.

WHAT TO MEASURE

23. In each plot the following should be recorded for tree species: (i) the species and diameter of each tree (≥7 cm dbh), and (ii) the species and number of regenerating saplings. Saplings are defined as woody plants ≥130 cm tall and <7 cm dbh and can be 'small' or 'large' as defined in Table 3. The logic of using saplings to assess natural regeneration is that there is a much higher chance of them surviving to maturity compared with seedlings. If the area contains coppice

Table 3

Nomenclature and size criteria for seedlings, saplings and trees

	Diameter at breast height (cm)	Height (cm)
seedling	n/a	<130
sapling (small)	<3	≥130
sapling (large)	3–6.9	≥130
tree (small)	7–24.9	≥130
tree (medium)	25–39.9	≥130
tree (large)	40–54.9	≥130
tree (very large)	>55	≥130

(or stems forked below 130 cm) treat these as follows: count no shoots as saplings if one of them is a tree; or if none of the shoots is a tree, count one of the shoots as a sapling if any are ≥130 cm. It is important that trees and saplings of coppice origin are tallied separately (a form for collecting this information is attached as Appendix 2). If 'Frame' trees have been selected and permanently marked (see Mason and Kerr, 2001) these should also be recorded separately.

24. The presence of seedlings, whether or not they are browsed, and the amount of competing vegetation is important and must be noted while the plot is being assessed on the monitoring form (Appendix 2). The information on seedlings, browsing and other vegetation will help understand why a stand is not regenerating or why the seedlings are not surviving to become saplings. For further information on natural regeneration of conifers see Nixon and Worrell (1999) and for broadleaves, Harmer and Kerr (1995).

25. In stands where the density of trees is low (<300 ha^{-1}) and the density of saplings is high (>5000 ha^{-1}) it is recommended to use a smaller concentric plot for the regeneration assessment. For example, when a shelterwood of 125 stems ha^{-1} has successfully produced a *simple structure*, 0.05 ha plots could be used for the trees and 0.01 ha plots (with the same plot centre) could be used to count the saplings.

26. If information on volume or tree stability is required then it will be necessary to estimate top height. If an accurate estimate is required you must carry out a separate top height assessment for main species in the stand using procedures described in Hamilton (1975) and Forestry Commission (2001). Otherwise, using the procedure described here, measure the total height of the largest dbh tree in every second plot and use the mean of these as an estimate of stand top height. It is important to be clear how you will use the height information before committing the resources to it.

27. One possible use of height data could be to use top height to estimate form height and hence volume (volume = form height x basal area). A worked example of how this was done for a woodland in the Chilterns is given by Reade (1990) and in a mixed woodland in Thetford Forest by Kerr (2002). Another use of height measurements is to evaluate the height (cm): dbh (cm) ratio of trees in a stand. A value of <80 indicates reasonable stability whereas >100 suggests unstable trees.

INTERPRETING THE RESULTS

28. An important first step to aid interpretation of results is to be clear about the desired future structure and species composition of the transformed block. This should be included in the transformation plan described in paragraph 3.

Stand structure

29. Paragraphs 30–33 suggest how to use the data collected to describe the diameter distribution of the block. This information can then be used to define appropriate stand interventions for the area, depending on the desired final structure, i.e. *simple* or *complex*. Guidance on stand interventions for *simple* and *complex* structures can be found in Mason and Kerr (2001).

30. The diameter data collected should be collated to investigate the distribution of diameters. When the diameter data are plotted out in diameter classes it is unlikely to give an exact representation of the whole stand. For example, sample data from the study of Kerr *et al*. (in prep.) are shown in Figure 2a and b and can be compared with the diameter distribution of the whole stands, shown in Figure 3a and b. In order to obtain a good representation of how the sample relates to the whole stand it is recommended to divide the sample data up into four size classes of trees shown in Table 3 and calculate the percentage in each, as in Table 4. Table 4 shows that the percentage of trees in each of the size classes in the sample is a good reflection of the actual stand. These size classes should then be used as a basis for specifying silvicultural interventions.

