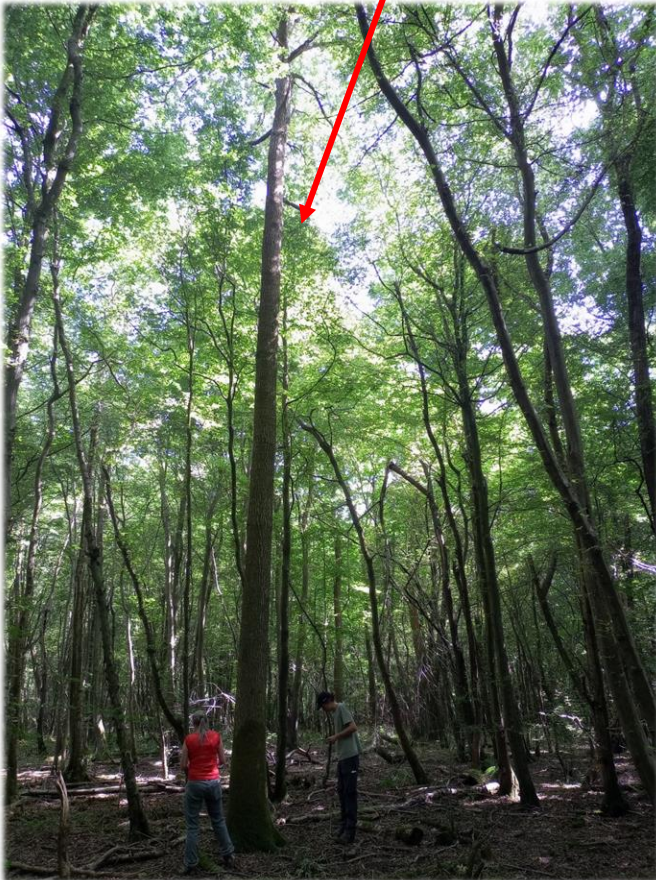


Using genomics to help breed better oaks

Eamonn Cooper

Why breed better Oak

Better timber quality



Increase in Oak populations



Supports a
diverse ecology

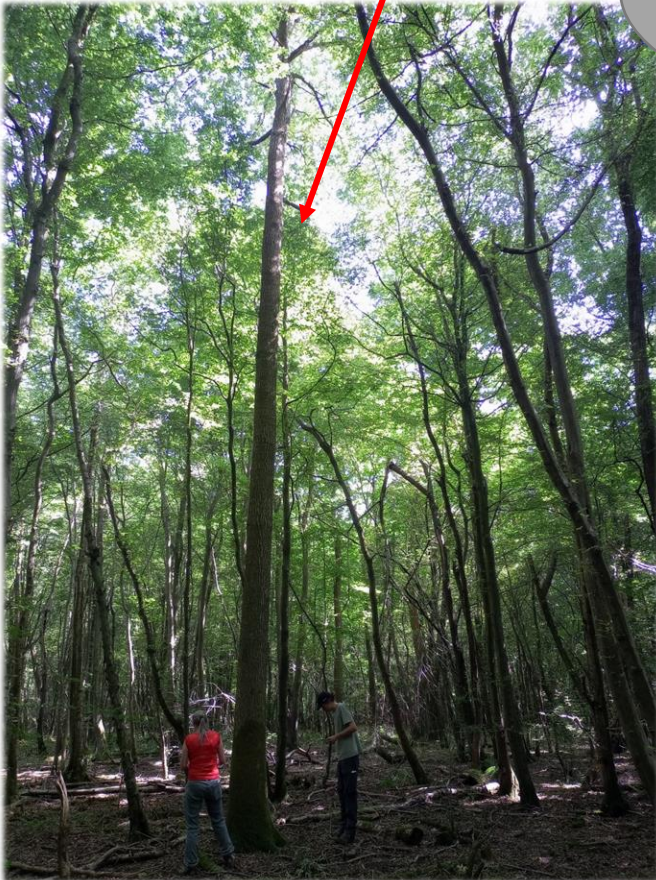


Disease and pest resistance



Why breed better Oak

Better timber quality



Supports a
diverse ecology



**All factors will serve to future proof Oak
against the ongoing threats of Climate
Change and Human interests**

Increase in Oak populations



Disease and pest resistance



How do we do this?

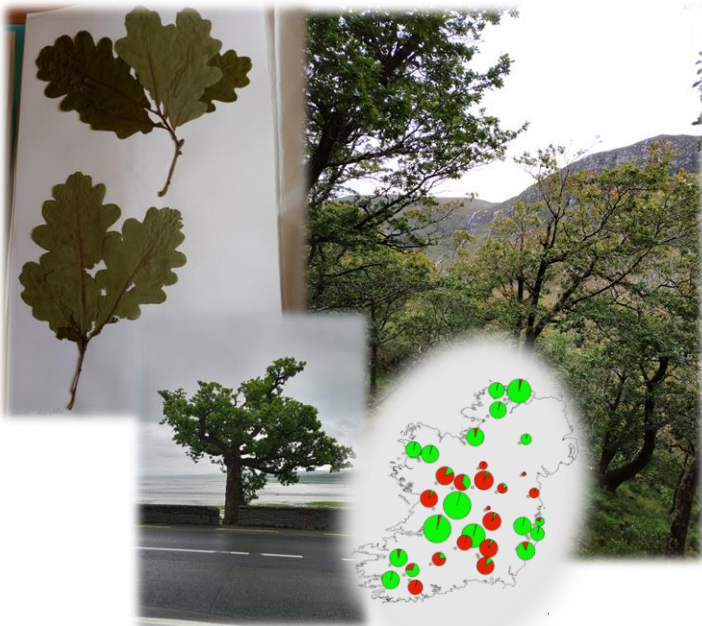
Selected Plus Trees

Progeny Trials

Genetic Testing

Informed approach to
selecting the best
trees and traits for
breeding.

