- *The Dutch have one of the most advanced oak tree breeding programmes in Europe with reproductive material available from selected and tested seed stands, and clonal seed orchards.*
- *They have developed a systematic methodology for oak seed stand registration.*
- *They have identified critical time and methods to improve the vegetative propagation of selected oak plus-trees, particularly the grafting of older plus-tree selections.*
- *They have developed an approach and establishing roadside seed stands as practised exclusively in the Netherlands.*
- *They have identified that the level of pollution by outside pollen in an oak seed orchard - over 70% which is impossible to control and the effects of which are unknown.*
- *Linear seed stands are planted along road sides to allow full development of the individual tree crowns resulting in earlier and more bountiful acorn production and to facilitate cost effective seed collection.*
- *The possibility of getting more tested seed to market relatively quickly by evaluating existing seed stand comparative trials with a view to converting these areas to a seed source should be explored.*
- *Based on Dutch findings, it seems that positive judgments can be made on the performance of seed stand progeny at about twelve years.*

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Oak breeding in the Netherlands: lessons learned on a recent Future Trees Trust (FTT) study tour

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Introduction

The Future Trees Trust Oak Group was established in 1995 and is one of seven species groups (oak, ash, cherry, birch, sycamore, sweet chestnut and walnut) working towards the improvement of broadleaf tree species using conventional tree improvement methods. The objectives of the FTT programme are to:

- Improve the quality and vigour of the planting stock of the main broad-leaved species used in Ireland and Britain;
- To promote research into provenance testing, selection and breeding of the designated species;
- Develop technologies to aid the rapid multiplication of improved material;
- Promote the use of improved material in commercial forestry;
- Undertake education, publicity, fund raising and lobbying to further the above aims.

The FTT Oak Group commenced its activities in 1997 with the establishment of a large scale plus-tree selection programme designed to select approximately 250 elite trees across Great Britain, Ireland and north-western Europe. This selection programme resulted in the establishment of eight seedling seed orchards in 2003, seven in the UK and one in Ireland at Ballyhea near Rathluirc, Co Cork. Progress has continued and plans are now well advanced for the establishment of a further ten clonal seed orchards (five of sessile oak, and five of pedunculate oak) across Great Britain (six) and Ireland (four).

In pursuit of this programme members of the FTT participated in a study tour to the Netherlands from 13-15th May 2013. The visit was mainly sponsored by the British Embassy in the Netherlands. The purpose of the visit was to see and familiarise the group with all elements of the Dutch Oak Improvement Programme which has been in existence for many years and is one of the most advanced of its kind. which has been in existence for many years. It also presented an opportunity to see the many aspects of the Dutch oak improvement programme first hand, meet Dutch colleagues working with oak, learn from their experiences and make useful comparisons with the FTT programme.

Oak in the Netherlands

Pedunculate oak is a very important species in the Netherlands and is the most widespread indigenous species in the country, accounting for approximately 16% of the forest cover. It is a species which is naturally present in most of the Dutch natural forest ecosystems. It also accounts for about 25% of roadside plantations many of which are of exceptional quality due to a process of continuous selection and progeny testing and the best of which are registered as selected and tested seed stands. Sessile oak is less important as a species its importance is mainly based on ecological considerations rather than as a valuable commercial wood producer.

A large number of comparative trials of progeny of Dutch seed stands have been established since 1978 by IBN-DLO which has replaced the former Forest Research Institute 'De Dorschkamp' and to-date almost all selected seed stands of oak which are listed in the Dutch National Catalogue are included in one or more provenance trials over a number of sites.

Stop 1 Stand quality and results of negative selection

The group converged at Schipohl Airport, Amsterdam at about lunchtime on Monday the 13th and were met by Liesbeth Bouwhuis and Irena Gucianu from the Embassy who had made arrangements for the group to travel on to Wageningen where we met Sven de Vries, Tour Leader and organiser of the programme. From Wageningen the group travelled to the first stop of the tour at Wolfheze.

