Growing Ash for Hurleys

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Abstract

A project to determine the optimum size butt in monetary terms for the production of hurleys from the Common Ash (*Fraxinus excelsior* L.) is described and the results presented. A system for growing ash for hurley production is outlined. A variety of silvicultural systems for ash are examined for profitability and compared with likely returns from Sitka spruce on the same sites.

Introduction

The genus *Fraxinus* consists of about 65 species mainly found in temperate latitudes of the Northern hemisphere. Only one is native to Ireland, the Common Ash, *Fraxinus excelsior* L. It is mostly found in lowlands but will grow to altitudes of up to 450m. Though ash has been planted in relatively small amounts it is probably the most common naturally occurring hedgerow tree in the country. Little information is available on seed origin. Trials in Britain from the 1930s detected little provenance differences. It was claimed in Germany that there were two distinct races, "water-ash" and "limestone-ash" however this is not certain and the apparent differences may be due to site factors.

Individual trees may bear wholly male, female or hermaphrodite flowers; males often exhibit the best stem form as female flowers are terminal. It flowers in April or May and the winged seeds ripen in August. In natural stands it usually occurs in mixtures, frequently with oak. Oak and ash woods can support a rich flora as both come into leaf late in the season. Though ash attains its best growth on rich, basic lowland soils, where it can grow to 40m, it usually occurs naturally in pure stands only on dry limestone sites where other tree species cannot compete. It has a lifespan of about 200 years. Ash produces a strong, springy timber and is used in the manufacture of furniture, tool handles and sports goods. In Ireland, the latter use is the major reason for the interest in the growing of ash on a commercial basis.

Ash for Hurleys

Every year about 450,000 hurleys are used in Ireland. They are all manufactured from the butt-section of the native Common Ash. Only the bottom 1.5m of the tree is used. The remainder is useless for this purpose. A consequence of this is that the butt is worth on average about ten times as much per m^3 as lengths further up the tree. It is the most valuable of all home-grown timber. At the prices currently prevailing it is possible to grow ash profitably. There is probably no other broadleaf tree to which this applies in Ireland.

One of the reasons ash butts are so valuable is that trees suitable for hurley-making are scarce. Demand exceeds supply. In the past there has been little planting of ash explicitly for this purpose. It is one of the most abundant of native tree species and occurs throughout the country, so there seemed little danger of a shortage occurring. However, most of the trees occur in scattered locations, being widespread in hedgerows, appearing in mixtures, in scrub and in the few remnants of broadleaf woodland. These trees are frequently not suitable for hurley-making, harvesting costs are considerable and the logistics of locating and harvesting such trees make them unsuitable for modern methods of large-scale hurley production.

Since plantation forestry commenced, ash has been planted occasionally in small patches but more usually in mixtures with conifers, particularly Norway spruce. These stands comprise the main source of hurley ash today. They are usually managed to provide commercial lengths of ash as well as hurley butts and increasingly they are failing to meet the demands of hurley manufacturers as other sources of ash outside the Forest and Wildlife Service (FWS) are exhausted. Recently ash has been imported, especially from Wales. Because of this the FWS has investigated the growing of ash specifically for the hurley market, to assess its commercial prospects but primarily to ensure that sufficient material is produced to allow the survival of the game of hurling and of the manufacturing industry by supplying enough ash to enable hurleys to continue to be put on the market at a reasonable price. This paper describes these investigations and their results.

Hurley Ash Project

The first question to be answered was what were the requirements of the hurley-makers, both in terms of quality and size of butt. Discussions with various manufacturers provided no clear consensus. The scale of operations varied considerably as did the production techniques. Preferences depended in part on the type of operation and on tradition. It was decided that from the point of view of growing ash profitably we would assume the most modern production systems and the co-operation of a hurley-maker was secured in a project to determine the optimum size and quality of hurley-butt.

(A) Material

Four size classes and three quality classes of butt were sampled from a stand of ash in Donadea forest, Co. Kildare. The breakdown is given in *Table 1.*

Table 1: Number of ash butts selected in each category.

	Size (Diameter at 1.3m in cm)				
Quality	18	22	26	30	46
Good	4	4	4	4	2
Fair	4	4	4	4	
Poor	4	4	4	4	

The quality of the stems was assessed standing by the hurley-manufacturer. The ash was planted in the period 1940-1946 and has an estimated average yield class (YC) of 8. The soil profile and site details are given in *Appendix 1.*

After selection a description of the stems was recorded and each tree was photographed on its 'best' face, as normally assessed, and at right angles to that direction. This was in an attempt to produce some objective grading system for assessing standing trees by relating their appearance to the actual hurley production.

The butts were then harvested in the normal manner and converted into hurleys. *Table 2* gives the results in detail. *Appendix 2* describes the conversion process and explains the hurley classification system.

