

Avondale - A National Forestry Resource

Michael Carey^a

Abstract

The year 2004 was the centenary of the acquisition of Avondale estate by the Department of Agriculture and Technical Instruction. The objective in acquiring the estate was firstly to establish a forestry school for working foresters in which young men could be trained in plantation establishment and management and, secondly, to enable trials to be laid down to determine the most suitable species for Ireland's forestry programme. The school was highly successful and provided the competence needed to deliver the successful forestry programme. Forest cover is now 10%, compared with 1.6% in 1904.

Between 1905 and 1913 approximately 49 ha of land was planted in 104 different plots. Eighty-four tree species were planted: 46 coniferous and 38 broadleaf. In addition, small pure groups of 16 rare species (nine coniferous and seven broadleaf) were planted in corners and in situations likely to suit them. This brought the total number of species planted to 100. Some species were planted pure, others in mixture with nurses, mainly larch and Norway spruce). Most of the planting took place between 1905 and 1907.

In addition to the experiment plots, an arboretum, covering an area of 17 ha, incorporating a pinetum of 6.75 ha, was also developed.

The conifers far outperformed the broadleaves in volume production. Of the conifers the best performers were: Sitka spruce, Corsican pine, Douglas fir, grand fir, Lawson cypress, European and Japanese larch, Monterey pine, Norway spruce, the redwoods (notably the coast redwood), western hemlock and western red cedar. Of the broadleaves the most promising were: beech, hornbeam, pedunculate oak, sessile oak, Spanish chestnut and sycamore.

The paper reviews the progress of, and lessons arising from, the initiative, and suggests a way forward in relation to the future management of the area.

Introduction

Avondale, near Rathdrum in Co Wicklow, the home of Charles Stewart Parnell in second half to the nineteenth century, and, in former times, the property of Samuel Hayes, the celebrated author of *A Practical Treatise on Planting and the Management of Woods and Coppices*, first published in 1794 (republished in 2003), has been at the centre of Ireland's forestry programme for the last one hundred years.

The area of woods and plantations in Ireland in 1903 amounted to 122,000 ha, representing a landscape cover of about 1.6%. The lack of woodland led to a consensus that action was needed, insofar as wood supplies into the future were concerned. The action programme centred on the setting up of a forestry school for working foresters, in which young men could be trained in plantation establishment and management and, secondly, laying down of a series of field trials to determine the most suitable species for Ireland's forestry programme.

^a Forestry and management consultant, Furze Lodge, Newcastle, Greystones, Co Wicklow, Republic of Ireland (careym1@eircom.net).

Although landlords had, during the eighteenth and nineteenth centuries, introduced many species to the country, and had planted quite extensively around their manors, there was no scientific information available on what constituted the best species for an afforestation programme, or how they might be managed from a silvicultural point of view.

Enquiries regarding a suitable site for the venture commenced in 1903, during which various localities and properties were considered in Cos Tipperary, Waterford and Wicklow. It was finally decided to purchase the Avondale Estate in Co Wicklow. The decision in favour of Avondale was very likely influenced by an approach by John Parnell, who had inherited the estate, to the Department with a proposition: “to place the estate under the Department as an experimental farm in part of which trees would be grown and experimented which would do for all parts of Ireland from Wicklow to Galway as we have so many diversified positions such a valley, hill, sea, lake and mountain exposures” (Forbes 1946). John Nisbet, who surveyed the woods in Co Wicklow in 1903, and was an expert witness to the Departmental Committee on Forestry in 1908, was also positive about Avondale. However, his preferred choice was Whaley Abbey Cottage estate, a few kilometres away in the same district (Nisbet 1903). Nisbet refers to the presence of the remains of an old sawmill in Ballytrasna wood on the Avonmore river which closed down in 1902 “when the stock of marketable timber in the estate became exhausted (except in the ornamental demesne woods and in the park timber)”. He also mentions the stone foundations of a small turbine sawmill worked by C.S. Parnell around 1878. Parnell it seems was more interested in timber processing than in forest management.

Avondale was seen to have advantages as a choice site because of its location in the centre of a relatively well wooded district, and its proximity to the Wicklow mountains in which forestry operations on a large scale were likely to take place, which they did subsequently. (The forest area of Co Wicklow increased from 7,000 ha in 1906 to 43,000 ha in 2003.)

Excluding tenanted holdings, and outlying portions of the property unsuitable for afforestation, the estate included the present country house and outbuildings, about 80 ha of unplanted grassland and 120 ha of woodland. The outlying areas, mostly mountain land, amounted to some 1,200 ha. A price of £9,870 was paid for the whole property.

Much of the planted woodland and trees on the estate dated back to the second half of the eighteenth century, and the silvicultural interests of Samuel Hayes, a man of many talents and a prolific planter of trees (McCracken 1968). In April 1768, Hayes was awarded a gold medal by the Royal Society for “having planted out since October last 2,550 beech trees under five years old not nearer to each other than fifteen feet” (Royal Society 1768). Many of these, and a limited number of other specimen trees, such as European larch, sessile oak, silver fir, Spanish chestnut and walnut, planted by Hayes, are still to be seen around the estate. The announcement of the award gave his address as Hayesville, Co Wicklow. The estate is referred to as such on a 1760 map of Co Wicklow prepared by Jacob Nevill (1760). However, Hayes subsequently changed the name to Avondale in 1770, and the property has this title on a revised edition of the Nevill map published in 1790.