Comparative Population

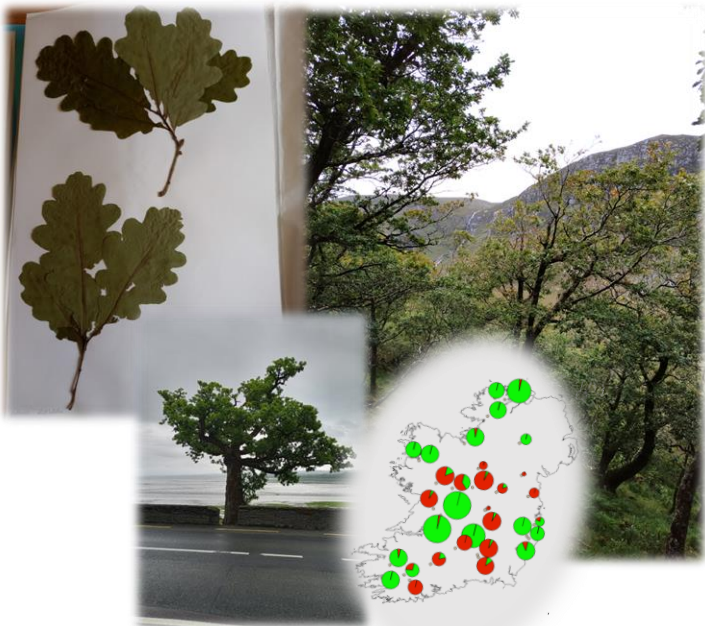


How do we do this?

Selected Plus Trees



Comparative Population



Progeny Trials



Genetic Testing

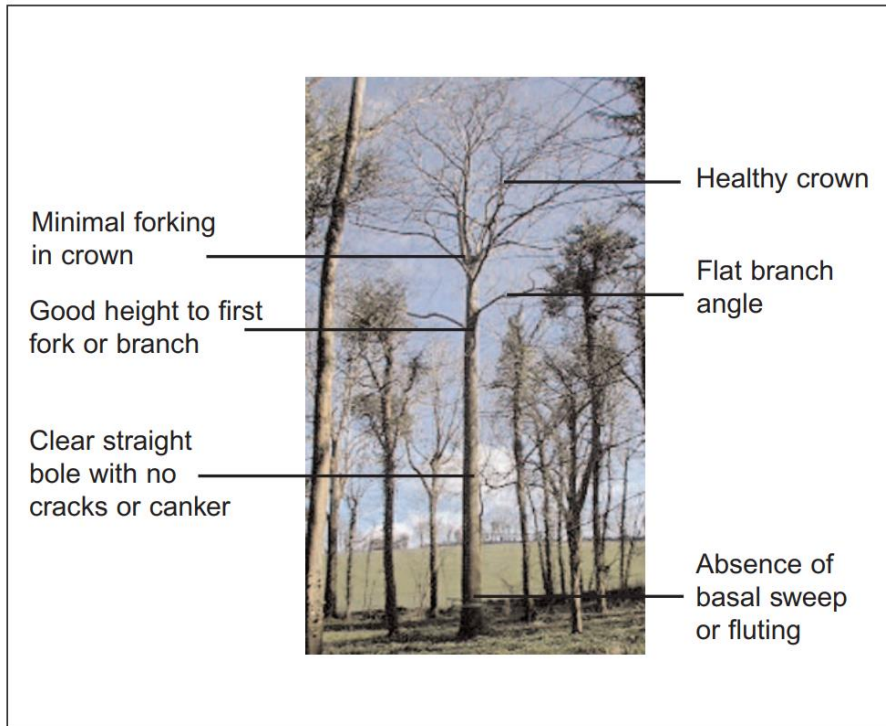


Informed approach to
selecting the best
trees to be breeding
from.

What are plus trees?

Traits selected for in Oak plus tree classification and breeding

- Dominant in the stand
- Tree form (straightness)
- Stem quality (absence of defects)
- Crown health (well distributed and able to sustain future growth)
- Branch free stem (self pruning)



Clark, J. & Wilson, T. (2005)



Plus tree at Forest of Dean Gloucestershire, England



Q.robur on the road of the Ferry in Tarbert county Kerry



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How do we do this?