(B) Results

(a) *Size of butt*

A monetary value was assigned to each butt based on the valuation of hurleys as described in Appendix 2. The curve for DBH v. an index of value/m^3 of butt is shown in *Figure 1.*

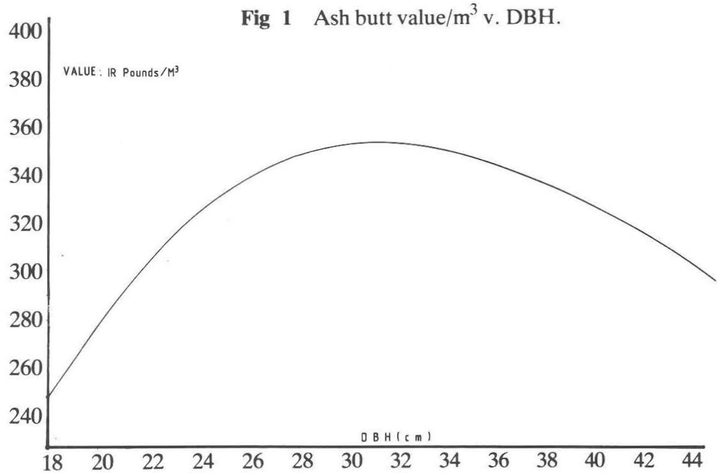
Table 2: Results of conversion of ash butts to hurleys.

Tree No.	Diam. Class (cm)	Rating (Standing) by Manufacturer	Assessment (Planked) Manufacturers Comments	Hurley Output				
				37"	36"	34"	32"	30/28"
1	18	Good	Fair	1				6
2			Fair	2	1	2	3	1
3			Fair			1	3	3
4			Fair				2	3
5	18	Fair	Poor				2	5
6			Bad			2	2	2
7			Bark Damage		1	2	5	1
8			Bad			2	1	1
9	18	Poor	Poor				2	8
10			Bad				3	2
11			Poor				4	3
12			Bark Damage		1	4		5
13	22	Good	Good	2	2	2	7	
14			Good		2	4	4	2
15			Fair	3		3	4	4
16			Fair		2	2	4	2
17	22	Fair	Poor	5		2	3	4
18			Fair	1		3	2	3
19			Fair		2	2	5	5
20			Poor		2	4	4	2
21	22	Poor	Poor		2	3	3	3
22			Fair	3	2		2	6
23			Bad		2		4	3
24			Bad		1	3	3	6

Table 2: Results of conversion of ash butts to hurleys (contd.)

Tree No.	Diam. Class (cm)	Rating (Standing) by Manufacturer	Assessment (Planked) Manufacturers Comments	Hurley Output				
				37"	36"	34"	32"	30/28"
25	26	Good	Good	5	3	3	1	5
26			Good	6	3	4	2	2
27			Good	6	5		3	1
28			Fair/Poor		2	4	6	4
29	26	Fair	Fair/Poor	2		6	4	5
30			Fair	1	4	5	2	4
31			Fair/Good	4	4	4	3	4
32			Fair	1	3	2	3	5
33	26	Poor	Fair	3	3	3	1	6
34			Fair	5		2		
35			Poor	1	4	2	1	8
36			Good	1	1	4	6	3
37	30	Good	Excellent	10	6	2		5
38			Excellent	8	2	5	3	5
39			Excellent	12	6	6		2
40			Good	8	5	6	1	1
41	30	Fair	Fair/Good	7	3	8	3	1
42			Poor	4	3	4	5	3
43			Good	6	3	5	5	1
44			Good	2	7	8	1	3
45	30	Poor	Fair	1	4	6	3	3
46			Bad	3	6	3	6	2
47			Fair	9	1	1	3	2
48			Fair/Good	4	2	2	5	8
49	46		Fair/Good	15	11	4	2	3
50	46		Fair	13	3	4	5	9

Fig 1 Ash butt value/m^3 v. DBH.



From this it can be seen that the optimum size of butt is in the region of 28-32cm DBH. The reason for the decline in value after this point is that in very large stems the timber in the centre of the tree is not used for hurleys, the butts are sold by the m^3, thus in larger butts there is an increasing amount of less valuable material.

(b) *Quality of butt*

An analysis of butt value by quality class indicated that the visual standing assessment by the hurley manufacturer was reasonably accurate. Table 3 gives a breakdown for each of the 4 size classes of value by quality class.

Table 3: Hurley value index (one senior hurley=1.0)
(Figures are relative units of value per unit volume)

Size Class	Quality Class		
(DBH cm)	Good	Fair	Poor
18	112	104	115
22	166	138	132
26	168	148	136
28	195	172	113

It can be seen that the larger the stem size the better the standing visual assessment of the worth of the butt. Only in the 18cm size class was this evaluation wrong. Based on these findings a visual grading for hurley butts can be described.

Fig 2 Quality Class 1: Good. Stems which are straight, free of branching or defects such as extraction damage or other injury. Even and well-developed buttressing of the roots, 4 roots being optimal.

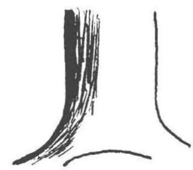


Fig 3 Quality Class 2: Fair. Straight stem, free from defects. Buttressing poorly developed or uneven, but with at least two good roots.