Fraser (1801) refers to “the improvements of Avondale made by the late Colonel Hayes, a name truly endearing to all who feel the enthusiasm of extending zeal for the rural arts”. He mentions plantations of larch and large Weymouth pine on “the front and side of the house large beech trees and remarkably well-grown fir, particularly the spruce”. Later, Radcliff (1812) refers to John Parnell’s involvement in tillage at Avondale and to lime being transported from Carlow as “manure using horses a wagon and carts imported from England”. Some of the areas subsequently limed were very likely planted with trees and this may explain why some of the plots described below suffered from butt rot (*Heterobasidion annosum*).

Between 1905 and 1913 approximately 49 ha of land was planted at Avondale along the Great Ride in 104 different plots. Most of the plots were 0.4 ha in area. The 84 tree species planted were comprised of 46 coniferous and 38 broadleaf species. Pure groups of 16 (nine coniferous and seven broadleaf and other rare species were also planted in situations considered “likely to suit them” (Forbes 1915). This brought the total number of species planted to 100.

Some species were planted pure, others in mixture with nurses, mainly larch and Norway spruce. Most of the planting took place between 1905 and 1907.

In addition to the experiment plots, an arboretum, covering an area of 17 ha, incorporating a pinetum of 6.75 ha, was also developed between 1905 and 1917. The collection was added to in the 1920s, 1940s and 1970s. By the mid 1970s it stood at 413 taxa, spread over 123 genera (MacOscair 1978).

One hundred years after the start of the initiative at Avondale, the forest area in the Republic of Ireland has reached 700,000 ha, 10% of the landscape. This has been a remarkable achievement, given the socio-economic conditions that prevailed, and the fact that planting for most of the 20th century was confined to marginal land or land peripheral to the needs of agriculture. Although many of the new forests were planted on land of poorer quality than that at Avondale, the experiment plots have provided a wealth of information on species adaptability and suitability.

The Forestry School also achieved its objectives. The students who trained there in the first two decades of the 20th century, and later on into the 1930s and up to the mid 1950s and again in the 1960s and 1970s¹, provided the expertise needed to develop the successful state forestry programme, and more recently the expanding private forestry initiatives.

Avondale is now owned and managed by Coillte Teoranta² (The Irish Forestry Board). In 2004, the company commissioned the author to carry out a survey of the experiment plots and, on the basis of the findings, to advance proposals for their treatment and management into the future. This paper outlines the findings of the survey, in addition to detailing the background to the establishment of the plots at the beginning of the 20th century.

¹ The school closed in 1914 but reopened again at Avondale in 1934, where it remained until 1955. It was then moved to Shelton Abbey near Arklow in Co Wicklow and subsequently to Kinnitty Castle in Offaly, in order to cope with increasing numbers of students.

² The commercial state forestry company, established in 1989.

Forbes and the forestry initiative at Avondale

A.C. Forbes, a “dynamic” 37-year-old lecturer in Forestry from Armstrong College of Science, Newcastle-Upon-Tyne, was chosen to drive the initiative at Avondale. Forbes was well acquainted with the history of forestry in Britain and Ireland, and was convinced as to its importance in the economic life of a country. His attitude was described as being essentially commercial; he had little time for social forestry or the acquisition of land for that purpose. He subsequently became the first Director of Forestry in Ireland. He was described in an obituary in the *Irish Times* as “not one of those men content to remain in a groove, and just to carry on as required until superannuation overtook him. He brought to his task a mind that refused to be circumscribed by short-term views, nor was it tolerant of temporary expedients” (*Irish Times* 1950).

Forbes had the view that Avondale was, in many ways, “not too suitable” for the purpose for which it had been acquired (Forbes 1946). He felt the area was somewhat on the small side to allow work to be carried out on economic lines and that “the bulk of it was fairly good tillage land not usually devoted to tree planting”. Although this may have been the situation for most of the 20th century, the major changes through which the agriculture sector is currently undergoing may result in the trials becoming increasingly relevant as better land is planted.

Nevertheless, Forbes set about his new task with enthusiasm and decided to turn the main part of the property into a forest experiment station on the lines of a continental forest garden. In addition to the training of foresters, he saw one of the main objectives as being to “prove as far as this can be done in one place, on a limited area, the cost of production, yield in timber and the comparative market of the species planted” (Forbes 1915).

Establishment of the experiment plots

In laying out the experiment plots the area was divided into 19 sections with separate species being allocated to a series of plots within each section. The layout is shown in Figure 1. Table 1 gives a breakdown of the species planted and the number of plots in each section.

