CONIFEROUS TREE SEED HARVESTING IN BRITAIN

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Some practical aspects in

Choosing and registering a seed source

Before 1950 little attention was paid to the quality or origin of the parent stand before making forest tree seed collections. As a result it is highly probable that the poor performance of many of our middle- aged crops can be directly related to one of these factors.
Furthermore the most prolific cone-bearing trees with easily accessible cone crops were commonly sought by seed collectors. Whenever possible, collections were made from the ground and still are and it is on the lower branches of trees that the highest incidence of self-pollination takes place; this sometimes results in low seed germination and plants with slow rates-of-growth and undesirable stem form.
In 1957 the Scottish Tree Seed Association was formed and in 1961 the English and Welsh Tree Seed Association. These two associations were amalgamated to form the Forest Seed Association in 1968. All were voluntary bodies and had the objective of encouraging the use of seed collected from the most suitable origins or from superior sources which were selected and registered by the associations.
When Britain joined the European Economic Community in 1972 it became mandatory to ensure that seed or plants of European silver fir, Beech, European larch, Japanese larch, Norway spruce, Sitka spruce, Corsican pine, Scots pine, Weymouth pine, Douglas fir, Red oak, Pendunculate oak, Sessile oak and poplar species for marketing are derived from approved home or imported sources.
This article provides guidelines to foresters wishing to decide whether or not to embark on commercial coniferous forest tree seed collections and, secondly, discusses methods that they can use in harvesting them.

Origin:
Basically, origin refers to the original seed source and is defined as: the area on which an indigenous stand is growing or the original indigenous source of a non- indigenous stand. Examples of origin are Hoquiam, Washington or Queen Charlotte Islands, British Columbia for Sitka spruce, and Long Beach, Washington or Hollis, Alaska, for Lodgepole pine.
Origin is very important for certain species and unless it is known it is probably best to restrict the replanting of material of unknown origin to sites and environments broadly similar to those of the actual seed source.

Provenance:
Is the area on which (an indigenous or non-indigenous) a stand of trees is growing.
In the case of indigenous stands, eg native natural Scots pine woods, the terms origin and provenance arc synonymous.

Performance:
If the origin is acceptable, as demonstrated in experimental tests, then the appearance of

the potential seed-crop trees on any given site is not so important, although it is desirable that it should be free of obvious disease or insect attacks and of good form and show good wind stability. In many cases the physical appearance (phenotype) of a tree is affected by the site but not the genetically-inherited characters (genotype) which of course remain unaltered.
As an example, Lodgepole pine of Queen Charlotte Islands' origin has been proved to grow with good stem form and resistance to windthrow on a range of moderate to difficult sites in northern Scotland. In its native habitat, where the trees grow on muskeg sites, the trees are small and stunted and their form is poor mainly due to the environment.
In contrast, south coastal origins of Lodgepole pine from Oregon and Washington, which also have poor stem form in their native habitats, grow very quickly on most British sites in their early years but after 10-15 years become increasingly unstable and very prone to snow and wind damage which results in quite unacceptable stem form.
It is therefore clear that origin and performance are closely linked and vital factors for some species when deciding whether to collect seed from a stand.

Selection:
Normally it is essential that seed collections be made from healthy, well- formed, dominant and co-dominant trees, since vigour is not strongly inherited whereas stem form is strongly inherited. Following such methods of selection, it is expected that the final crop yields of stands derived from selected material will be increased by two percent.

Registration:
Healthy, vigorous stands upwards of 4ha in area which have good stem-form — and preferably of a known acceptable origin — are well-suited for registration and inclusion in the 'National register of basic material for the production of reproductive material' which is maintained by the Forestry Commission under the EEC rules. In special cases smaller stands can be admitted. If they are to be marketed it is essential that seeds or plants derived from seed of the species listed in the 'Introduction' should be registered. Registration follows an inspection made by Forestry Commission staff and arrangements can be made through the local Forestry Commission Conservancy office which currently charges a £15 fee for the service. Applications for the registration of stands should normally be made at least one month before seed collections are to be made. Each registered stand, or sometimes a group of stands, is given a specific identity number.

