Forestry Commission **Research Information Note 285**

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ESTABLISHING NEW WOODLANDS BY DIRECT SOWING, by Ian Willoughby, Gary Kerr, Richard Jinks and Peter Gosling

Summary

Establishing woodlands by direct sowing of tree seed is an ancient technique that has recently been revived. Results from the monitoring of two recently established commercial sites, and three experimental sites subsequently set up by the Forestry Commission, are described. Although direct sowing is generally less reliable than planting, it is worth considering as a means of establishing ash and sycamore on lowland ex-agricultural sites, provided that appropriate protection and weed control is practised.

Introduction

1. Direct sowing or direct seeding is the process of artificially sowing tree seed directly on the final site for the proposed woodland. It is an ancient practice – Harmer and Kerr (1995) cite numerous references which describe a variety of techniques. For example, Evelyn (1670) advised *'Dig or plow a parcel of ground, as you would prepare it for corn, and with the corn . . . . . sow also a good store of keys . . . . . take off your corn or seed in its season, and the following year it will be covered in young Ashes'.*

2. The Forestry Commission has carried out over 70 experiments into direct sowing since the 1920s (Stevens *et al.*, 1990). The main conclusion from this work was that problems of predation of seed, unpredictable germination and vegetation competition were most easily managed within forest nurseries. On this basis they advised that the conventional establishment practice of planting trees raised in a forest nursery was preferable to direct seeding.

3. In recent years increased new planting on former agricultural land has led to a renewed interest in this technique. Watson (1994) described a system similar in many ways to the system described by Evelyn (1670), involving the under sowing of arable crops with tree seed. Advantages claimed for the system are:

   - It is cheap, with no protection or weeding operations required.
   - High densities of trees may become established, giving a greater potential for the production of quality broadleaved timber and more rapid creation of a woodland environment than conventional planting.
   - It uses techniques and equipment that are familiar to farmers.

   Watson's method is being practised commercially on a number of sites in southern England, two of which have been monitored by the Forestry Commission since they were sown.

4. The purpose of this Note is to present results from surveys carried out on commercially seeded sites and from three recent experiments, and to make some recommendations on the use of direct sowing. Information on machinery and costs obtained from the monitoring of a further two sites is given in Drake-Brockman (1995).

Monitoring of commercially established direct sowing

5. One of the sites, a fertile lowland area of 10 ha near Ledbury in Gloucestershire, was broadcast sown (except the oak which was drilled) in March 1993 with 103 000 seeds/ha of ash, sycamore,

Norway maple, oak, cherry, field maple and hazel in a 35:24:15:10:9:5:2 mixture. There was also some pear seed in a sludge applied to the site. Thirty randomly located permanent 3m x 3m monitoring plots were established, and at the end of each growing season the number of seedlings were counted (see Figure 1). Seedling height and browsing damage were also assessed at the end of 1995. The site was not fenced and evidence of significant rabbit activity was observed throughout the period.

