Forest Research

# Experiment Plan

**Central**

**Experiment**

**Number: FR 20003**

**Local**

**reference**

**Number:** Queens 32

**Experiment**

**Title:** Native pinewood restoration using direct seeding

**Key Words: -**

**Pesticide**

**Efficacy**

**Trial:** No

**Products:**

|  |  |
| --- | --- |
| **Product** | **Active Ingredient** |
| Trico | 63.96 g/kg sheep fat |
| Sluxx HP | 2.97% w/w ferric phosphate |

**EPPO**

**Standards:** [PP1/135](http://alpacorn.forestry.gov.uk:7777/pls/portal/url/ITEM/E614A7C84C35BC29E04012D3090A926D) (v.4) Phytotoxicity assessment

[PP1/152](http://alpacorn.forestry.gov.uk:7777/pls/portal/url/ITEM/E617EC02B7E083E6E04012D3090AC0F9) (v.4) Design and analysis of efficacy evaluation trials

[PP1/181](http://alpacorn.forestry.gov.uk:7777/pls/portal/url/ITEM/E61625FB47636B6FE04012D3090A9D03) (v.4) Conduct and reporting of efficacy evaluation trials, including good experimental practice

**Project:** Project Number 111208-1004, SG08

**Background:** Significant areas of native pinewoods on the national forest estate managed by Forestry and Land Scotland are not currently regenerating adequately though natural processes. In addition, extensive areas of clear felling have been taking place to remove non-native species (particularly Dothistroma infected lodgepole pine) and provide for the expansion of native pinewoods. Currently, native Scots pine is proving largely resistant to the Dothistroma it has been naturally exposed to. However, concerns over the risk of introducing new strains of Dothistroma that could potentially hybridise and overcome otherwise resistant trees mean that it is not currently possible to plant trees that have been grown in off-site nurseries on these restock sites. One potential solution might be to establish small scale, local tree nurseries in close proximity to the restock sites, as trees growing in such positions would in theory only be exposed to the same inoculum pressure as those arising from natural regeneration. However, to date Forestry and Land Scotland have not been permitted to take this approach.

Extensive areas of felled ground at Glenmore and elsewhere are therefore currently awaiting restocking. One option worth exploring further would be the use of direct seeding.

Recent research has identified a practical method of using direct seeding to establish a native woodland cover of birch, rowan and alder, which form an important broadleaved component of native pinewoods, on upland restock sites in Scotland (see Willoughby *et al*., 2019). The technique has the potential to deliver mixed stands of trees that are denser spaced, more naturalistic in appearance, more resilient over the long term, and at a similar cost, than those resulting from conventional, lower density planting (e.g. 2 m x 2 m or wider). However, whilst the technique has been demonstrated in a research context, it now needs to be tested on an operational scale, and a prescription has been developed to allow Forestry and Land Scotland to do so.

Direct seeding is generally less reliable than planting in the first year of the establishment cycle. In addition, compared to raising trees for subsequent out planting from a forest nursery, it is very wasteful of seed, with typically only between 1 – 5% of viable seed sown on site resulting in an established tree. This is because seed and seedlings may suffer mortality due to a number of factors such as unsuitable microsites for germination and subsequent growth, competition for resources, and for larger, more palatable seed, due to seed predation. For small, cheap seeded species such as birch, rowan and alder it is often possible, and economically viable, to broadcast sow sufficient quantities of seed to overcome many of these limiting factors (Willoughby *et al*., 2019). However, for larger, more palatable seed such as Scots pine, the cost of seed is usually too high to allow sufficient seed to be sown to make such an inundation approach practical (Willoughby *et al*., 2004). In nature, typically a seed rain of around 45,000 – 3,000,000 viable seed ha-1 might be required for successful Scots pine natural regeneration (Mason *et al*., 2004). Native Scots pine seed from appropriate local seed sources is particularly scarce, and could cost up to £2 – 3,000 kg. Consequently sowing 3,000,000 viable seed per hectare (assuming 120,000 viable seed kg-1) could cost around £50,000-75,000 ha-1 for seed alone, which is clearly uneconomic. However, if silvicultural approaches could be developed to reduce seed loss, such that seeding rates could be reduced to around 20,000 viable seed ha-1, then seed costs might only be around £500 ha-1.

Direct seeding of Scots pine has been practised fairly extensively in recent decades in northern Scandinavia (e.g. Hypponen and Hallikainen, 2011; Grossnickle and Ivetic, 2017) and more recently in Poland (Aleksandrowicz-Trzcinska *et al*., 2017). Using techniques such as mechanised strip or broadcast seeding, cultivation to expose mineral horizons of soil, creating indentations that collapse and bury seed, using high quality seed from orchards, fertilisation, and seed invigoration, have resulted in up to 15-20% of seed sown developing into an established tree (Bergeten, 1988; Nilson and Hjalten, 2003; Winsa and Bergsten, 1993; Winsa and Sahlen, 2001; Wennstrom *et al*., 1999; Erefur *et al*., 2008).

