Centre for Forest Protection

Forest Research

Internship diary: Scots pine breeding

1st October 2025 – 31st March 2026

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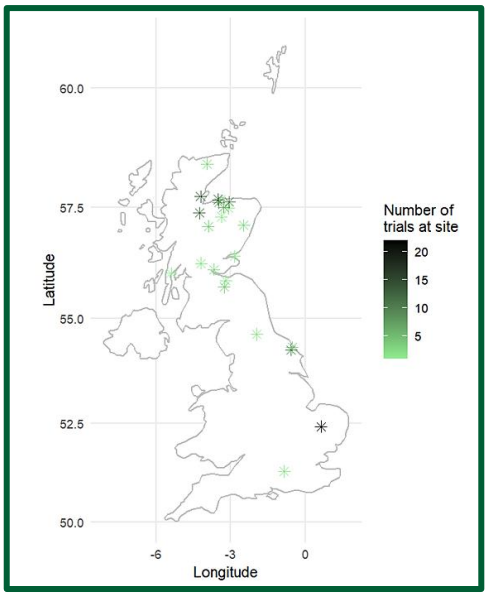
About my internship

Scots pine breeding

As part of the Centre for Forest Protection (CFP) project "Infusing resilience into the Scots pine genetic resource", I have been focused on restarting the Scots pine breeding programme. Previously, the Scots pine trials (top right), culminated in the selection of 226 parents to form the Scots Pine breeding population (Lee, 2002).



Locations of the old breeding trials (planted from 1957 to 1984)

Tree breeding objectives relate to producing desirable trees for timber and are now extended to resilience from threats like Dothistroma needle blight too. There is potential for further breeding, and supply of improved seed, to help the native Scots pine tree rival the formidable Sitka spruce in productive forestry. New progeny trials will be planted in the coming years.

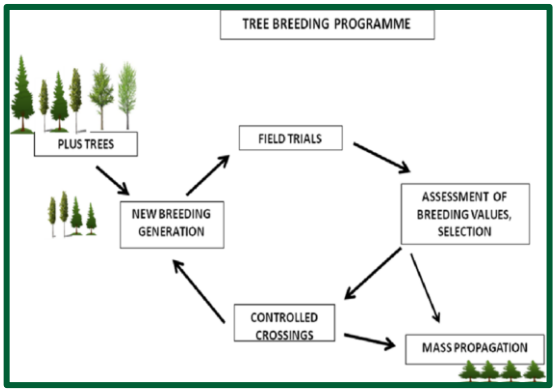


Diagram of the tree breeding cycle by Dhillon et al (2010)

Tasks in my internship

- Digitised >80 paper files of past experiments
- Data entry of spatial layouts of tree breeding trials using my own application built in Python
- Supported fieldwork and other activities
- Extracted 21,000 seeds from pinecones
- Prepared 36,000 seeds for sowing using cold stratification
- Learned the software DATAPLAN and mixed models to analyse old Scots Pine progeny trials

Key moments

Getting started

Starting at Forest Research was my first in depth exposure to forestry. I was therefore keen to invest some time into background reading and began a tree breeding glossary (see appendix). This helped me to develop my understanding throughout the internship. In the first few days, I was delighted to go out to see three sites:

1. Glencorse clone bank near our office, Northern Research Station

It was interesting to both see, and hear about, the history and variety of the forest genetics research that had been done. Many trees had been grafted onto rootstock whilst some had been propagated through tissue culture.

2. Yair, an ecological/provenance trial in the Scottish Borders

Yair was impressive for the range of research it is supporting; this became particularly evident later on at the James Hutton Scots Pine Research Day in November. Seed from Yair was extracted from cones last year by Connor O'Donoghue and is now being incorporated into the new breeding programme.

3. Kershopefoot seed orchard which is just over the English border.

At Kershopefoot, we took needle samples which were sent for genotyping. The purpose of genotyping was to confirm the identities of the trees we'd come back to take pinecones from in December.