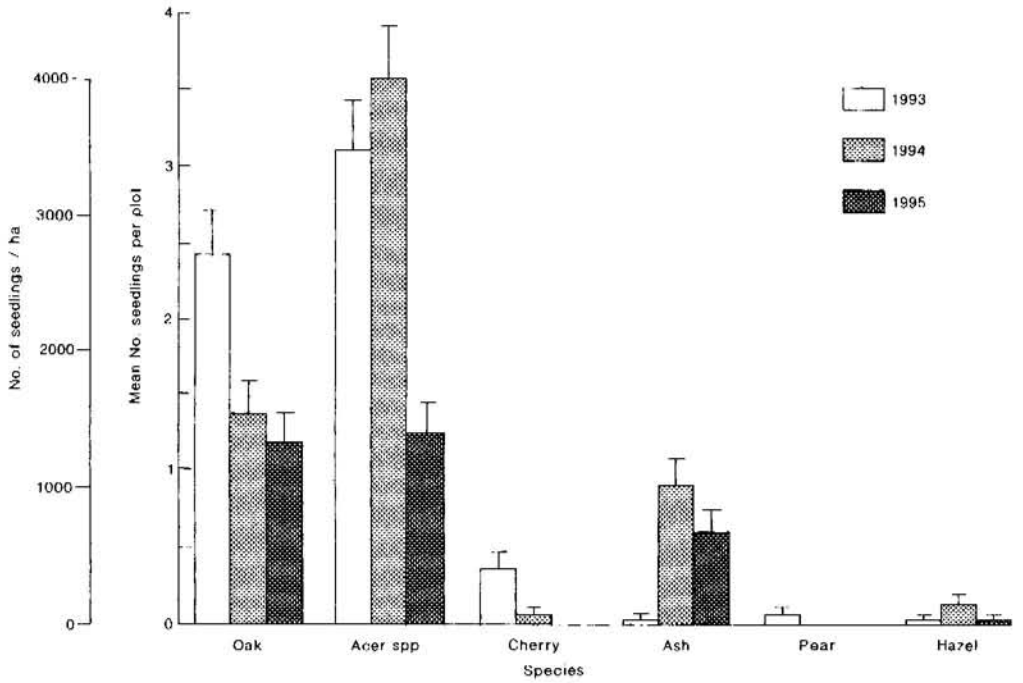

Figure 1 Direct seeding experiment, Ledbury.

6. At both the Ledbury site, and a second site near Cirencester (data not presented), there has been a downward trend in seedling numbers over the years. This is less apparent at the Cirencester site, but it is likely that seed fall from surrounding woodland supplemented numbers of ash and sycamore seedlings.

7. Analysis of plot count data using general linear models with Poisson errors showed significant differences between years. Numbers of oak, cherry and *Acer* spp. declined by nearly 50% after the first year, probably as a result of browsing from rabbits and competition for moisture from weeds. Numbers of ash increased in the second year due to germination of previously dormant seed.

8. Height growth was also poor at both sites. After three seasons' growth average seedling height was only 18 cm at Ledbury whereas effectively weeded and protected transplants could be expected to grow around 40 cm per year by comparison.

9. The objective of Watson's system is to achieve a stocking density of 10 000 trees/ha and to rely on high initial seedling density to overcome the pressures of browsing and weed competition. This tends to challenge modern silvicultural thinking advocating suitable weed control (Davies, 1987) and protection from browsing (Kerr and Evans, 1993) of planted trees.

10. At Ledbury, after 3 years, 3370 seedlings were present, with an average height of 18 cm. These stocking levels would be acceptable for protected, weeded, rapidly growing transplants. However, the direct sown seedlings exhibited a very patchy distribution – areas of dense seedlings were interspersed with large stretches of ground where none survived. At this stage of monitoring it is difficult to predict whether or not 3–15 000 browsed, weed stressed direct sown plants will lead to a healthy vigorous woodland of at least 2500 stems per hectare, of unforked evenly spaced trees. A woodland of correctly planted, protected and weeded transplanted trees would probably be

established within 5 years on a similar good quality site. Evidence suggests that it will take longer for a woodland to establish using a system which relies on sheer numbers of direct sown seeds to overcome the pressures of browsing and weed competition.

Experiments on direct sowing

11. Because of this uncertainty, the Forestry Commission established three further experimental trials. Two used non-dormant oak and Scots pine seed, at sites near Barton and Desford in the National Forest in the Midlands. Dormant sycamore and ash were used at Neroche, Somerset, and the performance of untreated and pre-treated seeds were compared. The effects on seedling height and survival from sowing an agricultural cover crop (linseed at 50 kg/ha at Barton and Desford, and spring wheat at 200 kg/ha at Neroche, harvested at end of first year), non-intervention (after initial ground preparation and sowing), and the maintenance of weed free conditions through the use of herbicides, were investigated at all three sites. The effect of fencing individual 10m x 10m plots on seedling survival and growth was also tested at the first two sites.