Table 4

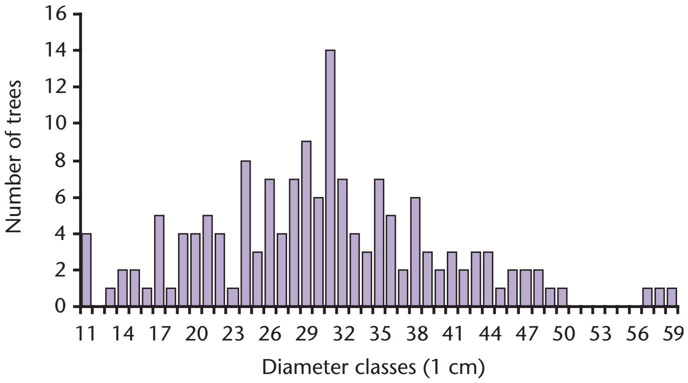
Comparison of sample data using broad diameter classes to reflect the structure of a stand

Tree size (see Table 3)	Diameter class (cm)	Wykeham % of trees	
		Stand	Sample
small	7–24.9	14	13
medium	25–39.9	53	55
large	40–54.9	31	29
very large	>55	2	3
TOTAL		**100**	**100**

Figure 2

Sample data from two stands

(a) Wykeham, 3.2 ha



(b) Stourhead (Western) Estate, 25 ha

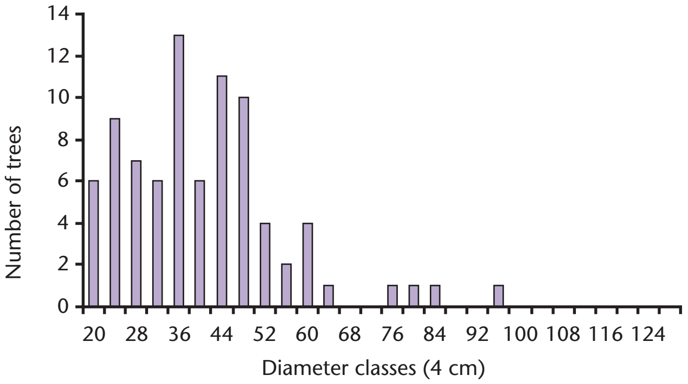
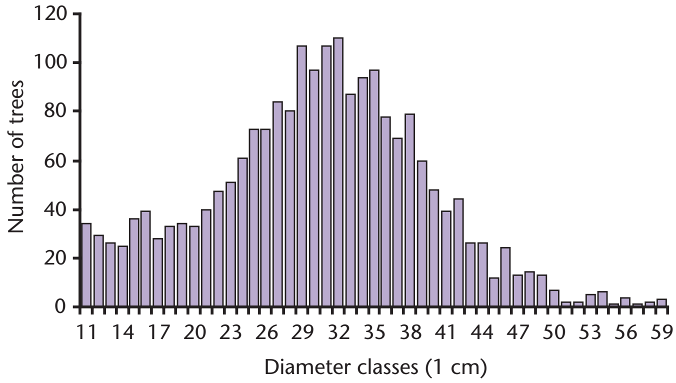


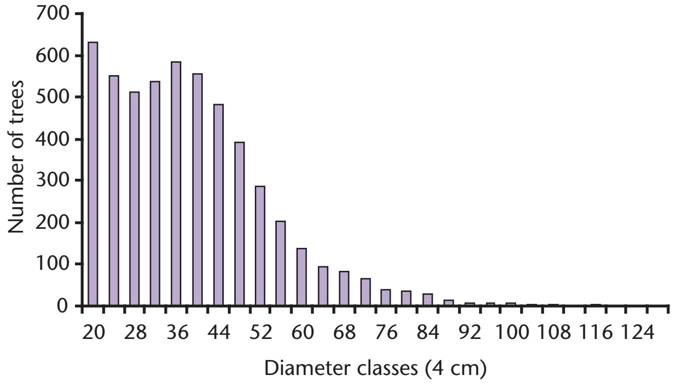
Figure 3

Data from whole stands sampled for Figure 2

(a) Wykeham, 3.2 ha



(b) Stourhead (Western) Estate, 25 ha

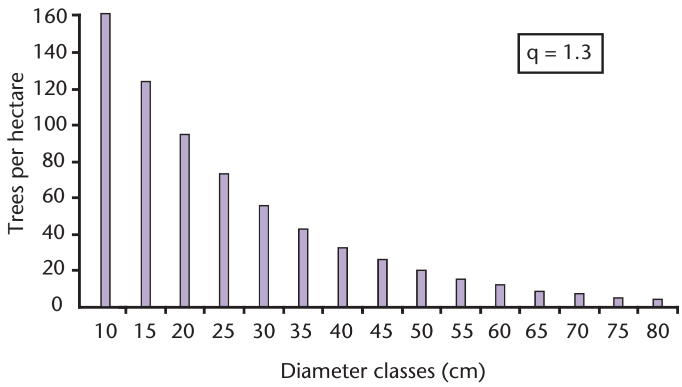


31. The diameter distribution of trees in an even-aged stand will often have a low number of small trees, a large number of medium trees and a small number of large trees (e.g. Figure 3a). If you are transforming an even-aged stand to a *simple structure*, in the early stages of transformation the canopy will continue to be even-aged and the distribution of diameters will be similar. As transformation proceeds the number of trees in the main canopy will be reduced towards a target density of 100–200 trees ha^{-1} (Mason and Kerr, 2001), and a new population of saplings and small trees will form. The size distribution of these new trees may be even, if regeneration was over a short period, or variable if regeneration occurred over a number of years.