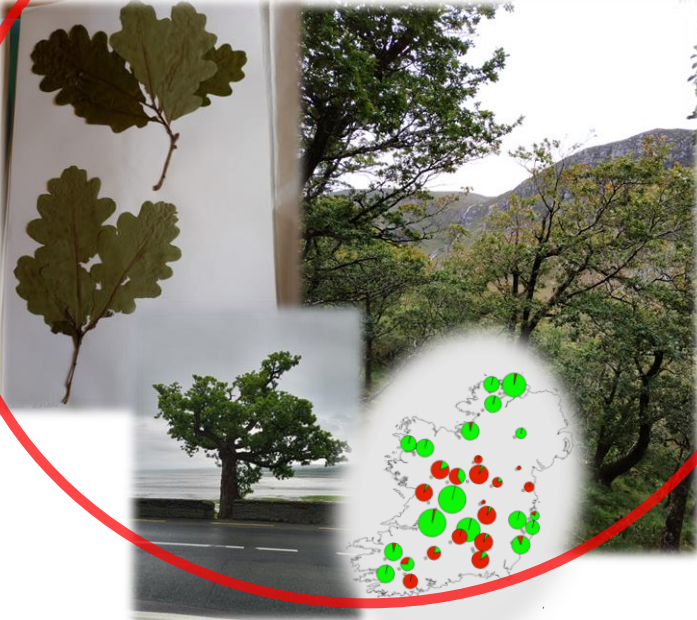
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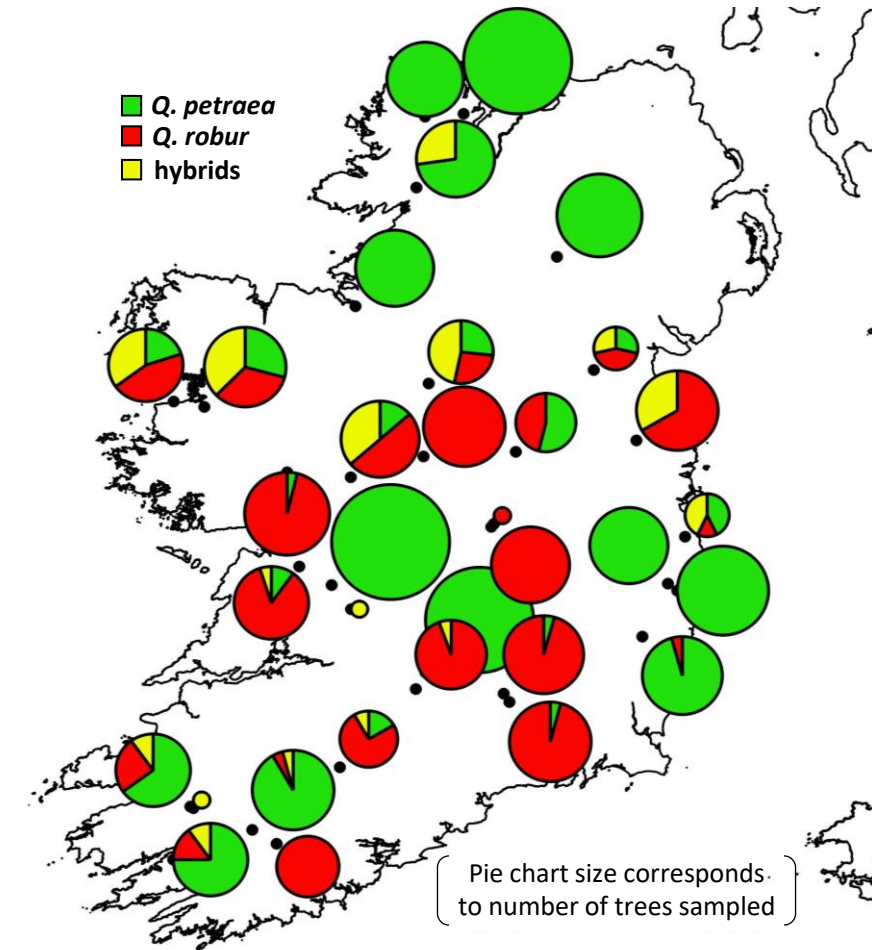


GeneNet project

- Two-year project funded by DAFM to map the genetic diversity of several native Irish tree species – one of which is oak.
- 682 individual trees sampled
 - 380 *Q. petraea*
 - 242 *Q. robur*
 - 60 putative hybrids
- Spread across 30 populations
 - Roughly 20 trees per population.
 - Sites mainly owned by Coillte, and NPWS (remaining owned by other state bodies or privately owned).
 - Three specimen trees (“King Oak”, “Royal Oak” and “Brian Boru Oak”).