Barton

12. From an estimated 100 000 viable seeds per hectare sown in May 1994, an average of 60 633 oak seedlings per hectare was determined by sampling at the end of 1995 at Barton. Average height at the end of 1995 varied significantly (P <0.06) with herbicide treated weed free plots showing significantly greater growth (mean height of 14.0 cm) than the agricultural cover plots (mean height of 10.0 cm). Far fewer Scots pine seedlings survived at Barton – 4866 per hectare on average – although only 62 000 viable seeds per hectare were sown. Numbers of Scots pine seedlings fell dramatically to an average of 1533 per hectare by the end of 1995. There were statistically significantly more seedlings (P <0.05) in the herbicide treated plots (3100 seedlings per hectare) than the no weed control (950 seedlings per hectare) or agricultural cover crops (550 seedlings per hectare).

Desford

13. Watson (1994) suggested that the presence of weed vegetation can act as an alternative feeding source for rabbits, and also as a source of side shelter, and hence may protect tree seedlings. This appears to be contradicted by results at Desford (seedlings sown in April 1995) where there was a significant interaction (P <0.05) between fencing and vegetation treatments – there were 240% more seedlings in the fenced than the unfenced plots where there was no weed control. Overall beneficial effects for fencing were not proved statistically, but there is no doubt that browsing can seriously reduce tree growth and survival (Stephens *et al.*, 1990).

Neroche

14. At the Neroche site, 210 000 viable seed/ha of ash or sycamore were sown in May 1995. Within both the pre-treated ash plots where the seed was non-dormant and likely to germinate in the first year, and the sycamore plots, the cover crop treatment resulted in statistically less seedlings surviving (P <0.001) at the end of the growing season (625/ha ash within the cover crop plots, compared with 6563/ha in the control plots). The wheat variety used grew relatively late in the season, and during the prolonged dry spell in April-June was still actively growing and hence competed strongly for moisture with emerging seedlings.

15. It may be premature to discount the benefits of cover crops on the basis of the three recently established experiments reported, but it seems clear that trees derive more benefit from weed-free conditions than from an agricultural cover crop.

Recommendations

Based on the initial results described earlier, combined with experience of the silviculture of planting trees on former agricultural sites, the Forestry Commission's Research Division offers the following recommendations regarding the use of direct seeding.

16. ***Species***

- Choose species which have predictable germination, or can be pre-treated reliably to achieve this – see Jinks and Jones (1995) for details of seed dormancy and pre-treatment regimes.

Table 1 Comparison of planting material costs of direct sowing with cost of planting transplants

Species	Seed					Transplants			
	Number ha^{-1}	Germination kg^{-1}	£ kg^{-1}	£ ha^{-1}	£ ha^{-1} inc sowing	Number ha^{-1}	£ $plant^{-1}$	£ ha^{-1}	£ ha^{-1} inc planting
Oak	100 000	200	3.50	1750	1790	2500	0.30	750	1000
Scots pine	100 000	112000	185.00	165	180	2500	0.12	300	550
Ash	100 000	8000	8.00	100	115	2500	0.25	625	875
Sycamore	100 000	4500	7.50	167	182	2500	0.25	625	875
Norway maple	100 000	3900	7.50	192	207	2500	0.23	575	825
Beech	100 000	2400	12.00	500	515	2500	0.25	625	875
Birch	100 000	150000	80.00	53	68	2500	0.15	375	625
Wild cherry	100 000	3000	21.00	700	715	2500	0.20	500	750

Notes:

Transplant prices are average prices for 1+0 or 1+1 stock as appropriate for each species.
If an owner can collect quantities of seed from their own woodlands the cost of seed may be reduced.
Cost of seeding is assumed to be £20/ha for oak (drilled), and £15/ha for all others.
Cost of planting is assumed to be £250/ha.

- Table 1 shows a comparison of the relative costs of planting or direct sowing different species. Choose species that are cheaper to sow at high densities, than to plant. Seed should be cheap enough to allow a possible complete re-sowing of a site should initial attempts fail.

- The use of direct seeding should not alter the basic silvicultural principle that species must be matched to the site (Kerr and Evans, 1993). Preferred species should grow vigorously and produce quality timber.

- Ash (using pre-treated seed) and sycamore fulfil all the above criteria and are particularly suitable species. Birch, cherry and Norway maple may be worth considering.