For sowing of cheap seeded species the most successful approach is to broadcast sow over as large a cultivated area as possible, to maximise the chances that seed will find a suitable germination niche (Willoughby *et al*., 2019). An alternative approach is to spot seed, and then focus energies in protecting those individual spots. The aim in this latter case would be to achieve circa 2,700 stems ha-1, and there is some evidence that if initial seeding rates are too high and multiple pine trees germinate within the same spot, they may self-thin to a degree (Derr and Mann, 1971; Mason *et al.*, 2004), although additional intervention may be subsequently be required. The amount of seed that needs to be sown to achieve successful regeneration of Scots pine is not known, but is likely to range from 3,000 000 viable seed ha-1 if it is broadcast sown with no silvicultural intervention, to perhaps 20,000 viable seed ha-1 if effective silvicultural mitigation methods could be identified. For spot sowing, to achieve an evenly spaced crop of around 2,700 stems ha-1, sowing rates might need to be 100 viable seed spot-1 assuming a 99% seed loss, 20 viable seed spot-1 assuming a 95% seed loss, or 7 viable seed spot-1 if effective silvicultural mitigation could reduce seed loss to around 75%. Estimated costs of seed would be £4,500 - £6,750 ha (for 100 viable seeds per spot), £900 - £1350 ha (for 20 viable seeds per spot), or £320 – £480 ha (for 7 viable seeds per spot).

Given the scarcity of native Scots pine seed, and the fact that there are currently no other viable regeneration methods, it is worthwhile investigating the practicality of more intensive silvicultural intervention than would normally be economically viable for conventional direct seeding, to reduce seed mortality.

Key limiting factors causing seed and seedling mortality, and possible silvicultural interventions to overcome these factors include:-

|  |  |  |
| --- | --- | --- |
| **Limiting Factor** | **Possible silvicultural interventions to mitigate** | **Comments** |
| Seed predation | Seed burial by cultivation | Max 2 cm depth. Could mimic by hand by hoeing in. |
| Seed predation | Seed burial by addition of soil | Max 2 cm depth, use low fertility peat free potting mix. |
| Seed predation | Use of mammal / bird repellents | Aluminium ammonium sulphate no longer commercially available. Sheep fat (Trico) is the only commercially available repellent, but it is marketed as a deer repellent, and has not been tested for use in direct seeding, so phytotoxicity and efficacy is unknown. Past evidence suggests capsaicin might make the best repellent, but no product is commercially available, so testing it is a lower priority for our work. |
| Seed predation | Use of slug killer | Scale of predation caused by slugs not known. |
| Seed predation | Use of pelletised seed | Could combine with repellent etc. May not need to be buried. |
| Seed predation | Increased sowing rate | Required minimum rate unknown. Too low and may get no seedlings at all. Too high and may get too many in single spot or tree shelter. Could leave to see if self-thins. Sowing known quantity per spot could allow recommendations to be made on reduced sowing rate if necessary. Could go for one rate or test range. |
| Seed predation | Use of seed shelters | Various methods have been tried but simplest would be to use a conventional short 0.6 m tree shelter. SP will succeed in tree shelters if the shelters are removed early enough. |
| Seed predation  Seed germination and survival | Spring rather than autumn sowing date | Spring sowing date mimics nature for SP, but exposes seed to hot dry springs. Spring sowing date may require cold pre-treated seed. Autumn sowing date may give better seedling survival, but exposes seed to longer periods of predation. |
| Seed germination, survival and growth | Broadcast sow to maximise potential germination niches | Alternative strategy to concentrating seed in spots on best cultivated areas and trying to protect it. |
| Seed germination – lack of suitable microsite | Cultivation | Basal treatment – on podzol scarify as many traces across site as possible. |
| Seed germination | Seed invigoration | Makes seed difficult to handle? Not necessary for autumn sown. Cold pre-treatment more effective for spring sown? |
| Lack of nutrients | Fertilizer | Carry out foliar analysis and consider as basal treatment year 2 onwards. |
| Weed competition for moisture / nutrients / light | Cultivation | Basal treatment. On Glenmore podzol site, cultivation should give 2-5 years of weed suppression. If not herbicides may be required. LP natural regeneration may need to be removed. |
| Deer browsing | Fence | May not be possible on a large scale due to the presence of Capercaillie. Needs to be tested as likely to be limiting regeneration, particularly of broadleaves. |
| Deer browsing | Woody matrix | Sow birch, rowan alder anyway as part of natural pinewood components. May also deter browsing in unfenced areas. |
| Deer browsing | Tree shelters | Tall tree shelters might also reduce seed predation. |

**Objective:** To determine if direct seeding could be an effective silvicultural method for restoring and expanding native pinewoods

**Location:** Glenmore compartment 3142H, Grid ref: NH 9516 0906

**Species:** Scots pine (*Pinus sylvestris* L.)

Rowan (*Sorbus aucuparia* L.)

Birch (*Betula pendula* Roth)

Alder (*Alnus glutinosa* (L.) Gaertn.)

**Products and**

**Active**

**Ingredients:**

|  |  |
| --- | --- |
| **Product** | **Active Ingredient** |
| Trico | 63.96 g/kg sheep fat |
| Sluxx HP | 2.97% w/w ferric phosphate |

**Experimental**

**Treatments:**

S1 Untreated control, no sowing.

S2 SP sown in tree shelters.

S3 SP sown in tree shelters + burial.

S4 SP sow n in tree shelters + slug pellets + burial.

S5 SP sown in tree shelters + slug pellets + repellent + burial.

S6 SP sown in tree shelters + slug pellets + repellent + burial, spring sown, pre-treated seed.