The following are some of the other main features of the plots:

- None of the plots were replicated. This was a serious shortcoming in terms of experimental design. However, the soils at Avondale, although mainly light in texture, are generally relatively fertile from a forestry point-of-view. The main variation in soil type relates to changes in the physical composition of the parent material and slope, both of which influence drainage. In general, apart from a few localised areas, the drainage is free.
- The use of mixtures was adopted across the plots in order to reduce the cost of plants and secondly to minimize the risk of frost damage to the nursed species. Frost was seen as a risk factor, which was well founded, in that some of the more susceptible species, including Sitka spruce and silver fir, were damaged in the early years after planting. The following principles applied in the case of the mixtures:
 - (a) The species intended to represent the main crop formed at least 25% of the

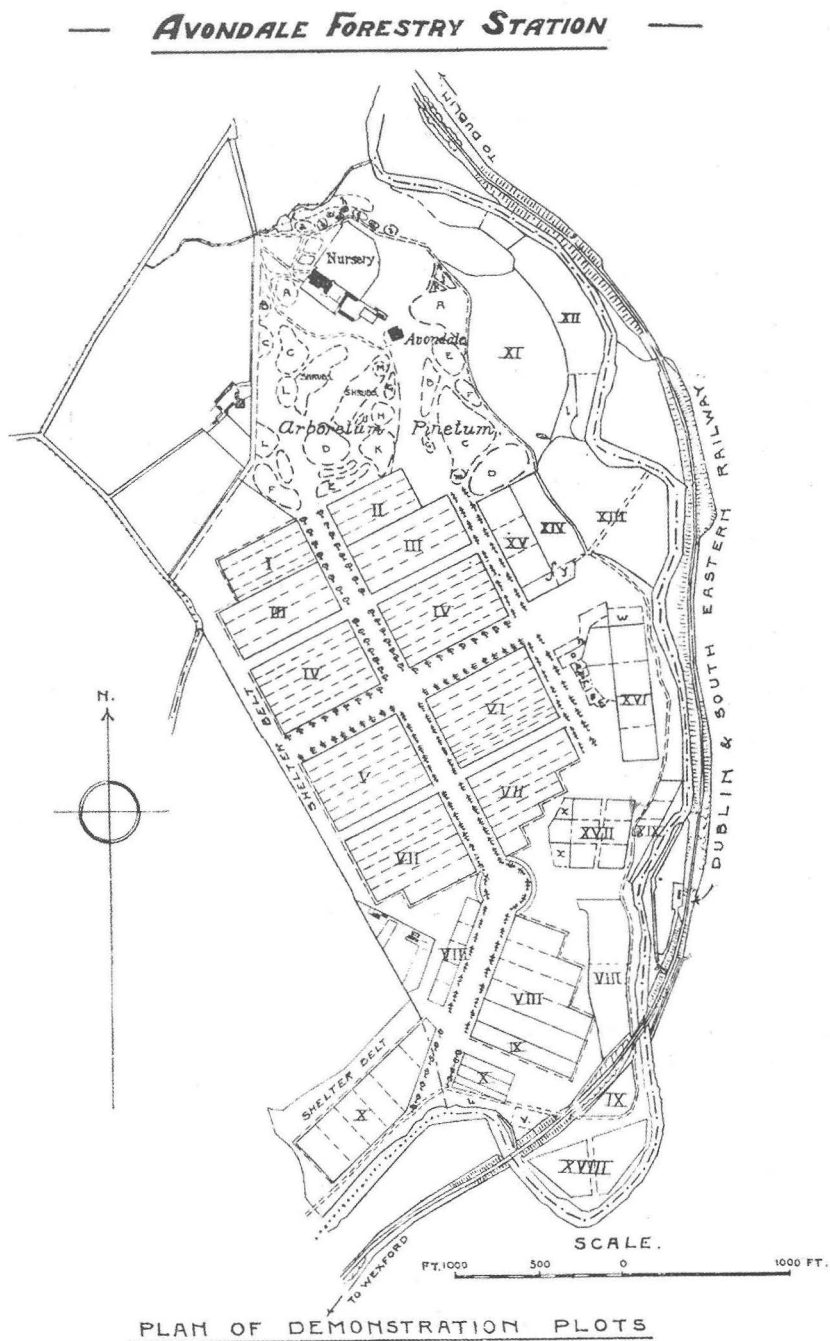


Figure 1. Layout of the species demonstration plots at Avondale (Forbes 1915).

total number planted. At a general planting distance of 1.22 m (4 feet) apart this provided for about 1,682 main crop and 5,045 nurse trees/ha.

- (b) Nurses were either closely allied to the main crop, or, as in the case of larch, capable of being commercially harvested at an early age. They were intended not merely to draw up or nurse the main crop, but also to enable the planting to be carried out at a cheaper rate than if the more expensive species alone formed the crop.
- (c) The two most common nurses of the important forest trees were larch and Norway spruce, so far as space would allow.
- (d) Pure crops of all the important species were planted side by side with the same species in mixture, with a view to noting their development under both conditions.

Larch and Norway spruce were mainly used to nurse the broadleaf species. Scots pine was used as a nurse for most of the more unusual pines and common silver fir for the fir section. Beech was used with larch and oak, ash with oak, walnut and American ash, hickory and tulip tree. In most cases larch outgrew all other species, which necessitated cutting back of the side branches. Norway spruce had the same effect in some instances. Silver fir and ash failed as nurse species due to frost damage.