- Shrub species and open space should be included in a woodland design to provide variety and diversity of habitat. Shrub species should be planted rather than sown to enable precise placement and maximum benefit within a woodland.

17 ***Site preparation***

- Kill any established weeds on site with a pre-plant application of glyphosate at 5 litres per hectare. Fully cultivate and rotovate the sites when conditions are suitable (not too wet or too dry) usually in autumn or spring, to achieve a firm fine tilth.

18. ***Protection***

- Assess the likely browsing pressure on a site. If deer are present, establish a combined deer and rabbit fence. Rabbits will usually be present – fully rabbit fence the entire site and ensure no rabbits are within the fenced area. Inspect fences regularly to ensure their integrity. Pepper (1992) gives details of necessary fencing specifications for different mammal species.

19. ***Sowing***

- Broadcast sow seeds, then roll with a ridged agricultural roller to integrate them into the soil. Ash, sycamore, birch, cherry and Norway maple should be incorporated into the top 2-5 cm of the soil surface.

- Aim to sow tree seed in mid to late April – this will allow the use of an overall spray of glyphosate at 1.5-5 l/ha to control any newly germinating weeds. Leave at least 1 week between spraying and subsequent sowing. Aim to sow in a moist cold spell, and avoid (delay) sowing if a hot dry spell is expected.

- Precise survival factors for direct sown seed are unknown, so it is recommended that a minimum of 100 000 viable seeds (determined from a seed viability test) per hectare are sown, with the intention of establishing around 10 000 reasonably evenly spaced vigorous trees by year 10. This figure allows for losses from germination failure (the difference between seed viability and actual germination), predation, drought, herbicide damage, weed competition, etc.

20. ***Vegetation management***

- From the available evidence there seem to be few silvicultural advantages to using an agricultural cover crop. Initial results from ADAS trials on direct seeding appear to confirm this (C.P. Britt, personal communication). Arable cover crops may allow increased initial income, but are probably detrimental to woodland establishment and long term revenue. If a cover crop is used, sow immediately after tree seed, and aim for species that will have finished their active period of growth before the trees main growing season.

- To maximise early tree growth, aim to maintain weed free conditions on the site for the first 2-4 years after sowing, or until trees have become established. This can be achieved relatively cheaply through the use of overall sprays from tractor-mounted sprayers. It is difficult to devise herbicide treatments that will control a broad spectrum of arable weeds and yet still be safe to use over dense, irregularly spaced tree seedlings. A degree of herbicide damage may be possible – sufficient seed should be sown to allow for this eventuality. However, the benefits of release from weed competition will outweigh any possible disadvantages from using herbicides. Recommendations for vegetation management after seedling emergence through the use of herbicides are contained in Research Information Note 286 (Willoughby, 1996).

21. ***Subsequent treatment***

- Following the practices outlined above, the direct sown woodland should be established within five years of sowing. An ideal stocking would be around 10 000 stems per hectare, evenly spaced throughout the site. If after losses from predation, weed competition with seedlings or through herbicide damage there are still more seedlings than this on a site, respacing operations will need to be considered at around year 10. The precise nature and timing of such operations will vary from site to site, but in general are likely to take the form of racks cut mechanically every 12 metres, followed by some selective cutting between racks by hand, but this will depend on the nature and density of the seedlings present.

- Open space should be designed within the woodland at the outset, and if necessary cleared by year 10, once the trees are well established.

- Adam (1993) details some of the practices to consider when commencing a respacing operation.

Conclusion

22. Early results from recent trials suggest that direct seeding has potential as a method of establishing some tree species on ex-agricultural land in the lowlands, provided the correct species are selected, and suitable fencing and weed control operations are performed. All establishment techniques can be performed using existing or modified agricultural equipment, and many of the techniques are similar to conventional agricultural practice.

However, the success of the technique is **far less predictable** than conventional tree establishment techniques. It should only be attempted with species whose seed is cheap enough to permit a complete re-seeding operation should an initial attempt fail.

Following the recommendations listed earlier, direct seeding may be worth **consideration** as an alternative to planting on good quality sites where mechanical access is easy, and where ash or sycamore are the intended main species.

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