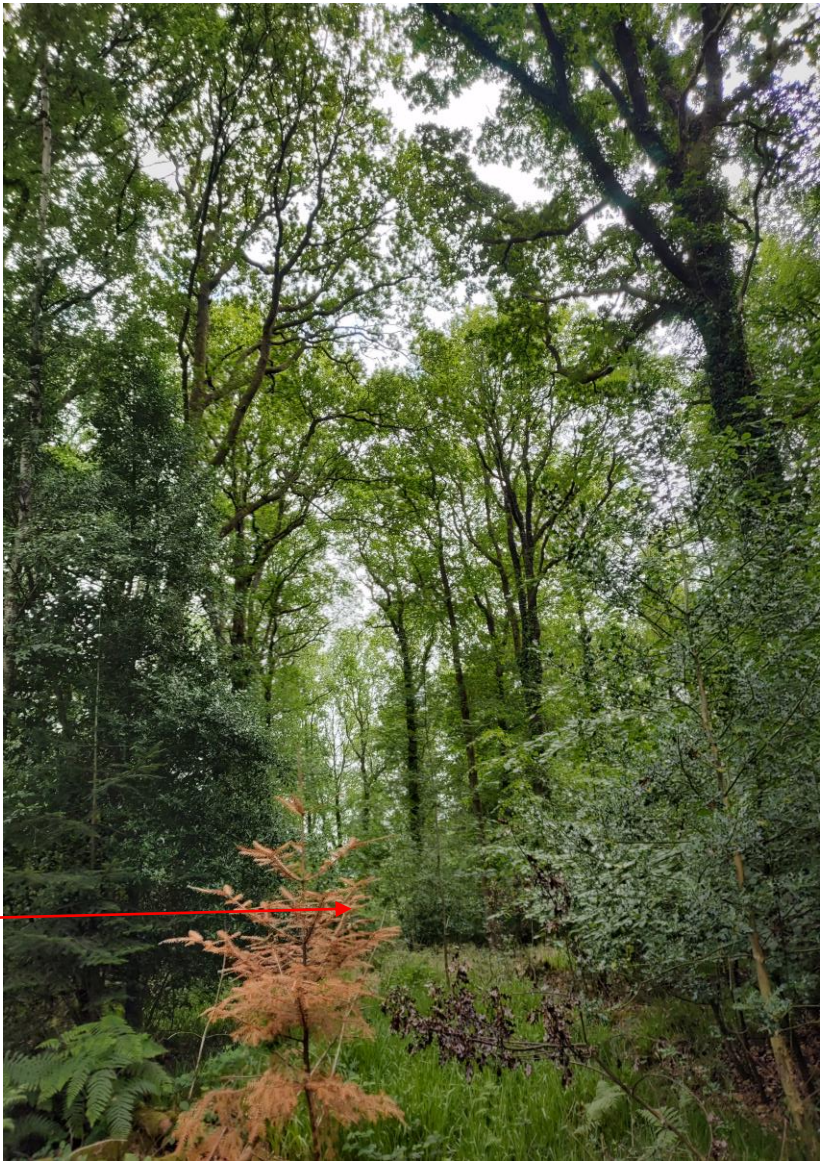
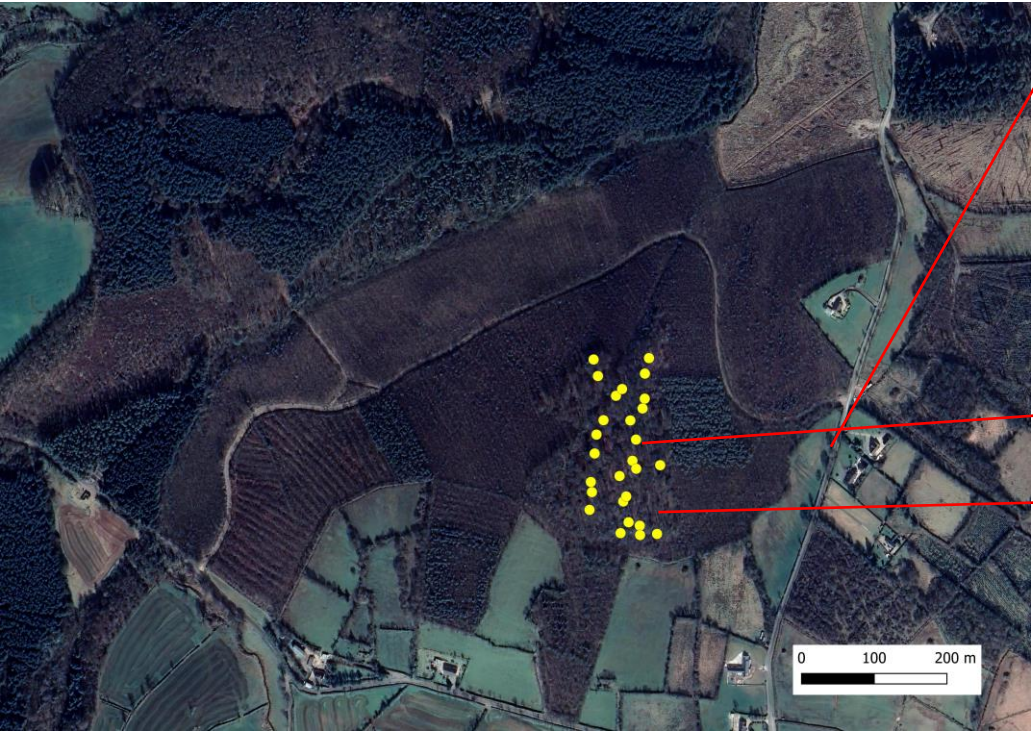
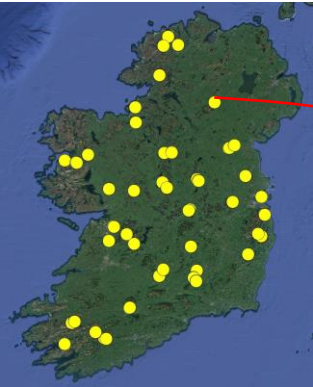