Table 1. *Main genera planted at Avondale, 1905-1912.*

<i>Section</i>	<i>Genus</i>	<i>Number of plots</i>	<i>Area ha</i>
<i>I</i>	<i>Maples</i>	4	1.21
<i>II</i>	<i>Elms</i>	4	1.21
<i>III</i>	<i>Beech, Spanish chestnut, hornbeam</i>	8	3.23
<i>IV</i>	<i>Oaks</i>	14	5.26
<i>V</i>	<i>Silver fir</i>	7	2.83
<i>VI</i>	<i>Spruce</i>	7	2.83
<i>VII</i>	<i>Pine</i>	14	4.85
<i>VIII</i>	<i>Larch</i>	7	5.66
<i>IX</i>	<i>Cedar</i>	2	1.01
<i>X</i>	<i>Ash</i>	9	2.73
<i>XI</i>	<i>Chestnut coppice</i>	1	4.45
<i>XII</i>	<i>Locust tree coppice</i>	1	2.42
<i>XIII</i>	<i>Douglas fir</i>	2	2.83
<i>XIV</i>	<i>Hemlock</i>	2	1.21
<i>XV</i>	<i>Cypress and juniper</i>	3	1.21
<i>XVI</i>	<i>Western red cedar, redwood, Cryptomeria</i>	4	1.61
<i>XVII</i>	<i>Hickory, walnut, plane, tulip tree</i>	10	2.02
<i>XVIII</i>	<i>Cherry</i>	2	1.61
<i>XIX</i>	<i>Poplar</i>	3	0.80
<i>Total</i>		104	48.98

Before planting commenced the whole area was ploughed, apart from the sloping area adjacent to the river that contained some scrub.

Plants were 2+2, 30-60 cm in height, depending on species. Considerable difficulty was experienced in sourcing some of the more rare species, with the result that quality varied.

Planting was done by digging pits, commencing in the autumn of 1905 and continuing on into the two following winters.

Filling-in and planting of species slow and difficult to procure continued until 1912.

The cost of planting was influenced by the availability of plants. Average costs for planting, including labour, trees and replacement of failures over the first three years are given as £12-£18/ha, equivalent to about €4,680-€7,020/ha today (Kennedy 2005).

Underplanting initiative in the 1950s

In the 1950s it was decided to underplant a number of the original plots with shade-tolerant species. The decision was influenced by the fact that the broadleaf plots, apart from beech and hornbeam, and the pine and larch plots, had 50 years' growth of briar, furze, hazel and other species, and were an impenetrable jungle. The decision led to some controversy, but was approved on the understanding that the new planting would not be allowed to become a constituent of the crop. Unfortunately this turned out to be difficult in practice. The end result of the decision was that a number of the plots, notably the elms, some of the Corsican pine plots, in addition to the Scots pine, eastern white pine and Monterey pine plots were underplanted with a variety of species, the most common being western hemlock, Lawson cypress, Douglas fir, grand fir and western red cedar. Corsican pine was underplanted with beech in 1957. The beech has grown poorly. In general Douglas fir also grew poorly when underplanted, whereas the shade-tolerant western hemlock grew well.

Species performance

Conifers³

Tables 2 to 6 summarise the performance of the coniferous species.

Fir (*Abies*) species

Grand fir was the outstanding performer (Table 2). European silver fir was used as the nurse species in all the fir plots and replaced with grand fir because of it being badly damaged by frost. It showed the greatest vulnerability to frost of all the fir species.

Spruce (*Picea*) species

All species grew well for the first few years, but Sitka spruce has been by far the best performer (Table 3), despite having suffered badly from both frost and aphid damage in the early years. Apart from Norway spruce, none of the other spruces showed any potential.

³ Conifer nomenclature is based on the Gymnosperm Database (<http://www.conifers.org/index.htm>).

Table 2. *Growth performanceⁱ of fir (Abies) species at Avondale.*

<i>Species</i>	<i>Common name</i>	<i>Yield class</i> <i>m³ha⁻¹yr⁻¹</i>	<i>Performance</i>
<i>Abies alba</i>	European silver fir	16	Frost damage. Windthrown in 1974. Top height 27.5 m. Poor quality.
<i>A. cephalonica</i>	Greek fir	20	Frost damage. Quality poor. Forking.
<i>A. concolor</i>	White fir	16	Frost damage. Poor quality/ multiple stems. Top height 26 m age 68. Windthrown in 1974.
<i>A. grandis</i>	Grand fir	26	Good growth. Two rotations since 1906. Wind damaged.
<i>A. nordmanniana</i>	Caucasian fir	16	Frost damage initially. Top height 26 m at age 68.
<i>A. numidica</i>	Algerian fir	na ⁱⁱ	Poor
<i>A. procera</i>	Noble fir	16	Good growth but frost damage initially. Felled in 1964, age 58 years. Top height 24 m.

ⁱ In 2004 unless otherwise statedⁱⁱ Yield class not assigned**Table 3.** *Growth performanceⁱ of spruce (Picea) species at Avondale.*

<i>Species</i>	<i>Common name</i>	<i>Yield class</i> <i>m³ha⁻¹yr⁻¹</i>	<i>Performance</i>
<i>Picea abies</i>	Norway spruce	14	Good. Windthrown in 1990s. Reached top height of 30 m.
<i>P. glauca</i>	White spruce	na ⁱⁱ	Poor
<i>P. jezoensis</i>	Yezo spruce	na	Poor
<i>P. mariana</i>	Black spruce	na	Poor
<i>P. omorika</i>	Serbian spruce	12-14	Grew well but died off after about 55 years. Attractive appearance.
<i>P. pungens</i>	Blue spruce	na	Poor
<i>P. rubens</i>	Red spruce	na	Poor
<i>P. sitchensis</i>	Sitka spruce	24	Very good. Severely frosted initially and suffered aphid damage. Fomes noted. The p 1925 plot currently has a mean height of 30 m and a mean dbh of 59 cm.
<i>P. smithiana</i>	Himalayan spruce	14	Poor. Frost damage.