Fig 4 Quality Class 3: Poor. Swept stem or a stem with minor damage. Buttressing very poor or else very uneven. Similar to trees which might be found growing on the side of a hedgerow.

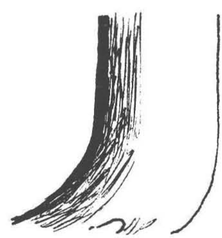


Fig 5 Quality Class 4: Unacceptable. Forking or branching below 1.5m.

(C) Use of Root Collar Diameter as Predictor of Butt Value

A measurement of the diameter of butt at ground level of all the trees used in the conversion study was taken. It was hoped that this statistic might give a better estimate of value than DBH. However, it proved less useful. The reason appears to be the many abnormally high readings which frequently did not reflect hurley production. The measurements were taken too close to the ground and perhaps a reading at about 0.3m up the stem might indeed improve prediction, unfortunately the measurement was not taken.

Rate of Growth

An important feature of a good quality hurley butt is that it be fast-growing. Quite apart from the economic benefit of attaining optimum size in as short a time as possible (which is dealt with later), slow grown trees do not provide the springy timber required by the hurley-manufacturer. Flexible hurleys absorb the shock of impact during the course of a game. It has long been an accepted fact by those who play hurling or those who make hurleys that fast growth produces stringy timber. A simple test is to be conducted at the Institute of Industrial Research and Standards to confirm this, however results are not yet available.

Growth and Yield

Information on the growth patterns of ash in Ireland is sparse. There are British Forestry Commission (BFC) yield tables for the species, however these are based on an initial spacing of approximately 1.8m and thinning is to marginal intensity. Only one experiment examining wider spacings exist on a reasonably good quality site. This is in Knocktopher, Co. Kilkenny. Details of the experiment are given in Appendix 3.

Because of the variability of the site, interpretation of the results is difficult. Differences in height growth within treatments exceed that between treatments. The yield class based on the BFC top height/age curves for 0.9m and 2.7m plots cannot be directly estimated. This is because spacing usually has a significant effect on height growth in broadleaved species — the wider the spacing the lower the height. Even on a site such as Knocktopher this trend is evident, though not statistically significant.

Table 4: Mean top height (m) by treatment. Knocktopher 1/63 at age 19 years.

Treatment:	0.9	1.8	2.7
Top Height:	11.43	10.90	9.03

An examination of the 1.8m plots would indicate that basal area growth for all three plots was close to that given in the yield tables for the yield class indicated in BFC Booklet No. 34. The Booklet states that for ash the sycamore/ash/birch table to be used should be one yield class less then indicated by the top height/age curves. For YC 10 ash, planted at 1.8m spacing and managed according to the management tables the main crop after thinning statistics in Table 5 would apply:

Table 5: BFC YC 10 table stocking/mean DBH/age (Figures rounded).

Age	Stems/ha	Mean DBH (cm)	Largest 350 stems (DBH cm)*
15	1120	10	13
20	660	15	18
23	660	18	21

* Estimates based on examination of Knocktopher data.

If we assumed that the mean difference in top height between the 1.8m and 2.7m plots of approximately 2m (Ref. Table 5) represents the true height depression due to wider spacing then the adjusted reading of the top height/age curves indicate yield classes of 4 for one of the 2.7m plots and YC 8 for two of them at age 23. Two of the 1.8m plots are YC 6 and one is YC 8. A comparison of the YC 8 plots of the three treatments is given in Table 6.

Table 6: Comparison of mean DBH and DBH350* for YC 8 plots at age 23.

	0.9m	1.8m	2.7m
Mean DBH (cm)	10	13	15
DBH 350 (cm)	13	16	18

* Mean DBH of 350 largest stems/ha.

With 1360 stems/ha the 1.8m plot above is considerably overstocked when compared with the yield table (890 stems/ha). This is reflected in the depression of mean diameter which the tables suggest as 15cm. In the 2.7m plot where stocking is close to the figure in the table the mean diameter is 15cm. Examination of the tables would suggest that thinning to marginal intensity would give a mean DBH of about 18cm at age 23 (Ref. Table 9) for YC 10.

If the increase in mean diameter with reduced density as illustrated in Table 6 is maintained with lower stocking levels than given in the yield tables a further increase in mean DBH of 2cm does not seem unreasonable if initial stocking is 1111 stems/ha (3m spacing). An examination of edge trees in Knocktopher would indicate that this assumption is probably conservative. Thus the statistics for such a crop are given in Table 7 below.

Table 7: YC 10, 3m initial spacing, thinning to marginal intensity.

Age	Stems/ha	Mean DBH	DBH 350
15	1111	12	15
*20	660	17	20
25	450	23	26

*Unthinned before this age.

If, instead of thinning to marginal intensity the number of stems were reduced to 700 at age 15 and to 350 at age 20 then greater diameter increments can be expected.

It is on the basis of arguments such as outlined above that Hurley Ash yield tables have been constructed. Obviously, given the extremely limited data-base they can only be validated by time and further experimentation; however, the assumptions are at all stages reasonably conservative.