Crop estimations

Sampling Cones for Seed:
Commercial forest tree seed collections should be made from groups of 30 or more trees. Collections should not be undertaken when crops are very light or only on scattered trees since both yield arnd seed viability will be low. In *Abies* spp and Douglas fir, light cone crops, low seed set and infestation by seed wasps *(Megastigmus* spp), often result in little or no sound seed.
A sample of cones from at least 10 and preferably 30 trees should be split longitudinally prior to bulk collection in order to establish that the seed count is good. Usually 4-6

sound seeds per exposed surface for pines; 8-10 for Sitka spruce; and 20 for Grand and Noble firs, is good enough to warrant a collection; they are recognised by the white, firm surface of the cut seed face.

Estimating the volume of collectable cones:

Cone crop estimations are difficult to make and impractical to do accurately. However, when the crowns of seed trees can he easily seen the following method can be used for large-coned species. Select sample seed trees as follows:
In stands of less than 1 ha - 5 trees
In stands of between 1 and 5 ha -10 trees
In stands of more than 5ha - 20 trees

Count all visible cones from one position on each sample tree and calculate the average number of cones per tree: for example in Sitka spruce.
Average 400 cones counted
one position per tree x 2 = 800
Seed trees per hectare = 40
Number of hectares = 5
Cones per hectolitre = 3200

By multiplying 800 by 40 by 5 and dividing by 3200 the number of hectolitres of cones is estimated at 50hl

The table overleaf gives information on the range and average number of cones per hectolitre for the main species and can be used to convert the total crop to volumetric units and the yield of cleaned seed per litre of cones.

Time of collection:

It is essential that cones be collected at the correct stage of maturity. To determine this, a sample of cones and its seeds should be cut to determine the stage of development of the seed embryo which should be clearly visible before collection; in addition the seed endosperm, which forms the bulk of the seed, should be quite firm.
The yield of fully-developed viable seeds will be greatly reduced if it is collected too early or not properly stored. On the other hand if collection is delayed until the cones begin to open then some seed will be lost. The table indicates the best collection periods hut a careful watch must be kept on the stage of development since variations do occur between different parts of the country and between different years.

Collection methods

Felling:
This is now the most widely used method of collecting cones from Sitka spruce and stands of other species over 10m tall and which cone heavily only episodically. Ideally the *seed trees* should be identified and felled before either thinning or clearfelling takes place. This may be difficult from the management point-of-view but accepting the importance and value of the seed, unusual practices may have to be implemented. Likewise when a seed source is to be sold standing there may have to be a clause in the agreement which permits the owner to fell the seed trees before total clearfelling. It is much easier if cones are collected from felled trees before the branches are removed by snedding.
Timing the fellings is all-important because there is a limited period during which the cones must be collected before any great loss of seed results after the cones begin to open. This is particularly important in the case of Douglas fir, *Abies* spp and north coastal Lodgepole pine sources which mature and ripen their cones very rapidly.

Climbing:
Normally this method is not recommended for reasons of cost, special safety training which is necessary, and the availability of suitable people. However, it should not be dismissed altogether and in situations of abundant cone crops and with, perhaps, difficulties of felling, climbing should be given due consideration.
In addition, heavily-coning seed trees could have their cone-bearing tops, or some branches removed by the climber, thus speeding the process and increasing yields without losing the trees. Forestry commission Forest Record Number 39 although now somewhat outdated indicates some of the collection methods and types of equipment.

From the ground:
Areas of young forests of desirable origin can be found by reference to planting records and when the stands are suitable in age and size for cone collecting from the ground or from short fruit- picking-type ladders. This ha been demonstrated in recent years and particularly for some origins of Lodge pole pine which normally flower at an early age. It is essential in such young crops to check the seed content before making collections since the pollen cloud at the Lime of pollination may not have been adequate for a good set of seed.