ⁱ In 2004 unless otherwise statedⁱⁱ Yield class not assigned

Pine (*Pinus*) species

Of the pines Corsican and Monterey grew best (Table 4). Corsican pine grew best on its own. It was suppressed when planted in mixture with either Norway spruce or European larch. However, the quality of the pure plot of Corsican pine underplanted with beech in 1957 is very good. The plot currently has a mean height of 27.0 m and a dbh of 51.0 cm. Monterey (*radiata*) pine is very impressive, where it survived. Macedonian pine is promising.

Table 4. *Growth performanceⁱ of pine (Pinus) species at Avondale.*

<i>Species</i>	<i>Common name</i>	<i>Yield class m³ha⁻¹yr⁻¹</i>	<i>Performance</i>
<i>Pinus banksiana</i>	Jack pine	na ⁱⁱ	Poor. Suppressed by larch nurse.
<i>P. contorta</i>	Lodgepole pine coastal		Not tested until 1964 when planted in a clearfelled noble fir plot. Grew vigorously but was of poor form and was windthrown, as is typical on fertile sites.
<i>P. nigra</i> var <i>salzmannii</i>	Corsican pine	16	Good form. Was underplanted with beech in 1957.
<i>P. nigra</i> var <i>nigra</i>	Austrian pine	na	Poor
<i>P. peuce</i>	Macedonian pine	na	Planted 1916. Comparable with good Scots pine.
<i>P. pinaster</i>	Maritime pine	na	Could not compete with larch nurse and died out.
<i>P. radiata</i>	Monterey pine	18	Growth impressive where it survived.
<i>P. rigida</i>	Pitch pine	na	Poor
<i>P. strobus</i>	Eastern white pine	na	Started well but died off.
<i>P. sylvestris</i>	Scots pine	12	Mixed quality and form.

ⁱ In 2004 unless otherwise stated

ⁱⁱ Yield class not assigned

Larch (*Larix*) species

Of the larch species Japanese and European larch grew best (Table 5). Many fine specimens of both are still present, particularly in plots of other species where they were used as a nurse. In the pure plots beech, Norway spruce and larch were used as nurse species.

Forbes described Tyrolese larch as doing badly.

Lack of information on the West American larch suggests it also grew poorly. However, according to Forbes (1915), extra seed for the species was sourced by Augustine Henry in 1910. The larch plots are now redundant and the area now forms part of the of the general forest surround. Hybrid larch (*L. x marschlinsii*) was not tested until the 1970s but its performance is impressive

Table 5. *Growth performance of larch (Larix) species at Avondale.*

<i>Species</i>	<i>Common name</i>	<i>Yield class m³ha⁻¹yr⁻¹</i>	<i>Performance</i>
<i>Larix decidua</i>	European larch	8-12	Grew well. Good quality.
<i>L. decidua var polonica</i>	European larch	na ⁱⁱ	One line of trees planted. Canker resistant.
<i>L. kaempferi</i>	Japanese larch	10	Grew well. Good quality.
<i>L. occidentalis</i>	Western larch		No records.

ⁱ In 2004 unless otherwise stated

ⁱⁱ Yield class not assigned

Other conifer species

Douglas fir, coast redwood, Lawson cypress, western hemlock and western red cedar, have all done well, and have benefited from their location on a sheltered slope (Table 6). Douglas fir has been a consistently good performer at Avondale.

Summary of growth performance of conifers

Of the 54 conifers tested in the initial experiment plots and later trials only a relatively small number were found to perform outstandingly well. These included:

- Sitka spruce.
- Norway spruce.
- Douglas fir.
- Grand fir. This had the highest yield class of all the conifers. However, its timber has limited use relative to the other high performing species.
- Corsican pine. The performance is impressive and the species warrants further investigation.
- Monterey pine, where it survived, is outstandingly impressive. The species warrants further investigation.
- European and Japanese larch performed consistently well. Their inherently lower yield class makes them less attractive options for commercial forestry. However, the vigorous nature of many of the old trees remains impressive. Should be allowed to continue on as long-term retentions, even though they have been harvested for timber over the years.
- Western hemlock. Performed well. Continues to be vigorous and healthy.
- Western red cedar. Performed well. Continues to be vigorous and healthy.

Table 6. Growth performanceⁱ of other conifer species at Avondale.

Species	Common name	Yield class $m^3ha^{-1}yr^{-1}$	Performance
<i>Cedrus atlantica</i>	Atlas cedar	na ⁱⁱ	Poor performance.
<i>C. deodara</i>	Deodar cedar	na	Mixed, poor performance.
<i>Chamaecyparis lawsoniana</i>	Lawson cypress	16	Good. Larch nurse.
<i>Cryptomeria japonica</i>	Japanese cedar	na	Bad frost damage. Form poor, forking.
<i>Cupressus macrocarpa</i>	Monterey cypress	na	Bad frost damage. Poor survival. There are a few excellent trees. Larch nurse.
<i>Juniperus virginiana</i>	Eastern red cedar	na	Failed. Taken over by larch nurse.
<i>Pseudotsuga menziesii</i>	Douglas fir	16-20	Good. Oregon provenance better than Colorado. Interior provenance also planted in 1929 and was poor.
<i>Thuja plicata</i>	Western red cedar	20	Good. Larch nurse.
<i>Tsuga mertensiana</i>	Mountain hemlock	na	Failed due to frost.
<i>T. heterophylla</i>	Western hemlock	22	Impressive. Prolific natural regeneration.
<i>Sequoia sempervirens</i>	Coast redwood	20	Good. Larch nurse.
<i>Sequoiadendron giganteum</i>	Giant sequoia	22	Good. Larch nurse.