Table 8: Yield Tables for Hurley Ash.
Initial spacing 3m (1111 stems/ha).
First Thinning (T1) leaves 700 stems remaining.
Second Thinning (T2) leaves 350 stems remaining.

YC	Age of T1	(Mean DBH)	Age of T2	(Mean DBH)	Age of C/fell	(Mean DBH)
10	15	(15)	20	(20)	25	(28)
8	18	(15)	24	(20)	30	(28)
6	22	(15)	31	(20)	40	(28)

Diameter refers to crop after thinning.

SITE AND NUTRITION

(1) *Soil*

Perhaps the greatest obstacle to the successful growing of hurley ash is the identification of good sites. Optimum sites occur in deep, moist, free draining soils in sheltered locations which are not prone to late spring frosts. These areas are also excellent agricultural land and are not commonly available for forestry. Good sites will normally occur in small patches. A rough breakdown of soil types ranked by suitability for ash is:

Good sites:
Well drained, moist brown earths.*

Moderate sites:
Surface water gleys not excessively water-logged.

Poor sites:
Peats.
Any water-logged soils, very dry or shallow soils.

The only definite indication of a good site is the existence of mature ash which is growing rapidly. The presence of prolific natural regeneration of ash, as is often found, for example, on gleyed soils after the removal of tree cover is not necessarily an indication of a good site.

(2) *Nutrition*

Ash is one of the most nutrient demanding of all tree species grown in Ireland and as such the question of fertiliser applications must be considered. Results from an ash manurial trial in Gorey, Co. Wexford, indicated that on a brown podsolic site the application of NP and K, lime, or both NPK and lime gave a positive response, with NPK only giving the best results in Gorey.

Details of the Gorey fertiliser trial and results are given in Appendix 4. On the basis of these results it is suggested that a positive response to applications of NPK can be expected on mineral soils of less than YC 10 which are neither water-logged nor excessively dry. On slightly acidic sites the application of lime should be considered. The optimum pH range for the growth of the species is thought to be 6-7.

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* Ref. Appendix 1. The site in Donadea which produced the ash used in the conversion study is described in detail to illustrate an example of an excellent ash site.

(3) *Other Site Considerations*

Protection from late spring frosts is a major consideration when selecting a site for hurley ash. Ash is very susceptible to spring frosts which damage and cause distortion fo the stem, and as it is vital to produce straight, clean stems up to about 1.5m for hurley production, frost-prone sites should be avoided. Exposed sites should be avoided. Ash performs best in a sheltered environment.

PRESCRIPTION FOR HURLEY ASH

Planting Stock: As there is no information available on provenance variation within ash it is recommended that seed be collected from straight, well buttressed, fast grown timber. Nursery practice should avoid the production of the typical J-root which can lead to uneven buttressing. Ash should be planted out as clean, single stemmed two-year seedlings, at least 50cm in height.

Planting and Site Preparation: Ash should not be planted on ploughed ribbons but be pit- or mound-planted. Steeply sloping sites should be avoided. These measures are to help ensure even buttressing. Spacing of about 3m square is recommended (1100-1200 stems/ha). At this spacing competition from ground vegetation will persist for several years therefore grass cleaning is critical as good survival rates are important.

Protection: Ash grows well in mixtures and likes a moist, sheltered micro-climate so it should be interplanted with Christmas trees, either Norway spruce or Noble fir. The number of Christmas trees to interplant can range from 1100 to 3300 stems/ha and the decision will depend mainly on the likely market. It is important that they be removed before they start to compete with the main crop. They will serve to surpress ground vegetation and protect the ash from frost and exposure.

Protection from rabbits, hares and sheep is essential. For the latter the usual sheep fencing should be used. In the case of rabbits and hares fencing is expensive and often not effective, so chemicals may have to be used. The timing and frequency of applications will depend on the severity of attack.

Tree guards have many advantages and their use is discussed in the section on economics.

Fertilisation: 800kg/ha 10:10:20 should be applied one year after planting and again every five years until clearfelling. If the site can be established as having a very high yield class (YC 10+), fertilisation is probably not effective.

Pruning: By about 6-9 years of age when the Christmas trees are harvested, approximately 700 of the best stems should be selected and all branches below 1.5m should be removed. Branches above this point should be left because they contribute to butt growth.

Thinning and Clearfelling: Timing of thinning will depend on growth rate. Assuming a good site and fertiliser application YC 10 should be achieved. In this case first thinning will be at 15 years of age and all stems except the selected 700 should be removed.

At age 20 the 350 of the remaining trees should be harvested and these will provide many butts suitable for hurleys. The best stems should be left. The minimum butt size acceptable is approximately 18cm. Finally, at 25 years of age the stand should be clearfelled. Anything less than YC 6 is considered unsuitable for hurley production. Even YC 6 is unlikely to produce a high proportion of top class hurleys due to its slow growth.

Table 9: Thinning and Clearfell ages for different yield classes.