S7 SP spot sown in tree shelters + burial + slug pellets, without sown broadleaved matrix.

S8 SP spot sown without tree shelters.

S9 SP spot sown without tree shelters + burial.

S10 SP spot sown without tree shelters + slug pellets + burial.

S11 SP spot sown without tree shelters + slug pellets + repellent + burial.

S12 SP spot sown without tree shelters pelletised seed, + burial, spring sown, pre-treated seed.

S13 As S1 but unfenced.

S14 As S4 but unfenced.

S15 As S7 but unfenced.

(Note – all treatments to be sown with a broadleaved matrix except S1, S7, S13 and S15 – see methods)

**Design:** A randomised split plot design consisting of fencing as the main plots and seeding treatment as the sub plots.

15 seeding treatments x 3 blocks (replicates) = 45 plots.

The three blocks will be laid out to match soil type or other site features if it varies, or distance from edge trees, or failing that randomly (to allow assessments / treatments to be carried out block by block).

Each block will be 0.6 ha.

Each plot will be 20 m x 20 m (0.04 ha).

Each plot will contain approximately 10 rows by 10 rows assuming a 2m x 2m sowing spot spacing is possible, allowing for a 1 row (2m) buffer.

Assessment plots will be the central 64 sowing positions (8 rows by 8 rows, approximately 18 m x 18 m).

Up to 1.8 ha will be required.

**Analysis:** **Source d.f.**

Fencing 1

Seeding treatment (S) 11

Block 2

Residual treatment df 28

**Total 44**

Mixed effects modelling will be used to account for the split plot design Response~Block+Fencing+Trt+(1|Block:Fencing), with treatments S13, S14 and S15 assigned to S1, S4 and S7 respectively to ensure the fencing effect is tested at the block level. Where results are analysed over multiple years, mixed effects modelling will be used, with plot random effects to account for plot-level repeated measures. Results for treatment comparisons will include estimated marginal means and p-values (adjusted for multiple comparisons).

**Methods:** Select site, and mark out treatments on site (SOP0006 v.2, SOP0048 v.2). Sub plots must be laid out so that they each contain the same number of sowing spots.

Kill any established vegetation with an overall application of glyphosate (e.g. as 5 l/ha Roundup ProActive, 360 g/l glyphosate) in early September 2020. Cut any existing conifer natural regeneration below the lowest live whorl.

In early October 2020 (a minimum of 4 weeks after any herbicide spray), fully scarify the site with the aim of killing any vegetation, breaking up brash, mixing organic material and mineral soil, and creating a freely draining mineral soil seedbed. Aim to scarify the site as extensively as possible, not just in discrete traces. Discuss the best approach with the scarifier operator given the overall site condition and the presence of stumps. It may be possible to achieve a good result by setting the scarifier discs as horizontally as possible, and possibly through making two or more passes. Based on the sites viewed in October 2019 (‘MacAlpine early felling 2017’) there is not excessive brash present, but were there to be, then the brash might potentially first need to be raked into discrete areas, or raked and possibly burnt, to allow the unpowered scarifier to operate. If, after cultivation, the site is overlain with significant amounts of organic material (e.g. brash, needle litter, and dead or live vegetation), or is subject to winter waterlogging, the subsequent direct seeding operation is unlikely to be successful.

After cultivation, fence the S1 – S12 plots against deer.

For treatments S2 – S7, S14 and S15, install 0.6 cm high staked tree shelters at approximately 2 m x 2 m spacing in the treatment plots, using as far as possible the same spacing throughout. The precise spacing may have to be varied depending on the results of the cultivation.

The tree shelter must be firmly buried in the mineral soil to a depth of at least 3 cm, and the soil firmed around the base of the shelter so that even with subsequent soil shrinkage no gaps will be revealed that mice or other small mammals could enter by.

For treatments S8 – S12, spot sowing should take place at the same spacing pattern as used for the tree shelter treatments. Given the high cost of native Scots pine seed, rather than broadcast sowing, the aim is to try to establish Scots pine at approximately the same spacing as might result from conventional planting.

Each sub plot should contain the same number of sowing spots (if necessary some spots might need to be left unsown to achieve this)

Aluminium ammonium sulphate animal repellent, is no longer available, so those treatments using repellents (S5, S6, S11), sheep fat (Trico) will be used instead. As this is a more experimental compound for this use, and we have no information on phytotoxicity to seed or efficacy in reducing seed predation, it will be used in a more restricted number of treatments than would be the case if aluminium ammonium sulphate were available. It is also not known whether seed can be pre-treated with sheep fat, and then still be handled efficiently afterwards, or whether the repellent product will make seed clump together too much to allow precise numbers to be sown. Therefore, Trico repellent will be applied after sowing, and before seed burial. Seed will be sown, then sprayed with 8 ml Trico (0.517 g a.i.-1 sheep fat), then buried to 2 cm as described below. This rate assumes 2,500 spots ha-1, but must be adjusted as necessary so as not to exceed the maximum product rate of 20 litres ha-1 Trico (12.9 kg a.i. ha-1 sheep fat).

For treatments using seed burial (S3 – S7, S9 – S12, S14 and S15), immediately after sowing cover the Scots pine seed with John Innes Number 1 peat / compost potting mixture to a depth of 2 cm and if possible lightly tamp down (a deeper covering may kill the seeds, but less will not help to prevent predation). Make a test application to judge the amount of soil required for each sowing spot, and record the approximate typical weight of soil used per spot. Alternatively, for treatments 9-12. It may be possible to dig a small hole and bury seed to 2cm.