Site names

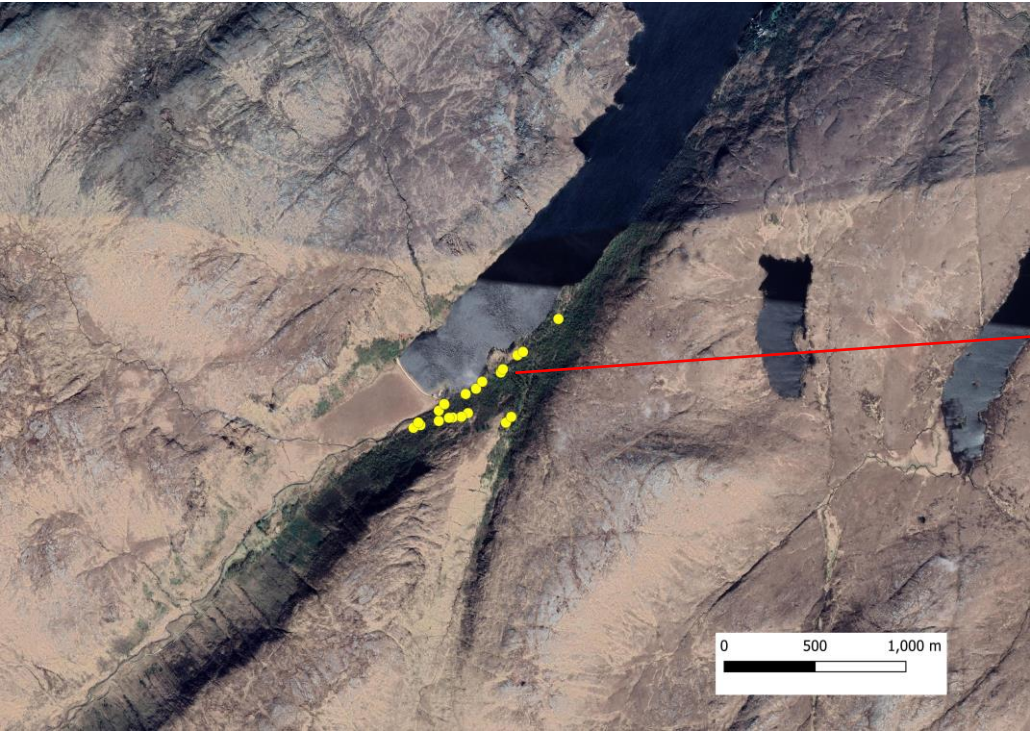
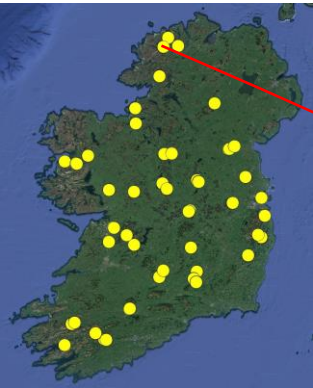


Species composition

Derrygorry, Co. Monaghan



Glenveagh, Co. Donegal

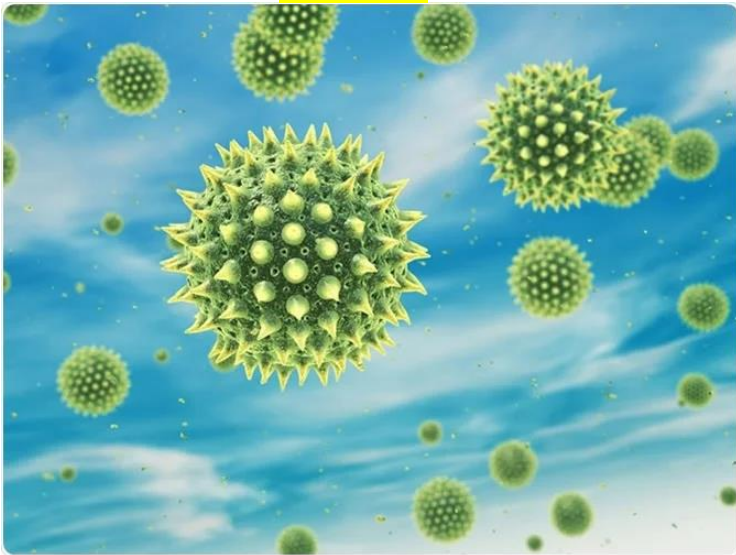


Genetic analysis



- Allows us to assess the levels of diversity contained within our native oak forests
- Analysis involves a focus on:
 1. Contemporary gene flow (**via pollen**) between individual trees and forest sites.
 2. Historic 'post-glacial' migration of oak (**via seed**) – *i.e.*, where does our oak come from?
- Although the oak genome has recently been sequenced, it is not practical to study the whole genome of each tree, so we use “genetic markers”.
- Genetic markers are regions of an organism’s genome which are variable – here, we look at over 400 different genetic markers for oak – this number offers very good resolution!
- Two types of genetic markers that we need to understand:

“nSNP”



Contemporary gene flow

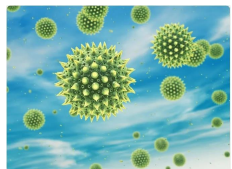
“pSNP”