YC	1st thinning Mean DBH 15cms	2nd thinning Mean DBH 20cms	Clearfell Mean DBH 28cms
10	15 yrs.	20 yrs.	25 yrs.
8	18 yrs.	24 yrs.	30 yrs.
6	22 yrs.	31 yrs.	40 yrs.

The system outlined above is aimed at getting a final crop of virtually open-grown trees to produce a mean DBH of 28-30cm in the shortest possible time while also giving the reasonable shelter which the trees need to thrive. This diameter has been calculated at the optimum in terms of hurley value per m^3 of butt.

Hurley Production

Based on the hurley ash yield table (Table 8) and the results from the conversion study, Table 10 gives the anticipated total production in terms of hurleys/ha/year.

As is evident from the results of the conversion study (Table 2) there is a very considerable difference in hurley output between butts of the same size. The figures in brackets in Table 10 show the production which could occur if butts of the very highest quality were grown; the non-bracketed figures are the numbers produced if the average stem quality is assumed equal to the best butts in the conversion project.

Table 10: Hurley Production (Hurleys/ha/year).

YC	Senior Hurleys	Others	Total
10	130 (180)	290 (320)	420 (500)
8	110 (150)	240 (270)	350 (420)
6	80 (115)	185 (200)	265 (315)

SUPPLY SITUATION

The Gaelic Athletic Association (GAA) estimate that about 450,000 hurleys/annum are used (all sizes). Based on the figures in Table 10 above and assuming the average production from good quality butts it is calculated that 47.6 ha annually of YC 10 Ash would be required to supply the market. Obviously if the very best quality butt could be achieved in each case the total production (from Table 10) would be greater and so the area required would be less.

Given a 25 year rotation, the amount of hurley ash plantation (pure, YC 10 and widely spaced) which would be necessary is about 1190 ha. So what is the acutal supply situation at the moment?

FWS Inventory figures indicate that in 1973 there were approximately 5,500 ha of ash plantation in private hands. However, much of it was regarded as over-mature by that time. Almost no private planting of ash has taken place since then, so it is likely now that much of the remaining area of private ash is unsuitable for hurleys. Eventually this area will be exhausted in terms of suitable hurley timber. There were about 1230 ha of ash in State plantations at the time. While this was generally younger than the private stock it was far from optimal in terms of usefulness for hurleys. As can be seen from Table 11 much of it is well past the stage at which it is likely to interest a hurley manufacturer. Table 12 shows the pattern of FWS planting since 1970. It can be seen that only in 1981 was the area planted close to the estimated area required, even assuming YC 10 sites. This situation is unlikely to be critical while relatively large areas of old ash remain which will always contain some suitable stems. However, discussions with purchasers and the recent surge in ash prices indicate this source may be drying up.

The difficulty for the FWS in trying to alleviate the problem is simply a shortage of suitable sites. Yield Class figures for broadleaves are not available but the mean YC of FWS ash is probably about 6, or just on the margins of butt suitability for hurleys and profitability for the grower. Given this type of land

Table 11: Ash in FWS Plantations by age class (area in ha).

Planting Period	Area	Planting Period	Area
Pre 1921	193	1945	145
1925	9	1950	131
1930	55	1955	87
1935	124	1960	70
1940	337	1965	53
		1970	23

Table 12: Areas of ash planted by the FWS since 1970.

Year	Area (ha)	Year	Area (ha)
1971	18	1977	36
1972	30	1978	18
1973	20	1979	8
1974	10	1980	0
1975	N.A.	1981	42
1976	27	1982	7

about 80 ha/annum would need to be planted, and the quality of the hurleys produced would be poor. As mentioned previously, the best ash soils are deep, free draining brown earths and as these soils are excellent agricultural soils they are unlikely to be acquired by the FWS. It therefore seems essential that State plantings be supplemented by private plantations. As little as an average of 2 ha per county per year of ash grown on good sites and carefully maintained should be sufficient to ensure future supplies of hurleys.

A comparison of GAA estimates of hurley use and FWS sales of ash butts appears to indicate that at present about half of the ash used comes from private sources. If this situation is to be maintained, private planting will have to recommence quickly.

Economics of Growing Ash

However successful the grower is at producing sufficient hurleys to meet the demand, he must anticipate a financial reward to justify doing so. Not only that, but in a commercial forest enterprise the return must be at least as good as the best alternatives. The analysis presented below examines the Net Discounted Revenue (NDR) for a variety of silvicultural regimes for ash and compares them with the expected returns from Sitka spruce on the same sites. Three site types are examined which typically would be likely to produce the three growth rates of ash of sufficient vigour to produce acceptable quality hurley butts. Details of the results by site are given in Tables 13-15. The assumptions taken in the analysis are outlined in *Appendix 5*.

The Sites

(a) Brown Earth

The best site for ash with a YC 10 achievable, often without fertiliser application. On such a site Sitka spruce should attain YC 22.

(b) Brown Podsolic

YC 8 ash and YC 20 Sitka might typically be found on soils of this kind, provided other factors are favourable. Fertiliser application could probably boost many of these sites to YC 10 ash.