A Scots pine tree at the edge of the Kershopefoot seed orchard. Whilst it was planted in 1988, it has been kept short to make reaching the pinecones easier.

Supporting glasshouse trials at UKCEH

My fellow interns Finlay and Daniel have been working on an abiotic stress project with Tom Sim and the neighbouring UK Centre for Ecology & Hydrology (UKCEH).

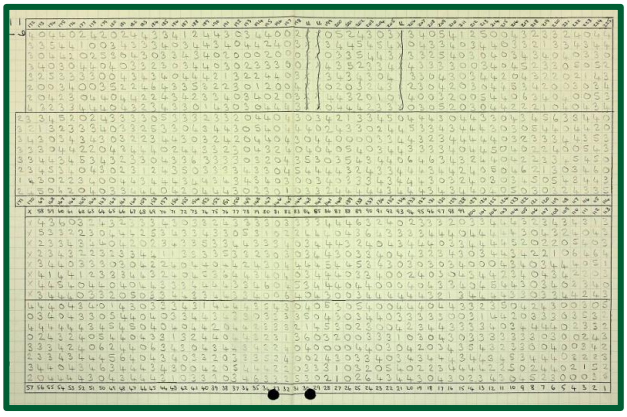
Whilst I visited in October, we placed clips around needles to measure the colour intensity of the chlorophyll, took needle and soil samples, and took height measurements. It was striking to see the scale of tasks like labelling and moving plants which underpin setting up forestry trials.

A needle sample from one of the young Scots pine plants in the experiment.

Digitising files

Amongst the activities highlighted in this diary, I had ongoing desk-based work. In the first months of the internship, I digitised paper records of the Scots pine progeny trials. Once the files were recalled from the secure storage, Records Digitiser Liga Gutane walked me through the procedure to scan and archive them with due care.

OCR scans allow text to be extracted, providing additional metadata about the experiments. Scanning gave me lots of time to think creatively about the coding I was working on. I also liked getting a glimpse into how things operated in previous decades.



The scans are the source of information on spatial layout, here shown by a measurement sheet. These are interpreted to give coordinates for each tree, used in spatial analysis.

Collecting cones at Kershopefoot Seed Orchard

Here I am collecting some cones. Photo taken by Richard Whittet

A fallen branch with 'hair ice'. It is held up against a tree for visual contrast. I enjoyed this article by TV presenter Nick Baker exploring the phenomenon.

Kirsten, Richard and I returned to Kershopefoot to collect pinecones in early December. It was a cold, dry day and we were lucky to be accompanied by a robin and spot some 'hair ice' (bottom left).

To restart the breeding programme, new trees must be sourced from seed. Seed was taken from this orchard because it had superior breeding values for both straightness and height.

We returned to each of the selected ramets that we had genotyped to gather around 100 pinecones. We were selecting closed cones with a greener tone which wouldn't have opened and dropped seeds yet, meaning more seed to be extracted.

Some ramets had pink labels on certain branches, signifying that any cones on those branches had been pollinated with a polymix. These controlled pollinations had taken place in 2024 by Owen Lewis; involving isolation bags stopping pollen landing

The controlled pollinated cones were particularly precious because of the effort taken to make them and for the insights on genetic inheritance that will be gained when they are used in the upcoming progeny trials. Standard open pollinated cones were also collected from the same genetic individuals.

The pinecones were stored to dry over Christmas.

Extracting seeds from the cones

In the new year, much of my time was devoted to conducting seed extractions from the pinecones we collected.

1) Opening the cones

The cones were subjected to 40°C temperature in an oven. This lowers humidity, causing the scales to open. In nature, they open and close based on humidity to help seeds fall out in favourable conditions. This photo shows an open pinecone and two of its seeds that shook out easily.

2) Tumbling the cones

The metal cage inside this tumbler rotates for two minutes. The seeds from the batch of cones fall out through the square gaps and are passed through the hole to collect in a bag.