For treatments using slug pellets (S4, S5, S6, S7, S10, S11, S14 and S15), after sowing and any seed burial treatment, add Sluxx ferric phosphate non-toxic slug killer pellets to each tube. These pellets are designed to resist breakdown in wet weather and contain 2.97% w/w ferric phosphate. Use a rate of 2.5 g per tube, so as not to exceed the maximum product dose rate of 7 kg per hectare (based on a tube diameter of 73 – 105 mm). Record the approximate number of pellets represented by 2.5 g. For treatments S4, S5, S7, S10, S11, S14, S15 reapply the slug pellets immediately before anticipated seedling germination in late March.

In November 2020 (March 2021 after any snow has melted for treatment S6 and S12), sow 20 viable Scots pine seed in each tree shelter (S2 – S7, S14, S15), or in a sowing spot of approximately 15 cm x 15 cm (S8 – S12). The actual number of seed sown will need to be adjusted upwards to reflect the viability percentage of the seed lot.

Using a sowing rate of 20 seed per spot anticipates a 95% loss in seed without any silvicultural mitigation, which would result in approximately 1 established seedling per spot. If significantly greater numbers of seedlings establish, they will be monitored for evidence of self-thinning. If necessary, decisions on any artificial respacing that might be required can be taken at a later date.

For treatments S2 – S6, and S8 – S12, S14, after the Scots pine has been sown (prior to spring 2021 sowing in the case of S6), the remainder of the intervening matrix in the plots will be seeded with a mix of birch, rowan and alder (around 1.3 ha in total).

Rowan seed should be purchased suitably pre-treated to break dormancy, ready for sowing in autumn 2020. For birch and alder, as the seed will be sown in the autumn it can be purchased un pre-treated.

Rowan, alder and birch seed should be mixed together and then mixed with fine, dry builders’ lime-free sand to aid sowing. The proportion of seed to sand should be approximately 1:10 by weight.

In early November 2020, the birch, rowan and alder should be sown together as an intimate mix, by hand, and spread as evenly as possible across the entire area, including on scarified and unscarified areas, to achieve a sowing rate of 2 million viable birch seed per hectare, 220,000 viable rowan seed per hectare, and 80,000 viable alder seed per hectare (the actual weight of seed applied will need to be adjusted to take account of seed viability).

To make sowing easier, conveniently sized bags of a known quantity of mixed broadleaved seed and sand sufficient to sow say 10 m x 10 m areas, should be pre-prepared by the TSU. Alan Duncan at Newton, or Plant and Seed Supply Branch at Alice Holt, or Shelagh McCartan, might be able to help with this if approached and enough notice is given.

Make a practice sowing over a known area (e.g. over a 10 m x 10 m area), to help ensure the correct sowing rate is consistently used during the main broadleaved sowing operation.

During transport, seed should be packaged such that it is protected and kept cool (e.g. using cool boxes) and sown immediately on delivery. If immediate sowing is not possible, the bags of rowan / birch / alder seed mix should be only loosely tied, and should be kept in a domestic refrigerator at around 5 ºC (i.e. not in the ice box or a freezer) until they are sown. Packets of rowan / birch / alder seed can be kept in this way for no more than a week. Dry Scots pine seed should be kept in tightly sealed bag in a domestic refrigerator, and can be kept in this condition for several weeks. If the seed is wet, treat it as rowan / birch / alder.

For the broadleaved matrix sowing, sufficient seed to sow approximately 1.3 ha will be required. Precise quantities of seed will depend on seed viability of the seed lot, and can be calculated using the spreadsheet in Appendix 2, but it is anticipated that approximately 4 kg of birch seed, 2.7 kg of rowan seed, and 0.4 kg of alder seed will be required.

It is anticipated that birch, rowan and alder seed will be supplied by Forestry and Land Scotland, via Alan Duncan, from that purchased for their adjacent operational sowing, but the TSU should check this is this case.

For the 1.5 ha experimental Scots pine sowing, approximately 78,000 viable seed will be required. Actual viability will need to be tested prior to sowing, but assuming a viability of 160,000 viable seed kg-1, this is equivalent to approximately 0.5 kg of seed.

Seed for treatment S6 should ideally be pre-treated to break dormancy for a spring sowing. This could be carried out by PSS at Alice Holt.

Scots pine seed is held by Alan Duncan at Forestry and Land Scotland.

Pelletised seed (S12) will be supplied by Shelagh McCartan. Unless otherwise notified it will be surface sown at a rate of 20 seeds per spot. Around 12,000 seed will be required. Seed is likely to be pre-treated for spring sowing, may also be invigorated, and may also be pelletised with aluminium ammonium sulphate repellent and ferric phosphate slug killer.

Monitor the site for weed invasion for 3 years after sowing, and consider treating with a selective weed killer if necessary, after discussion with the Project Leader.

**Records and**

**assessments:** Seedling survival should be assessed at the end of each growing season in October (and before leaf fall if the broadleaf matrix is being assessed).

The assessment should be carried out by counting and recording the number of Scots pine seedlings at each sowing spot in the central 18 m x 18 m of each sub-plot.