(c) Gley

Ash is unlikely to reach more than about YC 6 on these sites due to impeded drainage. They are frequently excellent Sitka spruce soils and YC 24 is not unusual for the species.

These three sites are isolated merely as examples of the sort of comparison that must be made to assess the financial aspects of planting ash. Obviously every individual site would have to be examined on its merits and an estimate of the yield class of ash and the alternative species made together with some judgement on the likely response of ash to fertiliser on the site in question.

The Silvicultural Systems

(a) Sitka spruce

The management system assumed is the normal practice of planting 2,500 stems/ha and thinning to marginal intensity. Felling age is 80% of the age of maximum mean annual increment, which is standard in the FWS.

(b) Ash only; 1100 stems/ha

This system assumes management according to the Hurley Ash Yield Table (Table 8). However, no Christmas trees are included.

(c) Ash only; 1100 stems/ha plus tree guards

As above, except it is assumed that all stems are encased in plastic tree guards 1.3m high. The guards have two main advantages, firstly growth is accelerated greatly in the first few years thus aiding the trees in getting above competing vegetation; secondly, and perhaps more importantly, they afford protection from hares and rabbits. While in this regime tree guards are regarded as optional they may be essential in some areas with low density initial stocking if establishment is to be successful at all.

(d) Ash 1100 stems/ha (no tree guards); Noble fir 1400 stems/ha
The Noble fir are added for the reasons given in the section on 'Prescription for hurley ash'. They are also a valuable cash crop as will be seen.

(e) Ash 1100 stems/ha with tree guards: plus 1400 Noble fir/ha
As for (d) above, with tree guards added.

(f) Ash 700 stems/ha with tree guards plus 3300 Noble fir/ha
The ash are reduced to the number at which all stems are expected to produce hurleys and the number of Christmas trees increased to maximise the cash crop and eliminate 'non-productive' ash plants. At such a low density of ash, tree guards are assumed to be essential.

(g) Ash 3000 stems/ha, 'Normal Management'
Ash planted at the density assumed in the British Management Tables and thinned accordingly. Trees of sufficient size when harvested are divided into hurley butts and 'commercial' ash.

The results

Table 13: Brown Earth; Ash YC 10, Sitka spruce YC 22.

System	NDR IR£(1985)	No. Hurleys /ha/annum
(a) Sitka spruce 2,500 stems/ha	4886	
(b) 1100 Ash only	4506 (3911)*	420
(c) 1100 Ash and tree guards	3447 (2852)	420
(d) 1100 Ash+1400 Noble fir	6247 (5652)	420
(e) 1100 Ash (tree guards)+ 1499 Noble fir	5188 (4593)	420
(f) 700 Ash (tree guards)+ 3300 Noble fir	6847 (6252)	420
(g) 3000 Ash 'Normal Management'	4357 (3610)	320

* Figures in brackets give NDR assuming fertiliser application as discussed.

Table 14: Brown Podsolic; Ash YC 8, YC 20.

System	NDR IR£(1985)	No. Hurleys /ha/annum
(a) Sitka spruce 2,500 stems/ha	4047	
(b) 1100 Ash only	3600 (2923)	350
(c) 1100 Ash and tree guards	2468 (1791)	350
(d) 1100 Ash + 1400 Noble fir	5341 (4664)	350
(e) 1100 Ash (tree guards) + 1400 Noble fir	4209 (3532)	350
(f) 700 Ash (tree guards) + 3300 Noble fir	5868 (5191)	350
(g) 3000 Ash 'Normal Management'	3153 (2348)	260

Table 15: Gley; Ash YC 6; Sitka spruce YC 24.

System	NDR IR£(1985)	No. Hurleys /ha/annum
(a) Sitka spruce 2,500 stems/ha	5701	
(b) 1100 Ash only	2177 (1375)	265
(c) 1100 Ash and tree guards	929 (127)	265
(d) 1100 Ash + 1400 Noble fir	3918 (3116)	265
(e) 1100 Ash (tree guards) + 1400 Noble fir	2670 (1868)	265
(f) 700 Ash (tree guards) + 3300 Noble fir	4329 (3527)	265
(g) 3000 Ash 'Normal Management'	1503 (605)	180

DISCUSSION

All three sites are assumed to be bare ground and reasonably flat, with no scrub present. These would be categorised in the FWS as 'Easy Mineral' sites. More difficult sites are considered unsuitable for the production of hurley butts. (The only exception to this would be reafforestation on similar ground). No roading costs are included. In many cases, such as small plantations or farms, no roads would be constructed and much of the suitable sites on FWS land are already roaded. The overall NDR values are therefore high, but, as discussed, not unrealistic for many potential ash sites. If the land has to be purchased the cost would have to be subtracted from the figures given to get the real return. On the first two sites types this would be a major consideration, as it would involve good quality agricultural land.

Comparing the ash treatments, on all three sites the rankings are the same. The ash plus Christmas trees are considerably better than the 'normal management' or widely spaced ash only. The 1100 stems/ha 'ash only' system produced better than 'normal management', however on the best site the difference is slight.