32. If you are transforming an even-aged stand to a *complex structure*, the aim is to change the diameter distribution to one which has a large number of small trees, a smaller number of medium sized trees and even fewer large trees (Figure 3b). The large trees are likely to be the 'Frame' trees described by Mason and Kerr (2001) and this can be checked if the trees are recorded separately. **The final form of the distribution could be anything between one with three pronounced peaks to a smooth distribution between different diameter classes, as in Figure 4.** The distribution shown in Figure 4 is generally referred to as a reverse-J diameter distribution.

Figure 4

A reverse-J diameter distribution



33. The reverse-J diameter distribution is one method for describing complex structures (Davis and Johnson, 1987; Philip, 1994; Nyland, 1996). Generally the number of trees in successive diameter classes reduces by a constant, commonly referred to as q, which is the ratio between the number of trees in one diameter class to the number in the next larger class. The actual structure of a block is determined and then compared with an appropriate target reverse-J diameter distribution. The difference between actual and target is then used as a guide to decide how many trees, and of which size, should be removed; further information on this can be found in Kerr (2002).

Regeneration

34. The guidance below may not be valid if the regenerating species are very different from those described as desirable in the transformation plan. For example, in a stand of Douglas fir where the plan is to regenerate a successor stand of 80% Douglas fir and 20% other species, the manage-ment of the stand would need to be reconsidered if all the saplings are sycamore, holly and rowan.

35. The amount of regeneration (natural and planted) that is desirable will depend on the management objectives for the stand. There is no evidence, as yet, to suppose that the relationship between stocking density and timber quality is different in natural regeneration compared with planting. Wherever production of quality timber is an objective, we believe that a target density of 2000 saplings ha^{-1} is required. The target of 2000 saplings ha^{-1} also assumes that there are additional seedlings present within the stand so that the effective stocking could be appreciably higher. If saplings develop into trees during the transformation they still count towards the target of 2000 ha^{-1}. However, the spatial distribution of the saplings and the timing of their establishment are different for *simple* and *complex* structures.

36. If you are aiming for a *simple structure* then at least 2000 saplings ha^{-1} will be required 10–15 years after the seeding felling. The seeding felling opens up the canopy to release advanced (existing) regeneration (Harmer and Kerr, 1995). The saplings must be reasonably evenly distributed over the site so that no more than 10% of plots have no saplings present and the minimum density in the other plots is 1000 ha^{-1}. This means that if 0.01 ha plots are used, the mean sapling count per plot must be ≥20 overall with ≥10 in 90% of plots 10–15 years after the seeding felling.

37. If you are aiming for a *complex structure* then the spatial pattern at the end of the transformation period will be a mosaic of groups of small trees interspersed with other groups of medium trees and an overstorey of large and very large trees. Therefore it is not necessary to have an even distribution of saplings over the site. At an early stage in the transformation (i.e. after 10–15 years), regeneration can be judged to be sufficient if 10% of the area meets the target density of 2000 saplings ha^{-1}. This means that if 0.01 ha plots are used, the mean sapling count must be ≥20 per plot, with a minimum of 10, on at least 10% of plots. The percentage of plots in this category would then need to increase to 50% at the end of the transformation period. An important consideration is the proportion of small saplings compared with the large saplings and 'new' trees (Table 3). As transformation proceeds the proportion of large saplings and trees must increase to indicate that advance regeneration is being released by appropriate stand interventions. The monitoring form (Appendix 2) requires the number of saplings to be recorded by species with a separate count of large saplings so that this information can be calculated.

38. The above stocking guides are based on observation of a range of conifer stands being transformed, judgement by the authors, and investigation of other regeneration manuals, for example Marquis (1994). They may need to be revised in the future, based on greater experience and on-going research studies. For example, densities lower than 2000 saplings ha^{-1} may be appropriate where production of quality timber is not an objective of management or if deer pressure is low. However, until more information becomes available we believe the figures are a sensible baseline for monitoring regeneration during transformation.

INTERVAL BETWEEN MONITORING

39. Formal monitoring should be repeated after a minimum of 5 years and a maximum of 10 years depending on stand reactions to transformation and the requirement for management information. Assessment of the stand and assessment of regeneration are best done at the same time to develop a complete picture of how the stand is developing. However, there are likely to be circumstances where the regeneration assessment is required more frequently than assessment of the stand

structure. For example, if the stocking criteria are unlikely to be met and the forest manager needs to know where and how many trees need to be planted. In addition to these formal assessments, regular inspections of the stand are also essential to develop an understanding of changes in the area, particularly if deer pressure is a problem.