Depending on the results of the scarification, there are anticipated to be up to 80 sown pots in total in each 18 m x 18 m assessment plot. Each assessment plot must contain the same number of sown spots.

Measure the height and root collar diameter of the 10 largest sown Scots pine trees in each assessment plot.

If funds allow, the broadleaved matrix will also be assessed. Count the number of broadleaved seedlings within a central 10m x 10m plot, by placing 100 1m x 1m plots, following the protocol developed for Slattadale 2. Obvious damage should also be recorded and, where known, the damaging agent.

If funds allow, seedling height and root collar diameter of birch, rowan and alder will be assessed each year by measuring the largest tree of each species in each 1m x 1m assessment plot. Any obvious specimens of natural regeneration present before sowing will be ignored.

If funds permit, vegetation cover is to be recorded in each 10 m x 10 m assessment plot in October, using 5 main vegetation classes including bare ground and tree seedlings, following the protocol developed for Slattadale 2.

Assess soil type (assumed from maps to be a typical stony podzol with induration).

Produce layout maps, and produce experimental record forms within 1 month of each operation / site visit (SOP0006 v.2, SOP0004 v3, SOP0084 v.3).

Location of records: Electronic folder stored in \Silv.Data\xxxx (NB this is a shared area and is accessible to all with access rights).

Paper folder kept at Alice Holt, room 125, fireproof cabinet, plan folder xxxx.

**Duration and**

**responsibilities:**

Duration: 3-5 years.

Project leader: Ian Willoughby

Layout, establishment, assessments, COSHH etc. : TSU (Mark Oram)

**CRD**

**approval:** At the time of writing, Trico has approval for use on forest crops, and Sluxx both have full on label approval for use on all non-edible crops. However, the TSU should check the approval status of these products in advance of their use in case the product is subject to phased withdrawal, in which case an experimental approval may be required – see Appendix 3.

**COSHH and**

**Risk**

**Assessments:** TSU responsibility. Refer to product labels and materials safety data sheets.

The TSU will need to carry out a site specific environmental risk assessment for pesticide use as outlined in section 7.10 of OGB 15 in order to fulfil FSC certification requirements for the national forest estate. This is in addition to the ‘Environmental Risk Assessment’ in Appendix 1.

For copies of labels and safety data sheets see:-

Trico:-

<https://www.laronkarn.co.uk/wp-content/uploads/2016/09/TRICO-UK-Label.pdf>

Sluxx:-

<https://www.certiseurope.co.uk/sluxx-hp/>

The experiment represents a low environmental risk – see Appendix 1.

**SOP’s:** SOP0004 v3 Record keeping for field experiments that test the efficacy or phytotoxicity of plant-protection products

SOP0006 v.2 Site selection and administration for field experiments

SOP0048 v.2 Marking and labelling field experiments

SOP0084 v.3 Mapping the location and layout of field experiments and monitoring sites

**Drafted by:** Ian Willoughby

**Date:**  2/12/19 (modified 18/9/10)

**Design**

**Approved:** Jack Forster (Statistician)

**Date:** 29/05/20

**Approved:** Helen McKay (Head of Centre)

**Date:** 20th June 2020

**References**

Aleksandrowicz-Trzcinska, M., Drozdowski, S., Wolczyk, Z., Bielak, K. and Zybura, H. (2017). Effects of reforestation and site preparation methods on early growth and survival of Scots pine (*Pinus sylvestris* L.) in south-eastern Poland. *Forests* **8**, 421.

Bergsten, U. (1988). Pyramidal indentations as a microsite preparation for direct seeding of *Pinus sylvestris* L. *Scandinavian Journal of Forest Research* **3**, 493-503.

Derr, H.J. and Manns, W.F. (1971). Direct seeding pines in the south. *USDA Agriculture Handbook* **391**. <https://www.fs.usda.gov/treesearch/pubs/29602>

Erefur, C., Bergsten, U. and de Chantal, M. (2008). Establishment of direct seeded seedlings of Norway spruce and Scots pine: Effects of stand conditions, orientation and distance with respect to shelter tree and fertilisation. *Forest Ecology and Management* **255**, 1186-1195.

Grossnickle, S.C, and Ivetic, V. (2017). Direct seeding in restoration – a field performance review. *Reforesta* **4**, 94-142.

Hypponen, M. and Hallikainen, V. (2011). Factors affecting the success of autumn direct seeding of *Pinus sylvestris* L. in Finnish Lapland. *Scandinavian Journal of Forest Research* **26**, 515-529.

Mason, W.L, Hampson, A. and Edwards, C. (Eds.) (2004). *Managing the pinewoods of Scotland*. Forestry Commission, Edinburgh.

Nilson, M.E. and Hjalten, J. (2003). Covering pine-seeds immediately after seeding: effects on seedling emergence and on mortality through seed-predation. *Forest Ecology and Management* **176**, 449-457.

Wennstrom, U., Bergsten, U. and Nilsson, J. (1999). Mechanizsed microsite preparation and direct seeding of *Pinus sylvestris* in boreal forests – a way to create desired spacing at low cost. *New Forests* **18**, 179-198.

Willoughby, I., Jinks, R.L., Kerr, G. and Gosling, P.G. 2004b Factors affecting the success of direct seeding for new woodland creation. Forestry 77, 467–482.