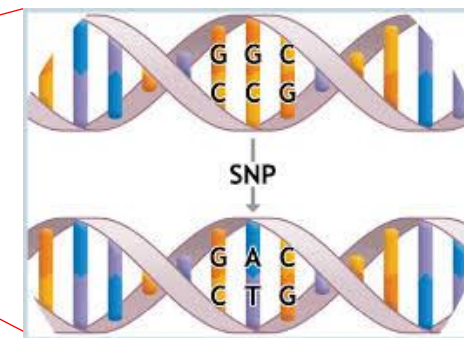
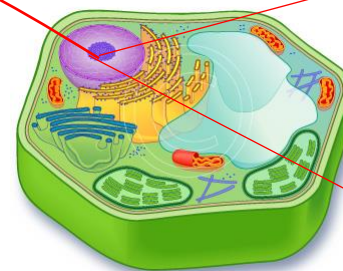
Historic species migration
since Ireland’s last ice age

Genetic analysis

- Variation at **412** nuclear Single Nucleotide Polymorphisms (**nSNPs**) analysed.



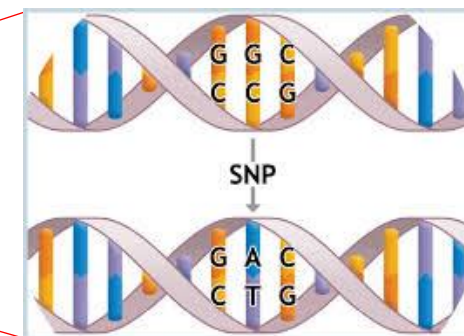
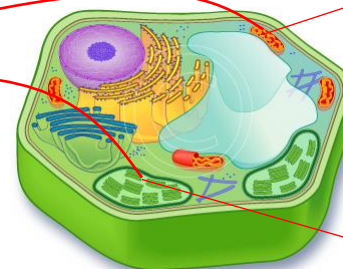
- Codominant markers, affected by sexual recombination, and higher mutation rate.
- Variation therefore **more recent** in time.
- Geographic variation often reflects pollen-mediated gene flow.



- Variation at **29** plastid (chloroplast + mitochondria) Single Nucleotide Polymorphisms (**pSNPs**) analysed.



