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NATURAL REGENERATION OF CONIFERS

HELPING FOREST MANAGERS TO PREDICT SUCCESS

Gary Kerr, **Victoria Stokes**, **Andy Peace** and **Barnaby Wylder** describe a simple method to assess the likelihood of successful natural regeneration of Sitka spruce, Scots pine, Douglas fir.

Over the past 20 years there has been a significant increase in the use of natural regeneration by forest managers in Britain. There are very good reasons for this:

- The use of natural regeneration has been encouraged by policy.
- Traditional methods of restocking are expensive.
- Natural regeneration can help to adapt forests against the risks of climate change.

However, in practice the use of natural regeneration is not a magic solution for many of the problems involved with the regeneration of a forest. Perhaps the most frustrating issue for forest managers is the unpredictability of the process, especially compared with replanting, where the manager has a high degree of control. The aim of this article is to outline a simple method that can be used by to assess the likelihood of success of obtaining natural regeneration of Sitka spruce (*Picea sitchensis* (Bong.) Carr.), Scots pine (*Pinus sylvestris* L.), Douglas fir (*Pseudotsuga menziesii* (Mirb.) Franco) and larch (European, Japanese and hybrid; *Larix* spp.).

Development of the method

Recent initiatives to increase the range of approaches used to manage forests in Britain have led to demands for more guidance on alternatives to clearfelling, continuous cover silviculture and the use of natural regeneration. In an attempt to provide better guidance to forest managers on natural regeneration we developed a spreadsheet-based tool that used the best expert knowledge and published information available. The idea was that by inputting information for a particular site into the spreadsheet a forest manager could assess the likelihood of obtaining successful natural regeneration of conifers.

To ensure that the method was valid we visited 129 sites located throughout Britain to collect data on four of the most common conifer species: Sitka spruce, Scots pine, Douglas fir and larch. An age range of between 31 and 90 years was selected to include standard rotations for the species in Britain and the extension likely to be necessary when using natural regeneration. The age range was divided into three classes: 31-45 years, 46-60 years and 60-90 years. The aim was to visit ten different sites in each of the 12 combinations of species and age class. The search for sites focussed on five Forestry Commission Forest Districts in which trial areas of Continuous Cover Forestry (CCF) had been established (McIntosh, 2000). The initial plan was only to use sites where transformation to CCF was being practised but this proved to be too restrictive, so all potential sites in each of the five Forest District were considered. To locate suitable sites the Forestry Commission's GIS sub-compartment database was searched to find compartments of each species as a mainly pure crop, in the correct age ranges, which were greater than one hectare in area. Each list was then screened in consultation with local forest

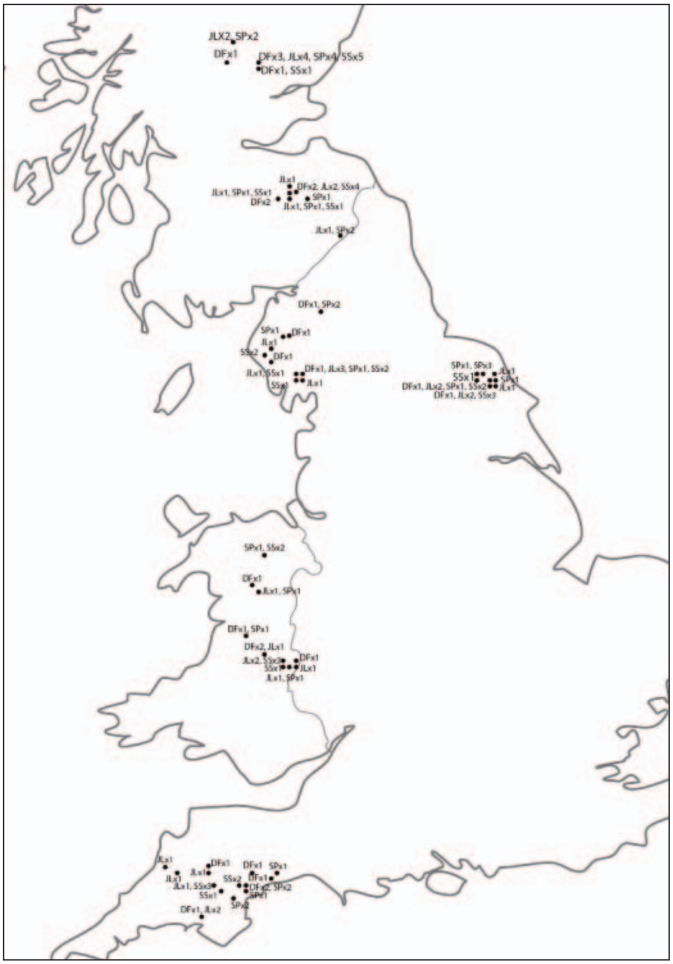

Figure 1. Location of the 129 validation sites in Britain.