Without the addition of the Christmas trees the ash alone cannot compete with Sitka spruce on any of the sites. However, on the two better sites the difference between 'normal' ash and the spruce is small and it would take a premium of less than 10% in the value of commercial ash over the spruce wood to make the ash more profitable. If there were a sustained supply of good quality ash available this seems very likely to be achieved.

Only on the gley soil does the gap seem unbridgeable, yet given the favourable cost factors assumed, even ash of YC 6 can be grown profitably using conventional silviculture. Pruning costs are not included in the analysis (some pruning would be required for commercial lengths) yet on the better sites, given a more favourable supply and marketing structure, ash, even when not grown specifically for hurleys, could be a competitive option.

In terms both of hurley production and profitability widely spaced ash combined with Christmas trees is clearly the best option. The consistantly best system, 700 ash and 3300 noble fir must be treated with some caution. Despite the impressive lead the extra fir give this option, the Christmas trees contribute only about one third of the revenue and with only 700 main crop trees this regime is very dependent on virtually all of them surviving and producing good quality hurley butts. To a lesser degree the same agrument could apply to the theoretically second most profitable option, 1100 ash and 1400 noble fir. The next option (e), where the tree guards should ensure the survival of most of the ash appears the safest bet.

Despite the added cost of the guards on the two best sites it is still somewhat more profitable than Sitka spruce.

The selection of this latter option as the best depends largely on ones assessment of the gains in terms of protection afforded by the tree guards. Any significant losses in the non-guarded treatments would quickly tip the balance of profitability.

A consequence of the good performance of the 'normal management' ash is that in the event of a glut of hurley ash causing prices to drop sharply (a situation which could easily develop) a net loss should not be incurred on the better sites.

Finally, the benefits of fertilisation are clearly illustrated by comparing NDRs after the application of 800kg of 10:10:20/ha at five year intervals (in brackets, Tables 13-15) of the YC 10 ash site with the figures for the unfertilised YC 8 systems. In every case it can be seen that YC 10, even with this intensive fertilisation is better than YC 8 without it. The benefits are even more pronounced when going from YC 6 to YC 8.

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APPENDIX I

Site details of ash stand used in the conversion study.

All trees used were from Compt. 259 I, Donadea Forest. The bulk of them came from Subcomparment 4, a stand of 0.9 hectares, though many were taken from adjoining sub-compts., which also contained ash. All the ash used was planted between 1940 and 1946, in mixtures of varying types with an initial stocking of about 4,800 stems/ha (all species included).

As most of the trees came from subcompt. 4 and it was the only stand which was predominantly ash, site details are given for this stand. Only the species mixture and planting year was different in the other stands.

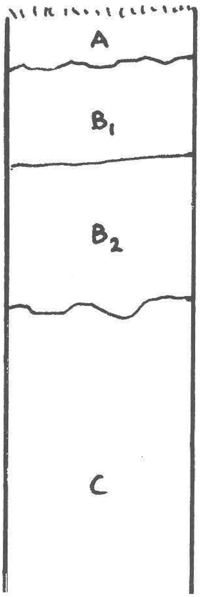
Comp. 259 I Sub-Compt. 4.

Area: 0.9 ha. Elevation: 90m. Aspect: Gently sloping to South.

Planted in 1940, pit planting. Soil Type: Brown Earth.

Ash YC 8. No fertilisation.

Soil Profile: Surface vegetation, grass, briars in places
No organic horizon.



A horizon: 5cm.
Dark loam, no stones, much humus and many roots.

B_1: 5-15cms.
Clay/loam, merging with A horizon, few roots, no humus, high clay content. pH 5.3.

B_2: 15-30cms.
Dark brown, free-draining clay loam.
Many lumps of charcoal present.
Many small-medium sized stones.
Merges to subsoil. Many roots. pH 5.8.

C: 30-100cm+
Reddish-brown, many medium-sized limestone stones.
Moister than other horizons.
Deep, no parent material at 1m depth.
Rooting to about 50cm.
Parent material; limestone drift.

Stocking (per/ha):
Ash 275 (mean DBH 25cm)
Larch 110 (mean DBH 31cm) Total: Approx. 600 stems/ha
Oak 110 (mean DBH 15cm)
Beech 100 (mean DBH 17cm)

APPENDIX II

Manufacture of Hurleys

1. The tree is felled by firstly clearing away earth and debris from around the base of the stem, then making several cuts with a chainsaw (depending on the number of buttresses) angled downwards. The base of the tree thus felled will have a somewhat pointed butt.

2. The stem is cut off at about 1.5m above the base. The extra length (greater than the length required for hurleys) is to allow for vertical cracking of the stem which occurs at the cut surface on drying.

3. The butt is removed and cut into slabs. These are flat boards, parallel to the direction of the buttresses. The number of slabs will depend on the number and size of the buttresses.

4. From each slab a hurley is cut and turned. They can be made individually or several at a time using a template.

Classification System

For the purposes of this study the hurleys produced were divided into five categories, depending on length. The most valuable category, 37" long are referred to as senior hurleys. The others are 36", 34", 32" and 30/28".