Mechanical:
In Britain most mechanical aids have been used in seed orchards where the ground is reasonably uniform and flat. Probably the best machines are hydraulic hoists, some of which are self- propelled, but the capital and running costs of such machines are high and can only be justified where there are heavy cone crops.
The cost of cone collecting tends to increase as the trees become taller and in such special situations as seed orchards the obvious answer to this is to limit tree height by topping and pruning. If such treatments are made to limit height growth it is likely that the height-to- crown diameter ratio is important in order to achieve a reasonable potential cone-bearing area. In these cases the critical height might be considered to be between 4-5m

which is well within reach of non-mechanical collection platforms as the ‘Talliscope’. Trailer-mounted scaffold platforms which can be hauled by a tractor and on which at least two people can work in complete safety and ease, have also been used where ground conditions permit.

Storage and transport:

Cones are normally collected when dry and placed in ½ hl woven sacks *(not* ‘Polythene bags) which are immediately labelled with the species name and identity number. Filled sacks can be temporarily stored in roofed, open-sided racks until transport to an extractory is arranged.

Approximately 300 half hectolitre sacks will fill a l0-tonne lorry. Sacks should not be filled to the limit in order to allow for cone-scale expansion during drying and in the case of *Abies* spp sacks should be only half filled. In the case of pine species all needles still attached to the cones should be removed if possible before despatch.

Do’s and don’ts

Forest tree seed is a vital basic resource which can be easily improved by simple procedures. If you have a cone crop on a plantation over 4 ha in extent grown from seed of good phenotype:

Do consider registration if it has not been registered previously.

Do make an estimate of the probable yield of cones from the best trees in the crop which should be marked

Do consider especially felling the best trees or along ridesides for the crop.

Do make arrangements well in advance to obtain supplies of hessian sacks and labels for the collection.

Do notify the Forestry Commission of the dates when collections are to be made from registered stands.

Do make provision for temporary storage of bagged cones in dry well- ventilated sheds or at least under cover.

Do arrange seed extraction quickly.

Never consider groups of less than 30 trees for registration or good stands surrounded by extensive stands of inferior quality - pollen contamination from outside inferior sources is a problem.

Never put collected cones into polythene sacks.

Never leave collected cones in sacks exposed to the weather.

Never collect on speculation and *check* that only current year’s cones are picked.

SEED PRODUCTION OF CONIFEROUS TREES IN BRITAIN

(1) ***English*** *Name*	(2) ***Age of*** *First Good Seed Crop (years)*	(3) ***Average Interval*** *between Good* ***Seed Crops***	(4) ***(5) (6) Recommended Time of Seed Collection*** ***(4) Earliest (5)Normal (6)Latest***			***(7)*** *Notes on Seed Collection*	(8) ***Average No of Cones/*** *hectolitre*	(9) (10) (11) *Yield grams* ***of Clean Seed of*** *cones/litre* *Low/Average/High*		
Earliest	*Normal*	*Latest*								
Lowest	***Average***	***Height***								
Scots pine Corsican pine Lodgepole pine	15.20 25.30 15-20	2-3 3-5 2-3	Nov Nov Mid-Aug	Jan Dec Late-Aug early-Sept	Feb Jan Late Sept		5500 2800 4500	5 ***5*** 2	6 ***9*** 4	8 13 7
European larch Japanese hybrid larch	15-20 15-20	3.-S *3-5*	Nov Sept	Feb/ March Sept	April Nov		10000 9500	7 10	10 14	29 16
Douglas fir	30-35	4-6	Sept	Sept	Oct	Collect when cones a light golden brown	3000	2	5	6
Norway spruce	30-35		Oct	Oct	Nov		1000	7	13	15
Sitka spruce	30-35	3-5	Sept	Sept' Oct	Dec		3600	5	9	13
Grand fir Noble fir	40-45 30-35	*3-5* 2-4	Aug Aug	Aug/Sept Aug/Sept	Sept Sept	Collect immediately the scales loosen and the cone softens. otherwise seed will be lost	700 2200	18	26 22	37
Western hemlock Western red cedar Lawson cypress	30-35 20-25 20-25	3 2.3 2-3	Aug Aug Aug	Sept Sept Sept	Sept Sept Sept	Collect as soon as cones change colour from bright green to yellow and the tips of the Seed wings are visible and ***a*** light brown colour	58000 190000 107000	7 12 26	13 14 44	23 18 63