managers to remove unsuitable compartments, i.e. ones with access problems, where harvesting was scheduled during the survey or there were other reasons to justify exclusion from the list. One of the authors then visited all of the sites to collect data, i.e. two sites in each Forest District for each combination of species and age class. The aim was to visit a minimum of 120 sites but in fact 129 sites were assessed (Figure 1). Sites were not assessed if the initial risk assessment indicated significant health and safety issues, or if on visual inspection the site already had more than 2500 seedlings and saplings per hectare of the canopy species. All sites were assessed between November 2008 and March 2009.

At each location a wide range of assessments were made of the trees, ground flora, site and the impact of deer (for a full description see Kerr et al., 2011) that were required by the 'spreadsheet based tool'. In addition, the assessor made an expert judgement of the likelihood of obtaining acceptable natural regeneration in the next five years; defined as 2500 seedlings per hectare (>50 cm in height) of desirable species with a reasonably even distribution across the site. The categories were: highly likely (81-100% probability), likely (61-80%), possible (41-60%), some chance (21-40%) or poor (0-20%). Photographs were taken at each site and the assessment of the likelihood of regeneration was checked later by the other authors. The field data were then input into the 'spreadsheet-based tool' and the results were compared with the expert judgement for the 129 sites. For just under half the sites (49%) there was an exact match between expert judgement and the output from the 'spreadsheet based tool'. Further statistical analysis of the data showed that there was an improved method of predicting the likelihood of successful natural regeneration. The improved method increased the match with the expert judgement from 49% to 88%. A further advantage was that instead of the 18 measures required for the 'spreadsheet based tool' the improved method only required five assessments. The rest of this article explains the improved method and outlines how it should be used in forest management. A full account of the development of this method has been published as Kerr et al. (2011).

How to apply the method

There are three steps:

- Assessment – collect information and score five aspects of the stand.
- Calculate the results – add up the scores and predict the likelihood of success.
- Interpretation – the method does not guarantee successful regeneration!

Step 1 – Assessment

The method has been calibrated for stands of Scots pine, Sitka spruce, Larch (Japanese, European and hybrid) and Douglas fir between the ages of 30 and 90 years. Assessments are required of five stand characteristics:

- Density of seedlings.
- Density of saplings.
- Percentage of the ground that is bare or covered with mosses.
- Amount of coning.
- Number of years since last thinning.

Density of seedlings

A seedling is defined as a tree that is up to 1.3m tall and of a desirable species for the regeneration plan. A visual inspection of the stand should provide enough information to score the density of seedlings as shown in Table 1.

Density of saplings

A sapling is defined as a tree that is taller than 1.3m but has a diameter at breast height of <7cm and is a desirable species for the regeneration plan. A visual inspection of the stand can provide enough information to score the density of saplings as shown in Table 2.

Percentage of the ground that is bare or covered with mosses

For every 10% of the ground that is either bare or covered by mosses add one to the score; 10% would score 1, 30% would score 3; the maximum value is 8 so cover values =>80% would score 8.

Amount of coning

This uses the standard coning assessment recommended in FC Bulletin 125 (Nixon and Worrell, 1999) as shown in Table 3. The most difficult species to assess is larch because cones persist on branches for years after shedding seed.

Number of years since last thinning

Examine records of the thinning history of the site and score as shown in Table 4.

Table 1. How to score density of seedlings.

Density	Seedlings per ha	Guidance on assessment*	Score
High	>1000	>16 seedlings	12
Medium	51-1000	2-16 seedlings	5
Low	0-50	1 seedling	0

*If unsure of how to make a visual assessment, this figure gives the total number of seedlings you would need to observe in ten 4m x 4m plots.

Table 2. How to score density of saplings.

Density	Saplings per ha	Guidance on assessment*	Score
High	>100	> 2 saplings	9
Medium	1-100	1 or 2 saplings	2
None	0	0 sapling	0

*If unsure of how to make a visual assessment, this figure gives the total number of saplings you would need to observe in ten 4m x 4m plots.