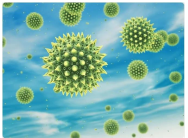
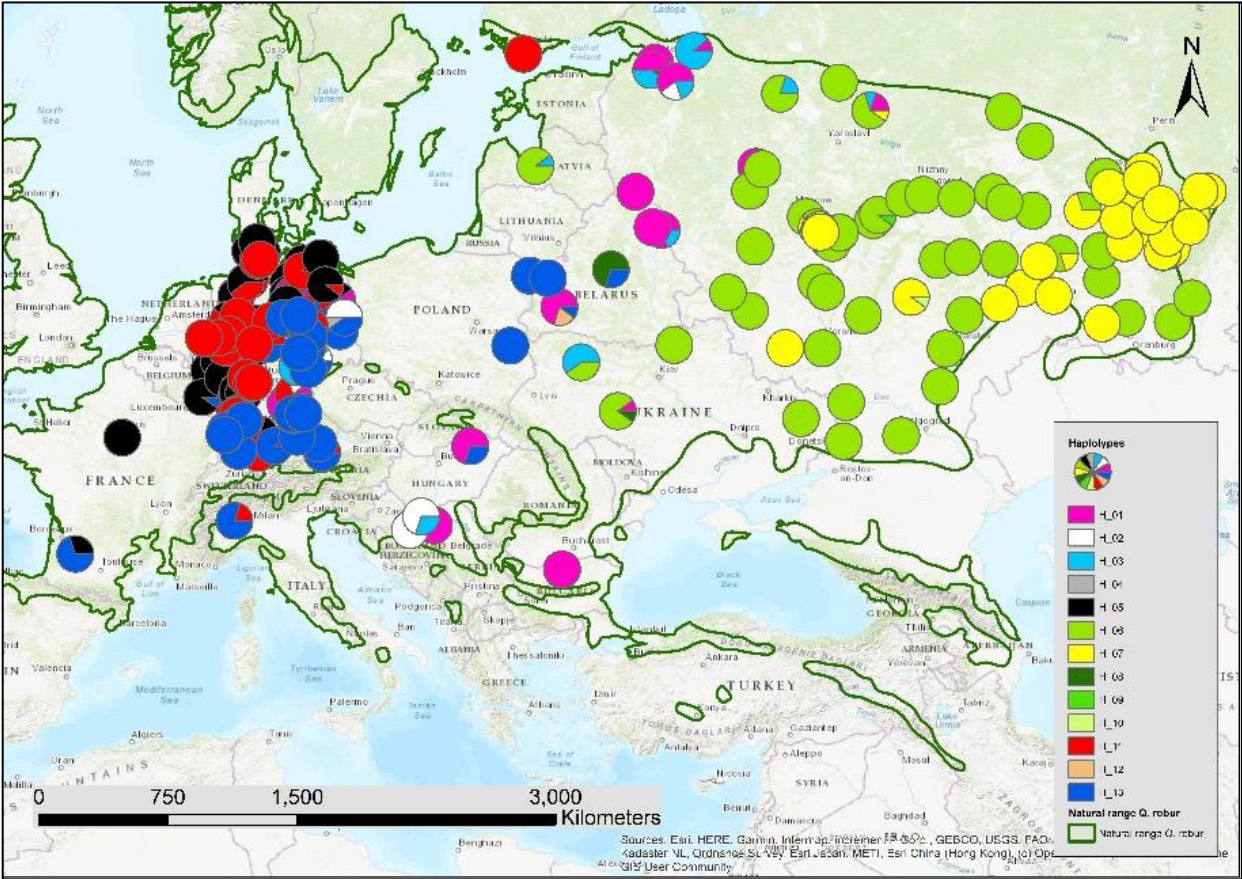
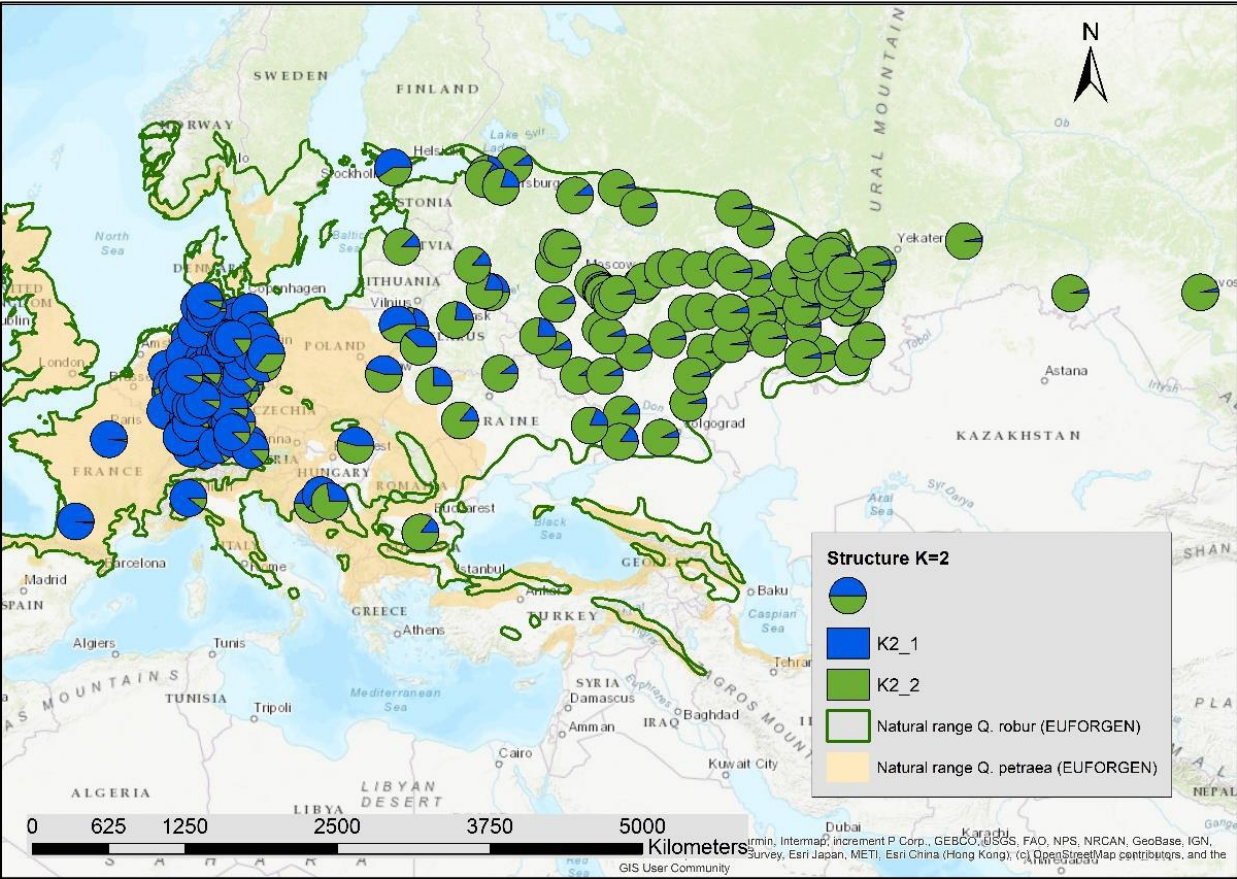
- Lower mutation rate, no sexual recombination, maternal inheritance (chloroplast).
- Variation therefore **more ancient**.
- Geographic variation often reflects seed-mediated gene flow.



- Variation at **441** SNP loci spread across three genomes.
 - nSNP data for 504 trees (>25% null allele cut-off)
 - pSNP data for 656 trees (>25% null allele cut-off)

Genetic analysis – why these markers?

(Degen *et al.* (2021), *Forests*, 12: 1425)



- nSNP markers show a clear east-west division, with a central hybridisation zone in between. (Degen *et al.* (2021), *Forests*, 12: 1425)