Willoughby, I.H., Jinks R.L. and Forster, J. (2019). Direct seeding of birch, rowan and alder can be a viable technique for the restoration of upland native woodland in the UK. *Forestry* **92** (3), 324-338. <https://doi.org/10.1093/forestry/cpz018> .

Winsa, H. and Bergsten, U. (1993). Direct seeding of *Pinus sylvestris* using microsite preparation and invigorated seed lots of different quality: 2-year results. *Canadian Journal of Forest Research* **24**, 77-86.

Winsa, H. and Sahlen, K. (2001). Effects of seed invigoration and microsite preparation on seedling emergence and establishment after direct sowing of *Pinus sylvestris* L. at different dates. *Scandinavian Journal of Forest Research* **16**, 422-428.

**Appendix 1: Environmental Risk Assessment**

|  |  |
| --- | --- |
| **ENVIRONMENTAL RISK ASSESSMENT** | |
| These questions are used to determine the level of environmental risk the experiment poses and what measures will be implemented to mitigate these risks. The Environmental Risk Assessment also seeks to establish that all current legislation is being adhered to.  ‘Internal’ applications, on behalf of Forest Research (only) are required to complete **SECTION ONE**.  ‘External’ applications, *i.e.* those on behalf of or made jointly with other organisations working on the Public Forest Estate are required to complete **SECTION ONE** and **SECTION TWO.** | |
| **SECTION ONE** | |
| Funding: | State whether there is adequate funding, plus contingency (~10-20% of total project funding), for the duration of the project lifecycle – including disposal and destruction of the trial. Yes. |
| Safety Mechanisms: | List any mechanisms and funding in place to ensure the safety of staff, goods and premises.  Furthermore state whether mechanisms are in place to manage the trial in response to external influences (e.g. vandalism and restricted access) Normal FD mechanisms. |
| Site Decommissioning: | Describe how the site will be decommissioned and associated funding. Remains part of FD. |
| Genetically Modified Organisms (GMO’s): | Does the experiment involve the use of Genetically Modified Organisms?  YES □ NO X□  If yes - the applicant should state how/whether they have ensured the trial complies with relevant devolved administration legislation regarding the trialling of GMO’s.  The applicant is aware that should the proposal gain FC approval, verification from Advisory Committee on Releases to the Environment (ACRE) will also be required. |
| Potentially Invasive Species: | Does the experiment involve the use of potentially invasive species?  YES □ NO X□  If the experiment is located in Scotland or Wales – state whether any species involved with the experiment are listed in Annex 9 of the Wildlife and Countryside Act (Scotland and Wales). If listed, in compliance with legislation, the applicant will require a licence of consent from Natural Scotland or Natural Resources Wales.  YES □ NO X□  If the experiment is located in Scotland - state whether any species involved with the experiment are classified as ‘non-native’ under the Wildlife and Natural Environment (Scotland) Act 2011. If the species is classified as ‘non-native’, in compliance with legislation, the applicant will require a licence of consent from Scottish Natural Heritage.  YES □ NO X□ |
| Use of Pesticides: | Does the experiment involve the use of pesticides not covered by a full approval, extension of authorisation for minor use approval, or long-term arrangements for extension of use?  YES □ NO X□  If *yes*, an appropriate experimental permit must be obtained from the Chemicals Regulation Directorate (CRD); see [www.pesticides.gov.uk](http://www.pesticides.gov.uk) for further details.  If the pesticide is listed on the FSC ‘highly hazardous’ list, it cannot be used on certified estates without a specific derogation issued by the FSC.  It may be possible for Forest Research to gain permission to use a ‘highly hazardous’ pesticide for experimental purposes on the FC Public Forest Estate if a formal request is made via the FC certifiers (SGS) to the Forest Stewardship Council stating:   * the reason for the use of a ‘highly hazardous’ pesticide; * the area on which this will be applied; * the controlled conditions under which it will be used; * the expected research time frame; and * how the FSC will be periodically updated about the research   Contact [Ian Willoughby](mailto:ian.willoughby@forestry.gsi.gov.uk) if you need more advice on this. See FC OGB 15 for other essential information on the use of pesticides on the Public Forest Estate by Forest Research. |
| Biosecurity Risk: | Does the experiment pose a potential biosecurity risk (such as a tree disease or insect pathogen)?  YES □ NO X  If yes – explain further details of the biosecurity risk and detail how the experiment will comply with FC Biosecurity Protocols. |
| Other Potential Environmental Risk: | List and explain whether the proposal poses any other potential environmental risks not previously listed e.g. radioactive substances or potential pollution of a watercourse.  State how these other potential environmental risks will comply with relevant legislation and list any organisations you are liaising with. |
| UK Forestry Standard: | Does the experiment follow the standards and accompanying legislation as outlined in the UK Forestry Standard?  YES □X NO □ |
| Classification and Justification of Environmental Risk: | Based on answers given to previous questions, summarise the environmental risks posed by the experiment and how they will be controlled/mitigated (e.g. through regular monitoring).    Finally classify the environmental risk of the proposal as:  ‘**Low**’ X  ‘**Medium**’ □  ‘**High**’. □  If the proposal involves the use of GMOs, aerial application of pesticides, potentially invasive species or poses a biosecurity/other potential environmental risk, the proposal will be subject to further scrutiny as set out in the ‘[Environmental Risk Assessment Process Flowchart](http://alpacorn.forestry.gov.uk:7777/portal/page?_pageid=33,368599&_dad=portal&_schema=PORTAL)’ before being accepted or rejected. (Download as an *Excel* spreadsheet from the FR QA intranet site, or contact the QA Manager for a copy.) |