At Wolfheze, the group were shown an exceptionally poor quality (bad form and very crooked stems) stand of oak that were privately owned. Growing alongside these were some equally poor form roadside trees which we later learned were progeny from the Wolfhese forest stand and reflected their parentage, also exhibiting poor form and crooked stems - poor form and crookedness as well as heavy branching and a strong propensity to forking. This stand was originally managed as a coppice stand where negative selection (removal of the best stems over a long time) had taken place for many years and this was reflected in the exceptionally poor form of the remaining individual trees as well as the roadside trees. Here, a wide discussion took place on the heritability of traits such as stem straightness, propensity to heavy branching and general poor form of the trees. The main purpose of the visit to this stand was to show that not all oak stands in the Netherlands are of good quality and that poor quality stands do also exist. It also illustrated that stem quality is highly heritable as in this case. Because of its poor overall quality this stand was not considered a seed stand. Moving from here the group's next stop was at a roadside stand at Ede de Klomp.

Stop 2 Oak seed stand selection and registration in the Netherlands

At Ede de Klomp (Plate 1) the group were shown the first stand of roadside trees – a 'tested' seed stand of some 1800 individual trees growing in double rows on both sides of a busy public roadway. This roadside stand was from progeny sourced from an older selected seed stand at Emdhoven. Here the group was introduced to one of the principals of a Dutch seed company, Johan Vink of PVM. A lively discussion took place on the process of seed-stand selection and detailed methodology of continuous seed stand review and seed collection control along with regulation in the Netherlands. It was highlighted that the regulatory authorities in the Netherlands have a very strict code of practice in relation to identification, selection and management of seed stands and great emphasis is placed on quality and continuous improvement of forest reproductive material. Other issues discussed included the regulatory process of seed collection and the very strict control systems used by the regulatory authorities in the Netherlands. The methodology for selecting seed stands was also outlined and a worked example (Table 1) was used to explain the process of weighting the different quality features.

Plate 1: Oak roadside seed stand (*Q robur*) comprising four rows of individual oaks at Ede de Klomp which is the norm for a considerable number (up to 50%) of oak seed stands in the Netherlands.

The original process of individual tree evaluation for pedunculate oak seed stands in the Netherlands was described by Jager (1994) who provides a diagrammatic explanation of the selection procedure (Figure 1 and 2).

It should be noted that the evaluation of a stand is based on phenotypic characteristics – that which is visible and sample trees are classified into four defined categories as follows:

(Category A) = A virtually branch free stem which is straight or almost straight with a slight bend which has a maximum deviation up to 0.1 of diameter. For the part of the stem which is in the crown it must be straight or almost straight and continue up to at least 5/6th of total tree height.

(Category B) = A branch free stem with a little bend with maximum deviation up to 0.25 and slightly crooked, up to 0.1 of diameter. For the part of the stem which is in the crown it must only have a slight bend or be a little crooked up to at least 5/6th of total tree height. According to Figure 2 the allowance for the bends (in the crown) is somewhat larger than for the branch free bole but this is not defined.

(Category C) = The bole of the tree is bent with a deviation of about 0.5 of the diameter or crooked with at least a deviation of 0.25 of the diameter. The stem continues into the crown for up to 2/3 ^{rds} of the tree height, however, that part of the stem in the crown is crooked but this is not specifically defined.

(Category D) = Branch-free part of the stem is similar to that of **Category C** but it does not have a defined stem into the crown

(Phenotypic characteristics: The observed characteristics of a tree or trees produced by the genotype. This is in response to the environment in which they are growing and as a result of stand management practices and that is outwardly visible).

Today in the Netherlands the registration of oak seed stands is based on the evaluation of individual trees (50 trees chosen at random) in a stand of trees including roadside stands (de Vries, S.M.G. and van Dam, B.C. 1997). Each of the 50 trees is assessed on a number of criteria, split into two groups. Group 1 criteria include: The form of the trunk below the crown, crown form and branch habit, while Group 2 criteria include: spiral grain, 'lumps' grooves and epicormic shoots.