Table 3. How to score amount of coning.

Coning	Description	Score
Light	A few cones (<50) on about one tree in 50	0
Moderate	A significant number of cones (50-100) visible on 25-50% of trees	2
Heavy	A large number of cones (>100) on 5-10% of trees, a significant amount on many others and at least a few cones on nearly every other tree	6

Table 4. How to score time since last thinning.

Thinning history	No. years since last thinning	Score
Very recent	1-3	6
Recent	4-10	2
Delayed	10+	0

Step 2 – Calculate the results
Once each of the five factors has been assessed and scored you then add up all the scores. A recording sheet has been included here (see Table 5) so that this can be copied and used on-site in the forest. Once a total score for the site has been calculated the estimated probability of obtaining successful natural regeneration can be found using Table 6. It should be noted that there is no total score for a probability of 41-60%, this was due to the range of sites used in the study and is explained in Kerr et al. (2011).

Examples of the application of the method to four stands are shown in Figures 2-4.

Table 5. Recording sheet for use in forest.

1- Density of seedlings			**Your score**
Density	**Seedlings per ha**	**Score**	
High	>1000	12	
Medium	51-1000	5	
Low	0-50	0	
2 – Density of saplings			
Density	**Saplings per ha**	**Score**	
High	>100	9	
Medium	1-100	2	
None	0	0	
3 - Percentage of the ground that is bare/mosses			
For every 10% add one to the score: 10% would score 1, 80% would score 8 etc.		**Score**	
4 – Amount of coning			
		Score	
Light		0	
Moderate		2	
Heavy		6	
5 – Number of years since last thinning			
Thinning history	**Years to last thin**	**Score**	
Very recent	1-3	6	
Recent	4-10	2	
Delayed	10+	0	
		TOTAL SCORE FOR SITE:	

Table 6. How to convert a total score into an estimate of the probability of obtaining natural regeneration.

Total score	Probability of obtaining successful natural regeneration in next 5 years	Description
0-17	0-20%	Poor
18-22	21-40%	Some chance
23-32	61-80%	Likely
33-41	81-100%	Highly likely

Step 3 – Interpretation

Once a result has been generated for a site it is important to understand it; a high probability does not guarantee successful regeneration and a low probability does not mean that natural regeneration is not possible. The following points are important to consider when interpreting the result.

In a strict scientific sense the method is only validated for the 129 sites on which data have been collected and hence there are dangers applying it outside this range. However, informal testing of the method on a wider range of other sites has revealed that it provides reasonably accurate results. A real advantage of the method is that it quantifies a complex process and encourages managers to consider 'what if' management scenarios.

The main outcome of the method is essentially an estimate of one person's judgement about the likelihood of regeneration being successful. A big effort was made to ensure this was correct, notably one person visited all the sites and his predictions were checked by other team members examining photographs of each site. However, the method has not been fully validated against what will actually happen to the natural regeneration on the 129 sites in the next five years. Further work in the future could aim to do this.

Some factors such as soil nutrient regime, the impact of deer, basal area and tree species were assessed but were not included in the improved scoring method. In general there is evidence that each of these factors will affect natural regeneration; for example the impact of deer as

Figure 2. The scores applied to this stand of Japanese larch were: seedlings = 5; saplings = 9; ground cover = 0; coning = 2; thinning = 2; total score is 18 which is 21-40% probability ('some chance') of successful regeneration over the next five years. The saplings shown in the picture probably arose from the disturbance caused when the stand was thinned in the past. Further regeneration is now impeded by the thick grass which has developed.

Figure 3. The scores applied to this stand of Douglas fir were: seedlings = 0*; saplings = 0; ground cover = 3; coning = 2; thinning = 2; total score is 7 which is 0-20% probability ('poor') of successful regeneration over the next five years. *Observations indicate seedlings are produced every spring but are browsed by deer, suggesting that reducing this impact is the priority for management.