**Appendix 2: Spreaadsheet for calculating sowing rates based on seed viability**

****

**Appendix 3: Experimental Approval**

|  |  |  |  |
| --- | --- | --- | --- |
|  | |  | |
|  | Chemicals Regulation Division  **Bev Kirby**  Mallard House  Kings Pool  3 Peasholme Green  York YO1 7PX  Tel: +44 (0)203 028 1198  Bev.Kirby@hse.gov.uk  <http://www.hse.gov.uk/> |
|
| Dr Ian Willoughby  Forest Research  Alice Holt Lodge  Wrecclesham  FARNHAM  Surrey  GU10 4LH | |
| Date 1 June 2020 | |
|  | |
|  |  |
| Dear Dr Willoughby | | | |

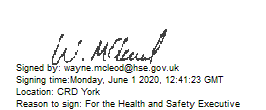
**COP 2020/00925: PERMIT FOR TRIAL PURPOSES:ADMINISTRATIVE APPLICATION**

Thank you for your application of 27 May 2020 for a Permit for Trial Purposes. Ministers have agreed to grant a Permit under Regulation (EC) Number 1107/2009 as attached to this letter.

This product(s) which is the subject of a permit for trial purposes must only be stored, supplied or used by the permit holder or their agent(s). The number of agents should be kept to a minimum and must be advised of all conditions of the permit.

Permits for Trial Purposes processed through the Administrative stream are issued upon receipt of the application and before we receive payment. We request that no payment is made prior to receipt of an invoice. If you have not paid, you will shortly receive an invoice in relation to this application from our finance department in Bootle which will require prompt payment.

Yours sincerely



HSE Digital Signature

BJ Kirby

Pesticides Delivery Team

[www.hse.gov.uk/pesticides](http://www.hse.gov.uk/pesticides)

**PERMIT FOR TRIAL PURPOSES OF A PLANT PROTECTION PRODUCT**

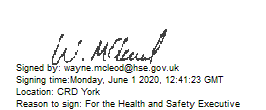
**PLANT PROTECTION PRODUCTS REGULATION (EC) No 1107/2009**

Products containing the active substances: as in attached list

Permit holder: Forest Research, Alice Holt Lodge, Wrecclesham, FARNHAM, Surrey, GU10 4LH, UK

This permit ends: 30 June 2023

Extent of permit: United Kingdom



HSE Digital Signature

This and the attached Appendices 1 to 2 are signed by the Health and Safety Executive (“HSE”) for and on behalf of the Secretary of State, the Welsh Ministers, the Scottish Ministers and the Department of Agriculture, Environment and Rural Affairs in Northern Ireland .

Date of issue 1 June 2020

**EXPLANATORY NOTES**

Application reference number COP 2020/00925

**APPENDIX 1: CONDITIONS OF THIS PERMIT**

## Failure to comply with the following conditions will result in the withdrawal or amendment of the permit under Regulation (EC) No 1107/2009 and may result in other enforcement action, including prosecution.

**Storage:** The substances in the attached list must be kept in a suitable container in a safe place under lock and key unless they are authorised products in their original container with the appropriate label attached.

**Use:**

Field of use: **ONLY AS AN EXPERIMENTAL SUBSTANCE**

Maximum area to be treated: Five hectares per annum in total for all crops and situations for each active substance in the attached list.

Operator protection: (1) Where the COSHH assessment indicates no increase in exposure compared with an on-label use, the label recommendations must be followed. In other situations see 2 and 3 below.

(2) Engineering control of operator exposure must be used where reasonably practicable in addition to the following personal protective equipment.

Personal Protective Equipment must be worn when handling and applying the product in accordance with the guidelines given in the ‘Code of Practice for Using Plant Protection Products Annex E - Guidance on using personal protective equipment’.

(3) However, engineering controls may replace personal protective equipment if a COSHH assessment shows they provide an equal or higher standard of protection.

Environmental protection: (1) Since this/these product(s) is/are potentially harmful to fish or other aquatic life, surface waters or ditches must not be contaminated with chemical or used container.

(2) (a) Since there is a potential risk to aquatic life from use direct spray from ground crop sprayers must not be allowed to fall within 5 metres of the top of the bank of any static or flowing waterbody or within 1 metre from the top of any ditch which is dry at the time of application. Spray from hand held sprayers must not in any case be allowed to fall within 1 metre of the top of the bank of any static or flowing waterbody. In all cases spray must be directed away from water. This product is not eligible for buffer zone reduction under the LERAP scheme.

(b) Buffer Zones must be measured in accordance with the guidance set out in Pesticides Safety Directorate’s booklet ‘Local Environmental Risk Assessments for Pesticides- A Practical Guide’, available from DEFRA Publications, Admail 6000, London. SW1A 2XX: Tel. 08459 556000 (and any amendments as made to it from time to time).

(c) Since there is a potential risk to aquatic life from use direct spray from broadcast air assisted sprayers must not be allowed to fall within 18 metres of surface waters or ditches.