ⁱ In 2004 unless otherwise statedⁱⁱ Yield class not assigned

- Lawson cypress. Performed well. Continues to be vigorous and healthy.
- The redwoods, notably the coast redwood (*Sequoia sempervirens*), are impressive.

Only four of these species now play a significant role in forestry in Ireland: Sitka spruce, Norway spruce, Douglas fir and larch - notably Japanese larch and hybrid larch (not included in the original plots).

Lodgepole pine played a highly significant role in the afforestation programme in the last century but was not included in the initial experiment plots at Avondale. However, according to O'Donovan (2005) the performance of "an original coastal lodgepole pine tree" at Avondale was said to have influenced Forbes in deciding to favour that provenance rather than the inland form for the national afforestation programme. This was to have far reaching implications for the state forestry programme, as the coastal

provenance, which was widely planted on infertile sites, grew well, but overall had very poor stem form.

The overall findings and performance of the coniferous species at Avondale over the last one hundred years therefore vindicate current policies on species selection. The key species, Sitka spruce, Norway spruce and Douglas fir remain vigorous and healthy and the most productive. Although a substantial area of the Norway spruce planted in 1905 was windthrown in 1998, when it was 93 years old, one of the remaining plots of the species has a current mean height of 25.7 m, and a mean dbh of 50 cm. The Norway spruce in this plot was originally planted as a nurse for pedunculate oak, but completely suppressed it.

The Sitka spruce planted in 1926 has a mean height of 29.6 m. Its performance is impressive, given that it is recorded as having suffered from severe frost damage and aphid attack in its earlier years.

Species such as western hemlock, western red cedar, Monterey pine, Corsican pine, and Macedonian pine deserve further consideration. Indeed the yield class for a number of these exceeds that of Norway spruce. Collectively, when taken as a group, they offer some opportunities for species diversification, particularly on reasonably fertile sites.

Broadleaves

Pedunculate and sessile oak were originally planted together. Overall performance of the two main oak species has been disappointing, although they are far superior to all the other oak species, most of which failed (Table 7).

Larch, hornbeam and beech were effective as nurse species in the oak plots, which grew better when nursed by these species, than where it was planted pure. Beech was the best nurse for the pedunculate and sessile oak, but tended to out-perform both species. Norway spruce dominated when planted as a nurse species. Ash and hornbeam were ineffective as nurse species for pedunculate oak. American oaks generally performed very poorly relative to European species.

Spanish chestnut did best when planted pure.

Summary of growth performance of broadleaves

Forty five broadleaf species were tested, 38 in the original series, followed by a further seven in later years. Only six of the broadleaf species showed any promise. None had a yield class greater than 8, and stem quality was poor to mediocre.

The most promising species were:

- beech
- hornbeam
- pedunculate oak
- sessile oak
- Spanish chestnut and
- sycamore.

Although the quality of the sycamore is mediocre, it is by far the best of the maple species tested and has an indicative yield class of 8. The absence of the grey squirrel from Avondale for most of the period of its growth allowed the species to reach its potential. The pest now occurs throughout the experiment plots.

Table 7. *Growth performanceⁱ of broadleaf species at Avondale.ⁱⁱ*

<i>Species</i>	<i>Common name</i>	<i>Performance</i>
<i>Acer saccharum</i>	Sugar maple	Poor. Outgrown by larch nurse.
<i>A. macrophyllum</i>	Oregon maple	Poor. Badly affected by frost. Larch nurse grew well.
<i>A. pseudoplatanus</i>	Sycamore	Grew reasonably well. Quality mediocre and may be related to provenance.
<i>A. platanoides</i>	Norway maple	Poor. Grew well initially. Quality poor.
<i>A. saccharinum</i>	Silver maple	Poor. Outgrown by larch nurse.
<i>Carpinus betulus</i>	Hornbeam	Good growth. Yield class 8. Suppressed by Norway spruce nurse. Best with larch nurse.
<i>Carya cordiformis</i>	Bitternut hickory	Poor records.
<i>C. glabra</i>	Pignut hickory	Poor records.
<i>Castanea sativa</i>	Spanish chestnut	Frosted initially. Suppressed by larch nurse. Best pure.
<i>Fagus sylvatica</i>	Common beech	Good growth and quality
<i>Fraxinus excelsior</i>	European ash	All ash species performed poorly.
<i>Fraxinus latifolia</i>	Oregon ash	All ash species performed poorly.
<i>F. nigra or pennsylvanica</i>	Ash from eastern US states	Failed
<i>Quercus rubra</i>	Northern red oak	Frost damaged. Beech nurse which is now dominant.
<i>Q. cerris</i>	Turkey oak	Failed. Yield class 4. Poor records.
<i>Q. coccinea</i>	Scarlet oak	Poor. Yield class 6
<i>Q. frainetto</i>	Hungarian oak	Grew well initially. Yield class 4. Poor records.
<i>Q. palustris</i>	Pin oak	Failed
<i>Q. petraea</i>	Sessile oak	Mediocre. Yield class 6-8. Best of the oak species. Larch and hornbeam effective as nurse species. Norway spruce nurse suppressed oak.