For evaluation, each trait is given a score out of 3. For example, for the trunk a score of 1 is given for a straight stem (less than 10% deviation); 2 for a slightly curved stem (deviation 10-25%) and 3 for a curved stem (deviation greater than 25%). For Group 2 traits, a score of 1 is given for no defects, 2 for defects hardly present, and 3 for moderate to many faults. The number of trees that fall in to each category is converted to a percentage, and the percentage of number 3 trees is subtracted from the percentage of number 1s. If the final score is greater than 90 for Group 1 traits, and greater than 300 for Group 2 traits, the stand is selected. An example of this system is illustrated in Table 1

For group 1: 147-53 = 94. A score over 90 is acceptable. For group 2: 346 – 24 = 322. A score over 300 means the stand will be automatically selected and entered on to the register of approved material – the National Catalogue of Seed Stands.

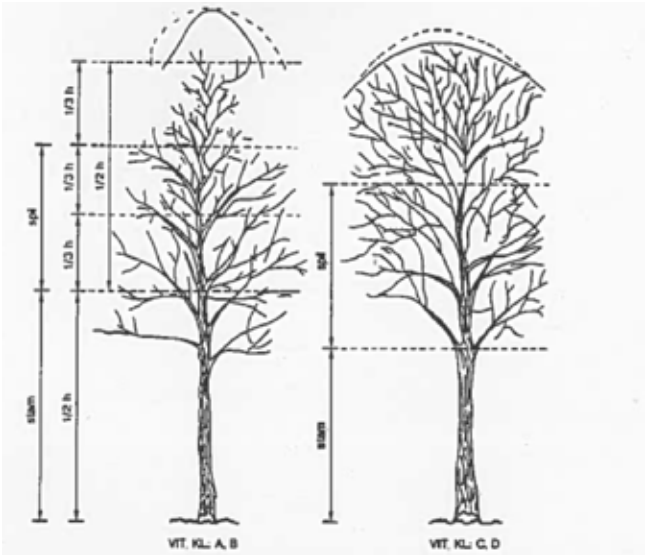

Figure 1: Classes based on phenotypic characteristics (observed characteristics of a tree, produced by the genotype in response to the environment and as a result of ongoing stand management). Adapted from Jager (1994).

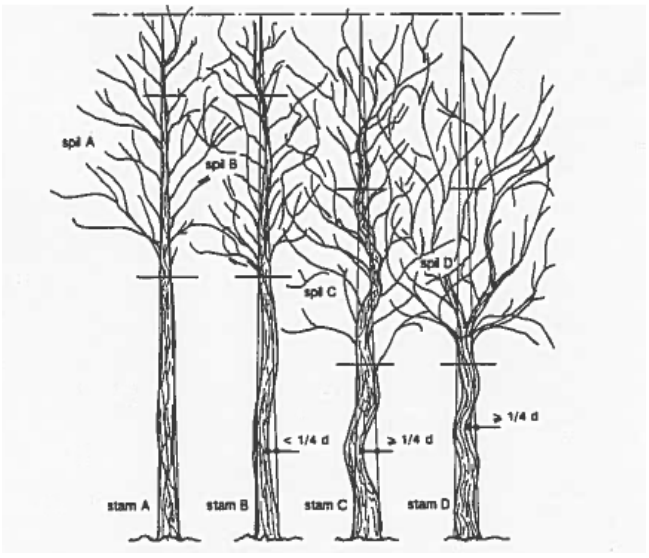

Figure 2: Classes A, B, C, D based on phenotypic characteristics adapted from Jager (1994)

Table 1: Worked example of oak seed stand selection

Group 1 Traits		% Trees		Group 2 Traits		% Trees	
Feature (1 best, 3 worst)	**1**	**2**	**3**	**Feature (1 best, 3 worst)**	**1**	**2**	**3**
Trunk below crown	70	30	0	Spiral grain	93	7	0
Trunk within crown	17	47	36	Lumps	70	10	20
Branching habit	60	23	17	Grooves	100	0	0
				Epicormics	83	13	4
Total	**147**		**53**	**Total**	**346**		**24**

Stops 3 & 4 Seed stand management

Gerderen was the third stop in the tour and it was here that the group saw the first 'selected' forest seed stand which was located in one of the state forests. A total of 395 individual stems constituted the selected stand which was second generation. Its origin was from an older stand which was also a selected seed stand but is now felled. To control epicormic shoot growth and to keep the ground clear of vegetation for seed collection, part of the stand visited had been under-planted with beech.