Notes. Column 3 figures refers to the intervals between good seed years. In Scots pine for example 2-3 years of relatively poor production will generally follow a good seed year. Columns 4, 5 and 6 The Sept/ Oct means at the end of September or beginning of October. 1 bushel 8 gallons 36.48 litres. First published in Forestry and British Timber 1981.

Small scale seed collections can cause problems

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In the past many forest tree seed collections have been made from very small populations. Later generations of trees derived from such sources could suffer from the effects of inbreeding, including slow growth rate and misshapen trees.

Tree growth is determined partly by the environment (which can be modified by the forester) and partly by the genetic constitution of the seed. Seedlots which have a narrow genetic base may adversely affect crop yields in both the first and subsequent generations. Reduced timber yield resulting from inbreeding is often referred to as inbreeding depression.

In extreme cases, for example when a tree is self-pollinated, or when very close relatives are mated, seed will often be infertile or seedlings so weak that they seldom survive for more than a few years or even months. However it is not always the first generation (F^1) which shows the full effect of inbreeding.

For example, if a seed collection is made from a single tree within a population, the vast majority of the resulting seedlings will be normal since many fathers will have contributed to the seed mix. But if these seedlings provide the parents of the next (F^2) generation, it will contain an appreciable proportion of seedlings of poor vigour and form.

Wild populations depend upon genetic variation to provide adaptability to environmental change and to ensure the continued existence of their future generations. In very small isolated populations, the less natural variation the less likelihood there is of future survival. In naturally outcrossing species (and all common British forest trees are outcrossing) the wild population carries a number of lethal or harmful recessive genes. Such genes are harmless in the hybrid state but mating between close relatives obviously increases the probability of lethal or undesirable effects becoming manifest.

Reduce genetic base

Very small populations can be dominated by one or two successful individuals which happen to have well-matched flowering periods and an abundance of flowers. Combinations within such small groups or between individuals will rapidly reduce the genetic base or amount of variability and so enhance the later consequential danger of inbreeding depression in later generations. This can happen in seed orchards (Hadders *et al,* 1975).

The Forestry Commission publication ‘Seed indentification numbers (anon, 1965)’ lists numerous small seedlots which, because of their size, must have been derived from only a few parent trees. Seed collected from the F^1 plantations from such small seed sources will probably exhibit inbreeding symptoms.

It is important, therefore, that seed should always be collected from a large number of trees which are well distributed throughout a stand of the desired species and origin. This will ensure that the opportunities for the mating of many females with many more males have been high and consequently a high degree of genetic variation in the next generation.

Some case histories

Douglas fir

Douglas fir has had an interesting but unfortunate beginning in Britain. The restricted sample of seed introduced by David Douglas in 1827 was used to establish a small group of trees at Scone, Perthshire and on other Scottish estates.

Seed from these trees produced some fine F^1 plantations but the F^2 generation from both natural and controlled crosses between trees has given rise to low seed yields and all the other usual symptoms of inbreeding.

Crosses between F^1 parents and other unrelated parents using controlled pollination techniques have resulted in high- quality offspring. Orr-Ewing (1965, 1976) in Canada has provided ample evidence of the commonly harmful effects of inbreeding in this species.

Noble fir

The early- history of Noble fir was similar to that of Douglas fir: the original introductions were planted either individually or in small groups which were later used as seed sources for commercial planting stock. In good seed years large quantities of seed can be obtained from a single tree.

Such a collection from a group of old Noble firs planted in the 1830s in the policies of Rosehaugh House, Easter Ross is estimated to have produced *2.5kg* of seed from between 6-13 trees. F^1 material from this collection was planted at Borgie Forest (Coronation Plantation) in 1953 and produced a large proportion of trees showing inbreeding symptoms of depressed growth and poor colour. Obviously it would be even greater folly now to collect F^2 generation seed from the Coronation Plantation source.