<i>Species</i>	<i>Common name</i>	<i>Performance</i>
<i>Q. robur</i>	Pedunculate oak	Mediocre. Yield class 4-8. Second best oak species. Dominated by beech nurse. Ash and hornbeam were not effective as nurse species. Norway spruce nurse suppressed oak.
<i>Q. tinctoria</i>	Black oak	Failed
<i>Q. velutina</i>	Black oak	Failed
<i>Ulmus americana</i>	American elm	Unimpressive. Not possible to differentiate the four species. All underplanted in 1958.
<i>U. glabra</i>	Wych elm	Slow start. Unimpressive. See above.
<i>U. procera</i>	English elm	Slow start. Unimpressive. See above
<i>U. x vegeta</i>	Huntingdon Elm	Unimpressive. High mortality due to disease.
<i>Platanus orientalis</i>	Oriental plane	Poor survival.
<i>Juglans nigra</i>	Walnut	Poor records.
<i>Liriodendron tulipifera</i>	Tulip tree	Died-out.
<i>Prunus cerasus</i>	Sour cherry	Poor
<i>P. serotina</i>	Black cherry	Poor
<i>P. alba</i>	White poplar	Did best of the poplars but poor.
<i>P. x canadensis</i>	Black Italian poplar	Poor. Unhealthy.
<i>P. x canadensis nova</i>	Black Italian poplar.	Poor. Unhealthy.
<i>Pterocarya fraxinifolia</i>	Caucasian wing nut	Poor records.
<i>Zelkova serrata</i>	Iron tree	Poor

ⁱ In 2004 unless otherwise stated

ⁱⁱ Information on the performance of the species in the lowermost 12 rows in the table is lacking, but in general none showed any promise.

The two native oaks, although their performance was generally unimpressive (yield class 4-8), were far better than the other species of oak tested, most of which failed.

Because of the lack of replication of the plots, and paucity of data, it is not possible to state which of the two oaks, pedunculate or sessile, performed best.

The findings on mixtures are also far from clear although larch, hornbeam and beech mixtures appeared to have a positive effect relative to pure plots of oak. However, beech took over in both the pedunculate and sessile oak plots, and is now the dominant species.

Beech grew relatively well and had an indicative yield class of 8. The current plots are reasonably impressive and of better quality than the other broadleaf species selected, apart from sycamore. As stated, where it was planted as a nurse with pedunculate or

sessile oak it tended to take over and dominate. These plots are now virtually pure beech, with few oaks remaining. The beech in the sessile oak plot currently has a mean height of 24.5 m, compared with 21.6 m in the sessile oak plot. This is indicative of a yield class of 6.

Spanish chestnut is also promising, although it suffered badly from frost in the earlier years.

Although a number of ash species were included in the plot series, none have grown satisfactorily. The acid nature of most of the soils at Avondale, (notwithstanding the earlier comment on liming in the nineteenth century), and the severe frost damage in the earlier years of the trials may have had a negative impact on the performance of the species. Their location on the lower lying areas near the river may have aggravated this damage.

Mixtures

As stated, mixtures of different species were used across the plots in order to reduce the cost of plants and secondly to minimize the risk of frost damage to the nursed species.

In general Norway spruce proved to be too vigorous as a nurse, suppressing main crop species such as pedunculate and sessile oak, beech, the other minor spruce species and Corsican pine. It also suppressed Douglas fir.

Larch was generally more effective as a nurse but suppressed Corsican pine, eastern white pine and the other slower growing pine species, such as Jack pine and cluster pine. Larch appeared to have a positive effect on the performance of hornbeam. It appears also to have been compatible with western red cedar, Lawson cypress and the redwood species. It is not possible to state if it had any positive effect on the growth of the other nursed species, however.

The lack of plot replication however makes it difficult to draw clear conclusions on the effect of mixtures, although larch/, hornbeam/ and beech/oak mixtures grew better than pure plots of oak. However, in the case of the two main oak species, beech eventually took over, became dominant and suppressed most of the oak.

Silver fir was not effective as a nurse species, due to its being badly damaged by frost.

Mixtures are commonly planted in practice nowadays, with larch being particularly well proven in terms of its nursing effect, particularly on impoverished mineral soils. Larch is also planted for other values, related mainly to the changing and attractive colour of its foliage with the seasons. Such values were not foremost in Forbes's mind in 1904.

Mixtures of spruce and pine are also widely planted, on peat soils in particular, but these were not included in the plots at Avondale. Neither were mixtures of Douglas fir and Sitka spruce. These now appear to be developing in interest.

Discussion and conclusions

The objective in acquiring Avondale in 1904 was twofold:

1. to establish a forestry school for working foresters in which young men could be trained in connection with plantation establishment and management and,

2. to enable trials to be laid down to determine the most suitable species for Ireland's afforestation programme.

The first objective has clearly been achieved: Avondale successfully realised its training role in the first half of the last century. The students who trained there in the first two decades of the century, and later, provided the competence needed to develop the state forestry program. Educational needs and services have changed since then; at present foresters are trained and educated at University College Dublin, Galway/Mayo Institute of Technology or Waterford Institute of Technology.