To determine the worth of the ash butts all hurleys produced were assigned relative values. A senior hurley was regarded as having a value of 1. The relativities are based on the selling price of the hurleys.

The values are:

37"	=1.000	32"	=0.562
36"	=0.875	30/28"	=0.375
34"	=0.687		

APPENDIX III

Details of ash spacing trial at Knocktopher, Co. Kilkenny.

Site: Brown earth.
Flat, former nursery site, small patches poorly drained.

Treatments: Initial stocking levels of 12,100; 2,900 and 1,340 stems/ha.
Randomised block, 3 replications.

Owing to the effect spacing has on height growth of ash, and in the absence of suitable yield tables the precise yield class of the 0.9m and 2.7m plots can only be estimated. However, top height and basal area figures indicate considerable variability in site productivity. This appears to be mainly due to the plots being on a former nursery site.

This variability was further compounded by the fact that 3 years after establishment each plant got a spot application of 'Potatoe manure' (1 part sulphate of ammonia; 3½ parts superphosphate; 1¼ parts muriate of potash) resulting in greater fertilisation of the closer spacings:

1140 kg/ha in the 0.9m plots
260 kg/ha in the 1.8m plots
125 kg/ha in the 2.7m plots

The response to an application of NPK in 1981 is discussed in Appendix 4.

Due to the poor growth the experiment was not intensively maintained for many years resulting in considerable overstocking in the more vigorous plots.

APPENDIX IV

Response of ash to fertiliser

1. Details and results of an experiment in Gorey Forest, Co. Wexford to test the effect of ground limestone and nitrogen, phosphorus and potassium fertilisers on the growth of polestage ash.

   Crop history: Planted in 1958. Single mouldboard agricultural pough. Initial stocking 3,700 stems/ha. Ground rock phosphate spot applied in 1971 at 375 kg/ha.

   Soil: Podzolic gley — brown earth (localised).

   Treatments (per ha braodcast in 1978):

   (1) 1.5 tonnes ground limestone

   (2) 3.0 tonnes ground limestone

   (3) 3.0 tonnes ground limestone plus 800kg 10:10:20

   (4) 800kg 10:10:20

   (5) Control

   Results: In the period 1978-1980 there were significant responses in basal area increment to treatments 2, 3 and 4 with the NPK treatments both being better than the lime only.

   From 1981-83 treatments 2, 3 and 4 were again significantly better than 1 and the control. However, the NPK treatments were no longer significantly better indicating that perhaps the response to NPK is short term, and that further applications may be warranted.

   Overall the NPK only treatment was best though the difference was not statistically significant.

   Analysis of basal area growth rate indicates an increase in yield class of from 4 in 1978 to YC 8 in 1983 in the plots which received 800 kg/ha 10:10: 20.

   (Details from M. Carey and E. Hendrick, Research Branch, FWS).

2. Based on the early indications from the Gorey experiment an application of 800 kg/ha of 10:10:20 was applied broadcast to all the plots in the ash spacing trial in Knocktopher (ref. Appendix 3). The results are very encouraging. Table A below shows the yield class distribution of the plots in 1981 before fertiliser application and the figures in brackets the yield classes of the same plots in 1985, four growing seasons after application:

Table A:

0.9m	1.8m	2.7m
<4 (4)	4 (6)	<4 (4)
6 (8)	4 (6)	4 (8)
8 (10)	6 (8)	6 (8)

All plots were one yield class higher after four years. Increases in top height (m) over the four year period is given in Table C.

Table B

0.9m	1.8m	2.7m
2.7	4.0	3.3
3.1	3.8	4.2
3.2	3.1	2.9

These figures indicate current growth rates of YC 10 or greater for all plots indicating a dramatic response to fertiliser application. The change is clearly evident by visual observation of the experiment.

APPENDIX V

Assumptions used in economic Analysis.

1. All costs and revenues in IR£1985.
2. For Sitka spruce and commercial lengths of ash the 1974-1984 DBH/price per m^3 curve (all FWS sales) is used.
3. Hurley ash is valued at £350/m^3 for 30cm DBH butts and all other size butts related to this using the DBH v. value/m^3 curve (Figure 1).
4. Net revenue from Christmas trees at harvest: £2/tree for systems including 1400 Noble fir/ha and £1.80 for 3300/ha.
5. Costs of site preparation, plants, planting, fencing and protection standard FWS costs for 1985 for 'easy mineral' sites. Rabbit fencing is included at 200m/ha on the ash systems where tree guards are not included. For grass cleaning atrazine application is assumed. Pit planting and no ploughing for hurley ash regimes; in the case of Sitka spruce and 'normal management' ash, agricultural plough and slit planting.
6. No roading costs included.
7. For all ash systems firewood is taken as equal to cost of marking and measuring the thinnings and clearfells.
8. For Sitka spruce standard FWS marking and measuring costs are taken.
9. Single rotation only calculated.
10. No land price is included.
11. The discount rate used is 4%.