Here the discussion focused mainly on the management of such seed stands and in particular stressed the need for frequent and heavy thinning to allow the final crop trees to develop large open crowns which resulted in associated regular heavy flowering and ultimately heavy acorn production.

The final stop of the day was at Nunspeet (Plate 3) – an exceptionally fine stand of 113 roadside trees in a selected seed-stand again in double rows at both sides of a busy public road. This was a remarkable roadside stand of fine individual trees, but here, as in all roadside stands visited, pruning especially high pruning was much in evidence which was undertaken in order not to restrict vehicular travel on the roadway especially large trucks. This pruning did not impact in any way on the proven exceptional quality of the progeny.

Day 2 - Stop 4 Oak seed orchards establishment and management

The morning's first stop was at a pedunculate oak clonal seed orchard at Bremerbergbos. This seed orchard is the only clonal oak orchard in the Netherlands was established in 1978. It is based on grafts of individual elite-trees which were selected over the entire country in earlier times, mainly in selected seed-stands including roadside seed stands. The original selections were of trees which were late flushing, which is considered an important feature, to avoid damage to late spring frosts. The original aim of the orchard had been for ten ramets of each clone. However, as some clones proved to be very difficult to graft in sufficient quantities, only 56 are represented in the Bremerbergos orchard.

Plate 2: Oak seed stand at Gerderen – first registered forest seed stand visited by the group.

Plate 3: Roadside seed stand at Nunspeet. Roadside seed stands are a feature in the Netherlands and account for up to 50% of registered seed stands. These seed stands allow for improved access and thus aid seed collection.

Discussions here were mainly about the continuing day to day management of such a clonal orchard and including replacement of failed clones, weed control in the orchard, procedures to encourage flowering, dealing with problems of foreign pollen from outside the orchard and the process of flowering, pollination and seed collection. Also raised were the future plans for the management of this orchard and the possibility of establishing further similar such clonal orchards in the Netherlands.

Grafting of oak typically presents many difficulties which the group were well aware of. In discussions on the methodology used in the Netherlands the grafting techniques seem to provide a much higher level of success than English and Irish experiences. In the discussions here it emerged that a particular technique developed by a Dutch nursery owner who had developed specialisation in oak grafting, had increased the success rate to a very high level. With this information the FTT oak group will now follow this up with the Dutch expert in an attempt to address similar problems experienced in FTT oak programmes. It emerged that time of grafting is considered critical and that a small window for successful grafting exists at the end of December only.

This orchard is in the 'qualified' category; progeny tests are ongoing but it is expected that its status will be raised to 'tested' when the most recent measurements had been fully analysed at the end of this year (2013). The orchard is located in a polder area and the site was chosen because it was considered isolated from oak in the neighbourhood. However studies on pollen flow and pattern of pollination here have shown that over 70% of the pollen recorded in the orchard is from trees outside the orchard, a finding that came as a great surprise to the tour participants. Seemingly this finding is in common with similar studies in other oak seed orchards in several parts of Europe.

Stop 5 Uses of oak timber

At Oostvaardersdijk - a reconstructed oak wooden ship, the *Batavia,* and a tourist project where the group were shown one of the main traditional uses for Dutch oak and the Dutch navy.

Stop 6 Oak nursery production

The final stop for Tuesday's programme was a visit to a specialist nursery producing oak transplants at Wildertsedijk, owned by Peter de Labie and his family. Peter is a third generation nursery man and takes exceptional pride in his oak transplants which are of the highest quality and are in great demand for renewed roadside plantations (Plate 4) .

On arrival at the nursery we were met by Peter who with his wife Heidi treated the group to a choice of tea or coffee and home-made pastries in their home close by. We then toured the nursery which was exceptionally well managed, with oak as one of the main species produced. Peter placed particular emphasis on his oak production methods (Plate 5), which demand much attention to each individual plant through continuous shaping, pruning, staking and relining every year and here he demonstrated the various stages in the system. Here we saw older (five years and over) trees managed very intensively to produce very fine straight individuals for roadside planting.