Sitka spruce

Between 1921 and 1955 over 14000kg of seed, approximately 80% of all the imported Sitka spruce seed, came from the Queen Charlotte Islands in British Columbia - an origin which has produced planting stock well-suited for most British needs.

The large importations have undoubtedly provided foresters in Britain with a sound genetic base for future commercial seed collections. Even assuming 100gm of seed per parent tree, the base population in the Queen Charlotte Islands must have been in the order of tens of thousands of trees.

In 1983 some 5000kg of seed were obtained by extensive collections principally in western Scotland and mainly from stands of Queen Charlotte Islands origin. The pollen cloud at the time of female flower receptivity was observed to be very substantial thus ensuring that inbreeding risks will be negligible in this large collection.

Variation between clones in seed, cone and pollen production can be high as shown from the data collected over a seven-year period from a 20-clone seed orchard at Ledmore, Dunkeld Forest, Perthshire in which each clone was represented by 20 grafted trees until thinned in 1969.

Subjective assessments of male flower production in a ten-year-old Scots pine orchard indicated that the amount of female flowering was not strongly correlated with male

flower production. From Table 2 it is clear that clones 295, 306, 307 and 363 in particular must be predominant in the seed-mix since they account for almost 70% of the entire cone crop and therefore 35% of the total genetic mix.
The variation between trees in seed yield per cone is an added complication when estimating the parental contribution to a seed mixture. The data in Table 3 has been taken from cone collections made by the Forestry Commission genetics branch over several years.
The data in table 3 supports the view that seed collections from small populations can be heavily weighted to favour certain individuals.

The Problem
A number of stands in Britain have been derived from seed collected from a small number of trees. Some of these stands have grown well and might be used later for seed collections. Second- generation plantations may be much poorer than the parent stand as a consequence of inbreeding. The problem will not be as serious when the female parent trees are surrounded by many others which serve as effective pollinators. The problem is likely to be most serious when collections are made from small isolated groups of trees or single trees.
The number of clones used in an orchard is immaterial *providing* the stands derived from orchard seeds are not used for further selection or inbreeding purposes. If such stands are used for commercial seed collections then some inbreeding depression will result and this could have disastrous effects by reducing some of the earlier captured genetic gain. Some breeders have estimated timber volume losses of 20% or more as a consequence of inbreeding depression (Gansel 1971: Eriksson *et al* 1973). It is essential therefore that full and detailed information on the pedigree of the component clones or families available for use in second-generation orchards is known if future problems associated with inbreeding are to be avoided.

A recommendation
Since 1921 the Forestry Commission has maintained a register of the quantity and identity of all sources of seeds and plants which it has handled. From this information crude estimates of the number of seed-bearing (but not necessarily pollen-producing) parent trees represented in the lot can be made.
Information on the source of planting stock is valuable and should be maintained with compartment records wherever possible so that in the event of the stand growing well its pedigree or source can be checked. This will enable better decisions to be taken on whether or not plants derived from it are likely to suffer from problems associated with inbreeding.

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See table two below of details of cones collected by year from Scots pine clonal orchard No 4

Table 2: Scots pine clonal orchard number 4.
Total number of cones by clones collected in years 8-14