DATA STORAGE AND RETRIEVAL

40. All data collected must be archived in such a way that they are safe and accessible to existing and future managers. A cautionary final note is that it is the authors' experience that many forest management systems do not possess the ability to archive data in this way. However, unless the problem is addressed much effort could be wasted.

41. Additional information which could be recorded are fixed point photographs and a diary of operations and useful observations. While these may seem unnecessary at the outset, as time passes they could be vitally important to ensure continuity, for example, when staff change or there is a requirement to demonstrate the changes in forest structure to targeted audiences.

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APPENDIX 1

CHECKLIST AND SUMMARY

1. What are the objectives of management of the area being considered?

2. Is transforming the stand to continuous cover an appropriate way of achieving the objectives of management? (If not, consider other silvicultural approaches.)

3. Have you evaluated the stand and site according to stage 1 of the procedure described by Mason and Kerr (2001)?

4. Prepare a written plan describing management objectives, site conditions, current and desired stand structure and species composition, and a transformation period. When data have been recorded this information should be appended in addition to planned stand interventions (paragraph 3).

5. Consider the use of permanent plots plots rather than temporary plots (paragraphs 8–10 and Table 1).

6. Stratify the area into blocks (paragraphs 14–17).

7. Estimate stand density (trees ha^{-1}) and select plot size and shape (paragraph 18 and Table 2).

8. Calculate the spacing between plot centres (paragraph 19).

9. Locate plots in block (paragraphs 20–22).

10. Use form (see Appendix 2) to record data on trees, saplings, seedlings and other vegetation at each plot (paragraphs 23–26).

11. Collate the data and interpret in relation to observations (paragraphs 28–38).

12. Define stand interventions for forthcoming period.

13. Archive data for future reference (paragraph 40).

APPENDIX 2

MONITORING FORM

2a. Monitoring form: worked example

2b. Monitoring form: blank for your use*

*The form may be photocopied freely. Alternatively, forms can be downloaded from: **www.forestry.gov.uk/publications**

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APPENDIX 2a: MONITORING TRANSFORMATION TO CONTINUOUS COVER: Worked example

Forest: Stourhead (Western) **Compartment:** M9/M10 **Date:** 31/01/02 **Sheet** 1 **of** 10

Plot area: 0.01 ha **Distance between plots:** 50 m **Assessors:** AB + GK

PLOT NO.	SPECIES	TREES[1]						SAPLINGS (and any 'new' trees)[1]			SEEDLINGS		OTHER VEGETATION	
		DBHs (≥7 cm)					Height (m)	Total number	With deer damage	No. dbh ≥3 cm	Number (estimate)	With deer damage	Type[2]	% cover
1	WRC	43	49					卌 I (6)			30	5	1	10
	ROW							II (2)			4	4	2	20
													3	10
													7	30
													8	40
2	DF	42	51	45				III (3)	I (1)	I (1)	2	2	1	25
	BE										3	0	6	50
	WRC							卌 I (6)	II (2)		12	2	8	25
3	DF	36	44					卌 II (7)	II (2)		5	2	1	20
	NS										7	3	2	10
													6	10
													7	70
4	DF	46	52	45				II (2)	I (1)		2	2	1	40
	BE	12											2	30
	HOL							II (2)			5	0	7	25
													8	20

1 Tally trees and saplings of coppice origin separately.
2 Use: 1 = grasses, 2 = bramble, 3 = ferns + bracken, 4 = other herbaceous and broadleaved, 5 = woody shrub, 6 = bare, 7 = leaf and/or needle litter, 8 = mosses, 9 = other (specified).

APPENDIX 2b: MONITORING TRANSFORMATION TO CONTINUOUS COVER

Forest: .... **Compartment:** .... **Date:** .... **Sheet** .... **of** ....

Plot area: .... **Distance between plots:** .... **Assessors:** ....

PLOT NO.	SPECIES	TREES[1]						SAPLINGS (and any 'new' trees)[1]			SEEDLINGS		OTHER VEGETATION	
		DBHs ($\geq$7 cm)					Height (m)	Total number	With deer damage	No. dbh $\geq$3 cm	Number (estimate)	With deer damage	Type[2]	% cover

1 Tally trees and saplings of coppice origin separately.
2 Use: 1 = grasses, 2 = bramble, 3 = ferns + bracken, 4 = other herbaceous and broadleaved, 5 = woody shrub, 6 = bare, 7 = leaf and/or needle litter, 8 = mosses, 9 = other (specified).