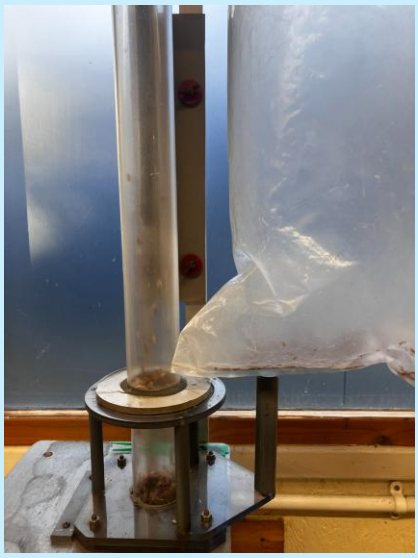
3) Removing the wings

The wings of the seeds are removed so that seeds entering long term storage are less susceptible to mould and so that seeds can be counted more easily. In this photo, the seeds have been rubbed in a bag to detach the wings. Some bags of seeds proved to be more stubborn than others, so this was not always a smooth and straightforward step. I did like how families of seeds (same mother) were consistent in wing colour but differed from other families.

4) Sieving out debris

Sieves of different hole sizes were stacked. This mainly achieved the removal of some of the finer dust from the lower sieves and some of the larger bits of debris, such as pine needles. After this, the batch could be air blown (step 5) to remove further debris and then the sieving was often repeated.

5) Air blowing seeds



In this action photo, material can be seen floating up the tube. With fine control of the speed of air, lighter material (often the detached wings) can be blown up and round into the waste bag. This step is also repeated until most of the debris is gone.

6) Final quality control

With most of the debris gone, any final impurities are removed. This includes cracked seeds, pieces of dirt that might accidentally get counted as seeds in step 7, and any wings that were not successfully removed earlier on.

7) Counting the seeds

This very helpful automatic counting machine (Pfeuffer Contador) vibrates to move the seeds and channels them one by one down the chute. It counts them as they pass through the hole. This data helps with stock taking and we found out that the closed pollinated cones had an average of 20 seeds per cone compared to an average of 5.5 seeds per cone for the open pollinated seed.

Millenium seed bank (MSB) at Kew's Wakehurst Gardens

The CFP team arranged a trip for us to Wakehurst in February. We were shown the MSB laboratories which receive and store wild seeds from around the world. As they work with some critically endangered species with few seeds, they are meticulous during their seed extractions. Some of their equipment is like ours and some is adapted for biosecurity of incoming pests or is used for fruits and other plant materials.

Landscaping in the gardens dappled with raindrops and crocuses.

Seed stratification

I had rounded off the extractions and been away on my trip to England - then it was straight back to the Contador (seed counter). This time, to count seeds into bags for stratification. This brought together seed from my extractions with seed from other locations, like Yair. Cold stratification is used to encourage seeds to break dormancy by mimicking winter weather.

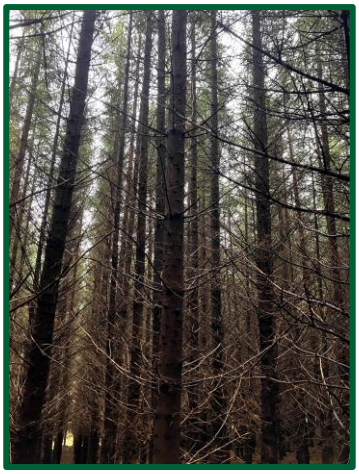
The seeds soak in water for a couple of days before being drained and returned to the fridge.

A Belgian seed lot getting used for the first time in a while!

Kintyre

My favourite part of the internship was working in Kintyre (a peninsula west of Glasgow) in the first week of March. Although it wasn't part of the Scots pine project, it was great experience to see inside a progeny trial. We had quite the adventure trying to reach the spruce trials on the first day then we soon got up to speed using IML-Resi drills to collect wood density data.