Day 3 Stop 7

The first stop was in an extensive forest area in southern Netherlands at Princenhage/Liesbos (Plate 6) where a number of oak stands mainly in mixture with beech had been surveyed as potential seed stands. Here two adjoining stands had been selected, while a third similar adjoining stand had been rejected due to what was then consider poorer quality at time of survey and adhering to the method described in Table 1. The original assessment took place in 1984. The quality of all these stands was excellent and even the rejected stand was considered by the group to be of such good quality that the consensus was that it should now be re-evaluated. Even our tour leader who is

Plate 4: A renewed roadside planting in an area where a former roadside plantation has been removed

Plate 5: Intensive oak production methods in Wildertsedijk Nursery

directly involved in the oak breeding programme in the Netherlands and in the formal selection of seed stands agreed with this suggestion and accepted the need for resurvey which was likely to lead to the approval of the rejected stand.

In an adjoining younger stand 'sudden oak death' was seen and was considered a worrying development, as many of the trees were dead or partially dead. Associated with the death of this stand was a severe outbreak of *Agrilus biguttatus* beetle had been recorded and was observed.

Stop 8 Progeny testing

The final stop was to a progeny trial of oak seed-stands in a replicated field trial in Schuddebeurs. This standard type of trial is used to evaluate the selected material and is used extensively in the Netherlands to test and ultimately to upgrade material from 'selected' seed-stands to the higher 'tested' category. In this case one-parent progeny reproductive material (acorns) are collected from a number of individual seed-stands – here it was from 24 stands, but throughout the entire country material from 119 seed stands are presently under test. The trials are regularly assessed for (1) height and diameter growth, (2) form, (3) flushing time and (4) survival. Based on the performance of these progeny which are tested over several sites, the best improved material - seed-stands - are identified and categorised.

Plate 6: Oak seed stand in mixture with beech in Princenhage/Liesbos forest.

Conclusion

The study tour was a great learning experience for all participants and resulted in new information on a number of areas relating to the ongoing work of the Oak Group of FTT. These included:

(1) The process of evaluation and the methodology used for the selection of seed stands in the Netherlands;

(2) Critical time and methods to improve the vegetative propagation of selected oak plus-trees, particularly the grafting of older plus-tree selections;

(3) The approach and method for developing and establishing roadside seed stands as practised exclusively in the Netherlands;

(4) The Dutch system of upgrading seed stands from the category 'selected' to 'tested' through continuous and ongoing progeny trials;

(5) The ideal tree spacing in an oak clonal seed orchard which according to our Dutch host is approximately 8 x 10m;

(6) The level of pollution by outside pollen in an oak seed orchard despite its very isolated location - over 70% which is impossible to control and the effects of which are unknown;

(7) The value of having linear seed stands along road sides to allow full development of the individual tree crowns resulting in earlier and more bountiful acorn production and to facilitate cost effective seed collection. This novel system has many merits and is worth consideration in an Irish context;

(8) Consideration be given to the adoption of a seed stand selection process mirroring that of the Netherlands system;

(9) The possibility of getting more tested seed to market relatively quickly by growing seed stand material in comparative trials. There are several seed stand sources being tested in existing Forest Research GB provenance trials that could, as in the Netherlands, be upgraded to 'tested' status almost immediately. Likewise, in Ireland, there are a large number of seed stand seed sources also in similar trials. Here consideration should be given to an evaluation of these trials with a view to converting them to a tested seed source;

(10) Based on Dutch findings, it seems that positive judgements can be made on the performance of seed stand progeny at about twelve years.

Acknowledgments

The group is indebted to a large number of people particularly Sven de Vries for organising the programme and planning the itinerary, accommodation at the various venues and for selecting and arranging for the site visits throughout the Netherlands. The group also owe a large debt of gratitude to the British Embassy in the Netherlands and in particular Liesbeth Bouwhuis, Science and Innovation Officer and Irena Guianu, Science and Innovation Intern for their work in organizing and coordinating the tour arrangements. We are also grateful to the people who met us along the way especially Johan Vink of PVM and Peter and Heldi de Labie for their kindness and hospitality shown at their nursery in Wildertsedijk.

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