Clone number	*1964*	*1965*	*1966*	*1967*	*1968*	*1969*	*1970*	*Total*	*%*
290	43	54	150	200	350	9252	880	10929	3.4
291	509	231	590	1552	433	9300	4900	17515	5.4
293	851	1190	936	1576	744	8030	10200	23527	7.3
295	891	1513	2744	4396	4380	16410	6520	36854	11.4
297	303	408	1300	3510	693	2980	1410	10604	3.3
305	174	129	420	1080	170	*	*	1973†	1.9†
306	240	166	270	1220	1320	16480	14420	34116	10.6
307	3149	6020	2680	11265	8686	44300	18140	94240	29.2
308	32	4	10	230	170	860	2240	3546	1.1
309	19	46	120	690	50	3860	8280	13065	4.0
362	57	8	30	230	200	2730	1480	4735	1.5
363	2381	4182	1604	5312	4382	*	*	17861†	17.3†
364	36	9	0	10	10	20	110	195	0.1
365	765	1325	1290	4192	3326	16060	3800	30758	9.5
366	135	109	840	630	280	2056	4700	8750	2.7
410	0	1	0	0	0	*	*	1†	0.0†
411	1	26	0	20	0	1710	1780	3537	1.1
412	195	554	205	1395	450	*	*	2797†	2.7†
414	57	49	150	270	60	1180	3940	5706	1.8
442	139	64	270	250	0	390	1470	2583	0.8
Total	9975	16088	13609	38028	25704	135618	84270	323292	

** = Clone Removed*
† = Data for 5 years only

SEED PURITY AND ITS PROCUREMENT

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Sadly it is not always possible to rely on natural events to achieve abundant regeneration and increasingly we require to resort to artificial means to conserve and recreate populations of a wide spectrum of native plants. Pressures against successful natural regeneration are of course considerable and varied from browsing to human land use.

In any scheme or plan to establish native plants, seed is usually the basic entity and procuring it is of prime importance. This should take account of the prevailing ecological and biological situation and ensure that a broad cross section of the population is sampled to provide adequate genetic diversity.

There is a half way house of using plants derived from seed collected in your own ecological region and while attempting to select for seed collection only the likely two contrasting examples are Scots pine (*Pinus sylvestris*) and whitebeam (*Sorbus aria).* Although we often refer to surviving Scots pine populations as ‘remnants’, they are by no means genetically depleted and on the contrary, variability in the relict populations is almost the highest of any plant species studied (Kinloch et at 1986). In contrast we have whitebeam which is uncommon in Scotland (Mitchell 1985) and occurs either scattered or in very small populations with unknown genetic diversity.

Seed procurement from these 2 species is at opposite ends of a spectrum and in the case of Scots pine the woodland must be “sampled’ to give a cross section of the population, following Forestry Commission guidelines. An exception to this would of course be the Glen Avon population with only some 25 trees.

In the case of whitebeam, as in a recent discovery of a native/natural population of some 30 to 40 old trees in the north of Scotland, every individual with berries can and should be sampled.

Because of the restricted nature of our wild areas and ancient woodlands together with the widespread planting of non local and exotic trees and shrubs one assumes there could he a corresponding increase in seed contamination resulting in the imparity of the native source. The scale of the problem appears to be largely unknown which in turn highlights the need for research into inter and intra specific crossing together within pollen dispersal. Problems may also result from the marketing of seed which is to be found impure - but which in some cases may simply be the result (as in the case of birch) of incorrect identification!

The Forestry Commission recommends buffers of some 400m between native pine seed (trees) and Scots pine of unknown or ‘foreign’ sources. This will not be adequate in very small populations where the species are likely to have derived from one or two trees

An interesting case of possible impurity arose in the seed year 1990 in gean *(Prunus avium*) which may have crossed with black cherry *(Prunus serotina*) which is a native of north America and was introduced into Britain in 1629 (Mitchell 1985).

Intermediates between sessile oak (*Quercus patraea*) and common oak (*Quercus robur*) are common (Mitchell 1985) which suggests widespread crossing between the species.

These few examples indicate some of the problems which could influence the purity of native tree seed and we can only observe what sound knowledge and experience teaches us and what we believe to be reasonable precautions in each seed collection undertaken. Our task however is not made any easier by natural variation and this can be extremely wide.

Lastly then, broadly based seed collections are essential in a conservation sense but there are also very sound economic reasons.

REFERENCES

Kinloch, B.B., Westfall, R. D. and Forrest G. 1. (1986) Caledonian Scots Pine Origins and Genetic Structure. New Phytologist 104: 703-727.

Mitchell, A. (1985) Complete Guide to Trees of Britain and Northern Europe. Guild Publishing, London.

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