Avondale's main training function now relates to the second objective, in that it provides hard evidence on the ground of the performance of the main commercial and non-commercial tree species over a long period. The series of plots now provide living proof for growers of what to expect from the various species, tested over a period of one hundred years. This is particularly so in the case of the broadleaf species.

Most of the surviving trees in the plots are now between 92 and 99 years of age. Although a number of the plots have either failed or suffered severely from storm damage (December 1998), and currently have an unsatisfactory appearance, collectively they represent a highly valuable pool of information on species performance. Although the plots are relatively small in area, they represent the largest areas and number of species tested out in Ireland over the last 100 years, apart from The John Fitzgerald Kennedy Park at New Ross in Co Wexford, laid down in the 1970s.

Nevertheless, given the age of the trees, their present state and condition, the progress and developments in forestry over the last century, which has seen a six-fold increase in forest cover, and the original objectives of the initiative, it is fair to question the relevance and possible role of the plots into the future. Is the forestry agenda at the beginning of the 21st century different to that in 1904 and if so are the forestry plots at Avondale still relevant, and if so why? Or are all the values now based on a mixture of sentiment, and confused with images of Parnell and his values?

In answer it can be said that the surviving plots, particularly those with good demonstration value, represent reassurance of long-term performance, insofar as the main tree species are concerned, given their longevity and continued health.

Furthermore, although a number of the original plots and trees initially planted no longer survive, having either failed or blown down or been replanted with other species, the bulk of the plots are still on the ground. These provide a large amount of information on the performance of different tree species under Irish conditions, and on the rationale behind the make up of the forest estate in Ireland, which is essentially man-made.

The plots have been divided into four categories based on their demonstration value and recommended future management (Table 8).

Although only 26 of the original plots are now considered to have high value as demonstration areas, those considered to have limited value, 36, should also be retained for the time being. The rationale behind this recommendation relates partly to the need to provide shelter for the important plots, and the sensitivity of the Avondale area generally in terms of felling, and its high amenity value. However, many of the plots in this category also serve a useful purpose in demonstrating the difficulties in growing the particular species concerned. The medium to long-term plan for this category will centre on their gradual removal and replacement over the next ten to twenty years, with the

Table 8. *Demonstration value and management recommendations for the experiment plots at Avondale.*

<i>Plot demonstration value and management recommendation</i>			
<i>Good, retain as experiment plots</i>	<i>Limited, but retain as experiment plots</i>	<i>None, manage as a normal crop</i>	<i>None, clear out and reforest</i>
<i>Number of plots</i>			
26	36	30	12

most successful species from the particular genera concerned. For example, the poorly performing maples will be replaced by a good provenance of sycamore. Beech will gradually replace the hornbeams. The exotic oak species will be replaced by native species (this is part of the present plan). All the fir species will be replaced by Douglas fir, and the spruce plots by either Sitka spruce or Norway spruce. Pine species will be replaced by Corsican, Monterey or Scots pine.

The overall aim is to rationalise the number of plots and species, by concentrating resources in the future on the gradual conversion of the area from its current experiment plot state, to a demonstration forest that reflects the lessons learned from the first 100 years, and focuses on the key species insofar as Irish forestry in the future is concerned.

A key element in all of this will see the establishment by Coillte of a new Centenary Forest Trail at Avondale that will enable the public to come to a greater appreciation of its arboreal and historic values.

Forestry has come through significant change in recent times and all the indications are that it will continue to change into the future, in line with overall societal change and expectations. There are a number of reasons for these changes:

1. farmers have become involved in the industry in a serious manner and their interests are likely to grow in the years ahead, given the imminent changes on the horizon;
2. sustainable forest management is now high on the agenda of the industry generally, and there is increasing emphasis on broadleaf planting and species diversification;
3. while the production of a sustainable supply of roundwood for industry at a competitive price continues to be the imperative, other non-wood values are likely to play an increasing role - these include forest recreation and carbon sequestration. The big concern in 1904 was the low forest cover of the country and the need to develop a forestry programme to address future timber supplies for the country. (Even to this day Ireland imports half of its timber needs.)

The initiative at Avondale played a key role in the development of the forestry programme through the training of foresters and the provision of information on an ongoing basis on the growth patterns of the many different species tested. Without both of these ingredients policy makers and practitioners would have been working in the dark, and it is most unlikely that the programme would have been as successful as it turned out to be. The forest plots at Avondale provide hard evidence on the growth and performance of a wide range of tree species. This information is highly relevant, not only

for the evidence it provides on the successful species but also on those that proved to be unsuccessful. In hindsight it would have been possible to draw more definite conclusions on performance of the various species had the plots been somewhat larger and replicated. However, the plots are what they are, and the results to date do provide adequate evidence on what the best species are likely to be in the future, and secondly on what species warrant further investigation.

All of the information is highly relevant to an expanding industry that is under increasing pressure to diversify in its choice of species and to increase the level of broadleaf planting. In many respects the results at Avondale constitute a wake-up call for the industry insofar as broadleaves are concerned, given the overall disappointing performance of practically all of the species on what must be considered a moderately good soil.

New planting now being planned for Avondale will reflect the changing values taking place in forestry, and at the same time reinforce the results from the original trials and in so doing ensure the learning curve continues to rise.

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