(3) Since there is a potential for the contamination of groundwater from use:

(a) Applications must not be made to sites with soils of high leaching potential. Details of the leaching potential of soils in England and Wales are given on Groundwater Vulnerability Maps available from the Stationery Office (for major and minor aquifers), and from the Environment Agency (for non-aquifer areas). In Scotland, a limited number of groundwater vulnerability maps are available. The Scottish Environment Protection Agency should be consulted for further information regarding these maps.

(b) In England and Wales applications must not be made to areas within a Zone 1 Groundwater Source Protection Zone or within 50m of other sources of groundwater used to supply drinking water. Details of ‘Groundwater Source Protection Zones’ in England and Wales are available on the Environment Agency’s website ([www.environment-agency.gov.uk](http://www.environment-agency.gov.uk)). There are currently no Groundwater Source Protection Zones in Scotland.

If conditions (3)(a) and (3)(b) cannot be complied with at the trial site(s) selected, or there is any doubt about such compliance, the permit holder must contact the Environment Agency or Scottish Environment Protection Agency as appropriate. The agreement of the relevant Agency to the acceptability of the site selected must then be obtained before a trial is commenced.

(4) Since there is a potential risk to bees from use, spray applications must not be made immediately preceding or during the flowering stage of the crop or weeds. Spray applications must also not be made where bees are actively foraging.

(5) Since this/these product(s) is/are potentially harmful to game, wild birds and animals precautions must be taken to protect them from harm. Applications must be made when mammals and birds are unlikely to forage in the area being treated. Spillages of chemical or treated seed must be recovered or buried.

(6) Since there is a potential risk to non-target plants, insects or other arthropods from use, applications must not be made within 6 m of the field boundary.

(7) Any run-off from the treatment of land not intended to bear vegetation must be prevented from entering surface waters and disposed of safely.

Other specific restrictions: (1) Full records of all applications carried out under this Permit for Trial Purposes, including details of the specific sites treated and their Ordnance Survey grid references, must be kept for ten years following application.

(2) Unless a current or subsequent authorisation or Permit for Trial Purposes that allows normal disposal (i.e. supply for human or animal consumption) is available, the following conditions apply:

(a) Normal disposal is not permitted for treated annual crops, or until at least five years has elapsed between treatment and harvest of perennial plants (e.g. apple trees) or ‘semi-perennial plants’ (e.g. strawberry). Harvested portions of treated crops must be destroyed by either burning, burying or disposal in a facility licensed for this purpose. Desiccation may be used, but only before the development of the harvested portion of the crop.

(b) The total area treated with the experimental substance at any one site must not be more than 2% of the area to be planted with any following edible crop at the site in which the experimental work is undertaken. This condition does not apply if the trial site is not to be used to grow edible crops in the year following treatment.

(3) Direct or indirect post-treatment exposure of humans or animals must be avoided wherever possible.

(4) This Permit for Trial Purposes does not apply to the application of a pesticide to a crop genetically modified to be tolerant to that pesticide.

(5) This Permit for Trial Purposes does not apply to the application of plant protection products from an aircraft (plane or helicopter).

**APPENDIX 2: GENERAL CONDITIONS OF THIS PERMIT**

## Failure to comply with the following conditions will result in the withdrawal or amendment of the Permit under Regulation (EC) No 1107/2009 and may result in other enforcement action, including prosecution.

**Label:**

The permit holder must follow the detailed requirements of all relevant Parts of ‘The Labelling Handbook’ available on HSE’s website at <http://www.hse.gov.uk/pesticides/topics/pesticide-approvals/pesticides-registration/labelling-handbook.htm>.

**Packaging:**

The permit holder must design and construct the packaging and fastenings to make sure they are strong and solid throughout so they will not come apart and will safely withstand normal handling; they can be repeatedly refastened and the contents cannot accidentally escape; the contents cannot attack either the packaging or the fastenings or form harmful or dangerous compounds with them and they are unlikely to attract children or arouse their curiosity.

**Adverse effects:**

The permit holder must immediately notify the Secretary of State, the Scottish Ministers and the Department of Agriculture, Environment and Rural Affairs in Northern Ireland (care of the Health and Safety Executive), if they have any new information on the potentially adverse effects of the authorised product, or of residues of an active substance in that product when used in accordance with the conditions of this permit. For those products approved under the ‘Plant Protection Products Regulations’ permit holders must also tell the other relevant competent authorities of the EC Member States (a list of which is available from the Health and Safety Executive) and the EC Commission. Failure to comply with this requirement is an offence.

**Provision of information:**

The permit holder must comply with all requests for information required by the Secretary of State, the Scottish Ministers or the Department of Agriculture, Environment and Rural Affairs in Northern Ireland in accordance with Article 67 of Regulation (EC) No 1107/2009.

|  |  |  |  |
| --- | --- | --- | --- |
| **Part C – List of Active Substance** | | | |
| **5** | **At least one column below must be completed for each active substance. A single entry for an active substance is sufficient for all formulations. Product names are not required, but should be provided if known. Please expand this section if required.** | | |
| **Product or code name/Active Substance** | | **BSI Name** | **IUPAC or CAS name** |
| Asulam (Asulox) | |  |  |
| Cycloxydim (Laser) | |  |  |
| Propaquizafop | |  |  |
| Aluminium ammonium sulphate | |  |  |
| Amidosulfuron (Squire Ultra) | |  |  |
|  | |  |  |