Evening seal spotting. One is swimming in front of the ferry too.



We also assessed straightness and branching (branch size, quantity, spacing and branch angle) which affect the quality of logs.

Crossing the stream to head back to the truck. On the first day the water level was high and harder to cross. Photo taken by Richard Whittet

The nearby town of Tarbert.

The exciting sight of a bright blue sky. Photo taken by Kirsten O'Sullivan

Reflection and next steps

My understanding of tree breeding has benefitted from seeing many of the different pieces of the cycle fitting together – from collecting scions/cones to eventually sending trees off to sites in lorries (pictured). Last week, I was even fortunate to see around a woodland highlighting species mixtures in forestry as well as a tour of a sawmill.

It has been a privilege to be involved in restarting the tree breeding cycle for Scots pine by preparing the seeds for the first round of breeding trials since 1987.

I am happy to have found a sector I enjoy working in. I will be staying on as a research assistant for a further three months to continue my work on the Scots pine project and look more deeply into the data. I am particularly looking forward to seeing the seeds germinate!

Grafted Sitka spruce trees heading out on a lorry to be planted in a Forestry and Land Scotland seed orchard.

Acknowledgements

Thank you very much to the Centre for Forest Protection for providing this opportunity. It has been a fantastic introduction to forestry which I would recommend to anyone looking for research experience in the sector.

I am especially grateful to all of my colleagues at Forest Research, including my team (pictured) who have been brilliant to work with.

Richard Whittet, Mike Charters, Kirsten O'Sullivan, James Baker, and myself in Kintyre. Photo taken by Richard Whittet

References

Dhillon, G.P. & Dhakad, A.K (2010). Tree Improvement. 10.13140/RG.2.2.21994.29127.

Lee, S.J. (2002). Selection of parents for the Scots pine breeding population in Britain. Forestry, 75(3), pp.293–303. doi:https://doi.org/10.1093/forestry/75.3.293.

Appendix – Tree Breeding Glossary

Term	Definition
Beat up	Forestry term. Replacing trees when they are dead or missing.
Brashing	Removing lower branches to improve access through trees
Breeding value	How well a tree can pass on a favourable trait to the next generation and therefore how useful it will be in the breeding population. The method of estimating breeding values has transitioned from comparing mean values of traits to calculating BLUPs with mixed models.
Checklot	A clone that is planted throughout multiple experiments for comparison.
Clone bank	Living archive of trees containing clonal copies of trees of interest. May consist of grafted trees.
Diallel	A mating design for a trial using specific crosses. Allows investigation into the additive vs non-additive genetic variation of a trait. Full diallel, half diallel, and partial diallel vary in the completeness of the combinations of crosses between the parents. AKA "full-sib"
GxE	When different genotypes respond to environmental variation differently
Open pollination (OP)	When seed is obtained from wind pollinated cones and so have an unknown male parent. AKA "half-sib" when used in the mating design of a trial
Ortet	The original tree which a clone has been produced from
Plus tree	A tree selected for its favourable physical traits
Polymix (PMX)	A type of controlled pollination where a known pollen mixture is applied to female cones
Progeny trial	A tree breeding experiment. The progeny/offspring of plus trees are measured to see how well the favourable traits are inherited. Can then calculate a breeding value for the parent.
Provenance	The location of the population where a tree was sourced from
Ramet	Each ramet is a separate copy of a clone
Rootstock/scions	A rootstock is a tree which has grown up from a seed and will be used to provide the roots for a grafted tree. The scion is a cutting from a young shoot of a tree to be cloned and is attached onto the rootstock.
Seed orchard	Plantation of trees for the purpose of producing cones. Trees can be pruned short to make cone collection easier.
Singling	Cutting all stems except the dominant stem of trees to promote upward growth
Thinning	Trees may have been planted close together originally to promote upward growth then thinning removes some of the trees to reduce competition between those remaining