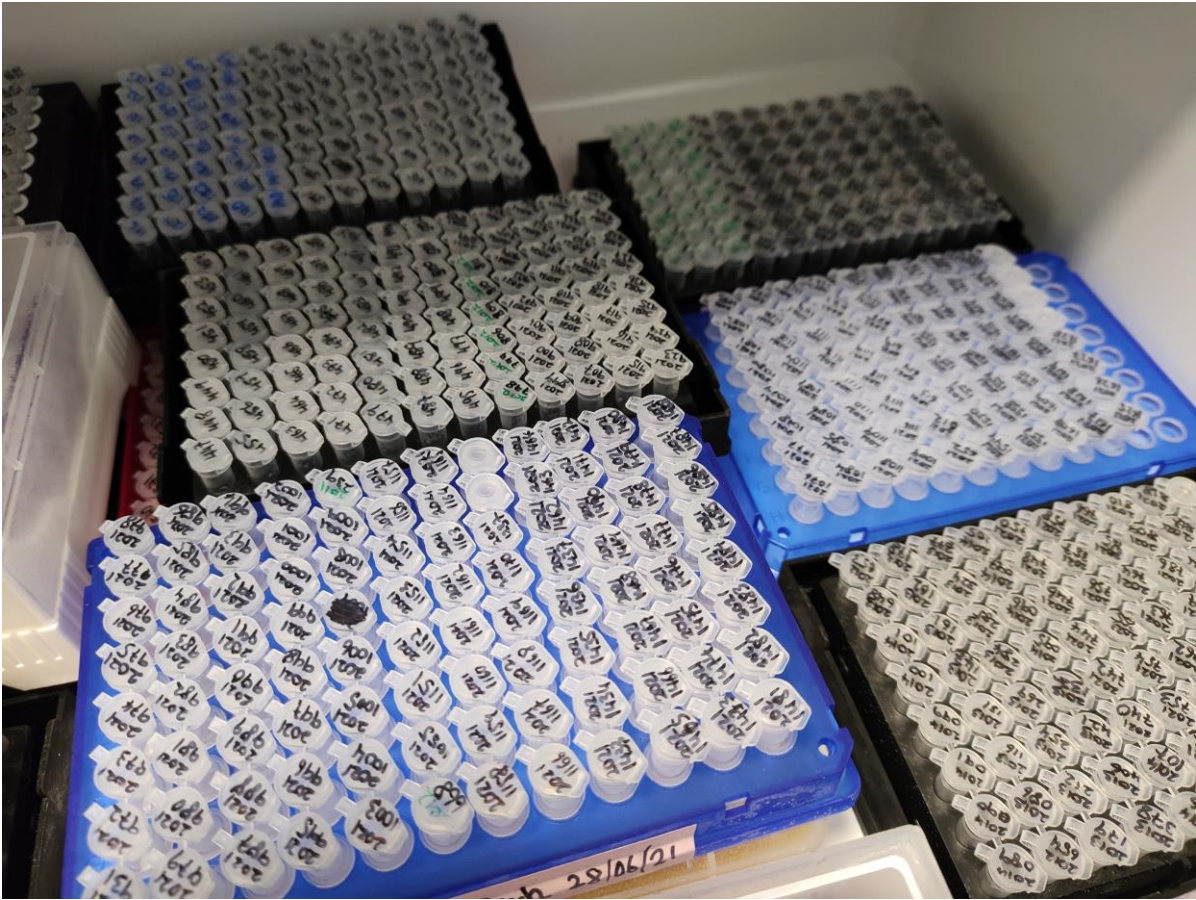


- pSNP loci show a more historic picture of oak in Europe (*i.e.*, its post-glacial recolonisation history). (Degen *et al.* (2021), *Forests*, 12: 1425)

Yet to be used on oak in Ireland and Britain

Genetic analysis – our final data

- DNA extracted from a total of 664 trees and shipped to LGC Genomics in Berlin.
- Genotype-by-sequencing (“SeqSNP”) performed, with **404 out of 441** SNPs being variable (*i.e.*, informative) in our samples.



	nSNP	pSNP
All		
<i>Q. robur</i>		
<i>Q. petraea</i>		
Hybrids		

24% (160 trees) had more than 25% of null alleles – these will be discarded ahead of all analyses.

Genetic analysis – what questions about breeding population can be addressed with these SNP markers/ loci and our data?

- Is the total genetic diversity of our breeding populations the same as (or close to the level of) our native stands? Implications for adaptability.
- Have our breeding populations captured all native haplotypes? Can some be added?
- Do any of our native populations contain unique sub-population structure? Should seed from such populations be collected?
- To what extent are non-native germplasm represented in our breeding populations?



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**An Roinn Talmhaíochta,
Bia agus Mara**
Department of Agriculture,
Food and the Marine

Degen, B.; Yanbaev, Y.; Mader, M.; Ianbaev, R.; Bakhtina, S.; Schroeder, H.; Blanc-Jolivet, C. Impact of Gene Flow and Introgression on the Range Wide Genetic Structure of *Quercus robur* (L.) in Europe. *Forests* **2021**, 12, 1425.
<https://doi.org/10.3390/f12101425>

Quine, Christopher & Atkinson, Nick & Denman, Sandra & Desprez-Loustau, Marie & Jackson, Robert & Kirby, Keith. (2019). An assessment of the current evidence on oak health in the UK, identification of evidence gaps and prioritisation of research needs: Action Oak Knowledge review.

(<https://www.researchgate.net/publication/341986922> An assessment of the current evidence on oak health in the UK identification of evidence gaps and prioritisation of research needs Action Oak Knowledge review)

Clark, J. & Wilson, T. (2005) The importance of plus-tree selection in the improvement of hardwoods. *Quarterly Journal of Forestry*. 99(1): 45-50. ([PDF](#)) [The importance of plus-tree selection in the improvement of hardwoods. \(researchgate.net\)](#)



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