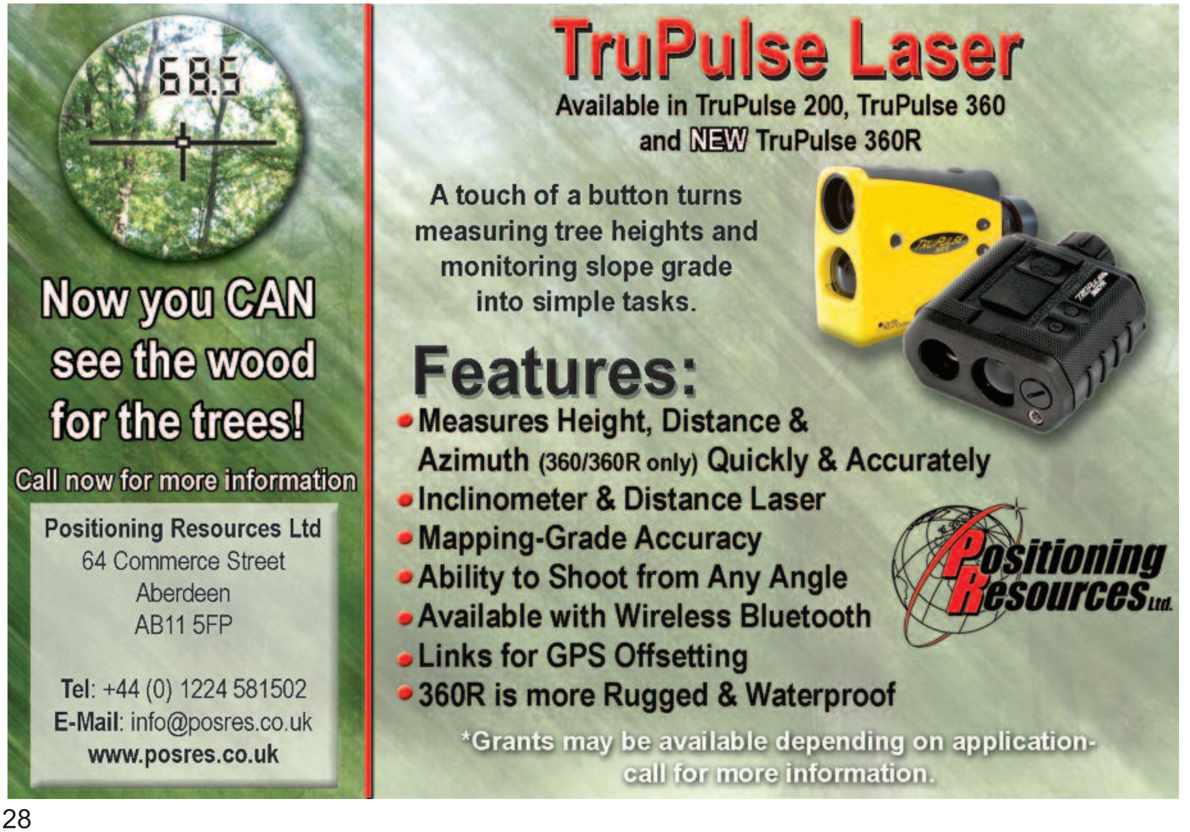

Figure 4. The scores applied to this stand of Sitka spruce were: seedlings = 12; saplings = 9; ground cover = 3; coning = 6; thinning = 2; total score is 32 which is 61-80% probability (‘highly likely’) of successful regeneration over the next five years. Careful thinning over a ten year period is now required to ensure that the regeneration that has established is converted into a new young stand of trees.

described in Forestry Commission (2010). However, the reason these factors are not included in the method relates to the fitting of the model to the data as explained in Kerr et al. (2011). One benefit of only having five factors to assess in each stand is that the method is straight forward and can be done visually by walking round the stand. This should make it more likely to be used by forest managers to inform their silvicultural decisions.

Conclusions

A simple method to assess the likelihood of natural regeneration of Sitka spruce, Scots pine, Douglas fir and larch has been developed and described. Forest managers are encouraged to try the method and feedback thoughts and comments to Gary Kerr at Forest Research.

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References

Forestry Commission 2010 The Woodland Grazing Toolbox. http://www.forestry.gov.uk/forestry/INFD-82TLHE (last accessed on 12 August 2010)

Kerr, G., Stokes, V., Peace, A. & Wylder, B. (2011) Prediction of conifer natural regeneration in a 'data-poor' environment. *Scottish Forestry*, **65**(4), 28-36.

McIntosh, B. (2000) Role of continuous cover silvicultural systems in the management of the Forestry Commission estate. *CCFG Newsletter,* 16, 5-9. Continuous Cover Forestry Group, www.ccfg.co. uk.

Nixon, C.J. & Worrell, R. (1999) *The potential for the natural regeneration of conifers in Britain*. Forestry Commission Bulletin 125. Forestry Commission, Edinburgh.

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