IRISH FORESTRY

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The Society of Irish Foresters

The Society of Irish Foresters was founded in 1942 to advance and spread in Ireland the knowledge of forestry in all its aspects.

The main activities of the society centre around:

(a) Annual study tour
(b) Indoor and field meetings on forestry topics
(c) Production of two issues annually of Society's journal "Irish Forestry"

There are three types of membership:

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Technical Members shall be persons desirous of promoting the objectives of the Society: at the time of election hold a degree or diploma in forestry of a recognised university, or who have succesfully completed a full time course at a forestry school or who hold the Foresters Certificate of the Society: in all cases subject to approval of council.
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Cover: Dr Mark L. Anderson, 1895 – 1961. Anderson was effectively the founder of The Society of Irish Foresters. For an account of his career see the item *Mark Anderson – Scottish Forester* elsewhere in this issue.
(Photograph by courtesy of Dr Douglas Malcolm, Convener, School of Forestry, Institute of Ecology and Resource Management, University of Edinburgh.)

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Society of Irish Foresters
1942-1992

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1. British Forestry in 1990
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3. The Long Term Global Demand For and Supply of Wood
4. UK Demand For and Supply of Wood and Wood Products
5. Development of the British Wood Processing Industries
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Editorial

Ireland's forests are regarded as a natural resource by the politicians and public alike but it is a resource that has not developed by itself alone. Virtually every tree that we see in our forests today is planted, every cubic metre of timber harvested has been the result of the skill and effort of a previous generation of forest workers and their managers.

In the year the Society of Irish Foresters was founded some 1,800 ha were established and 134,000 m^3 of timber harvested. Today, fifty years later these annual figures have increased to 21,000 ha and 1,930,000 m^3 respectively.

Ireland is now supplying 55% of its constructional timber and is self sufficient in palletwood. By the turn of the 21st century it will be a net exporter of timber. This is a remarkable achievement by any standards and the Society of Irish Foresters has, over the years, played a significant role in this success story.

Since its inception in 1942 the Society has purused the aim of 'spreading the knowledge of forestry in all its aspects'. Field days, symposia, study tours, forest walks, exhibitions, evening meetings and publications have been the means by which the Society has accomplished its objectives. Generations of Society members and associates, have benefited from these efforts, not only by being informed of current events, but also, by providing a social forum which bound the profession together and raised the image of forestry in the public eye. Much of this work, however, was accomplished with little publicity.

Times are changing. The formation of a large State commercial forestry company – Coillte, the emergence of the private sector as a significant force in forestry and the greater awareness of environmental values by the public are events that will greatly impact on forestry in the coming years. The Society, as the main body of professional foresters within the country, is in a unique position to take a responsible position to influence and guide the development of the sector by providing informed opinions on forestry policy and practices that are in harmony with the environment and will lead to the sustainable development of the resource.

The next fifty years of forestry will certainly be very different form those past. No longer will the Society continue to be the sole organisation with an interest in forestry in this country. Other organisations are emerging, and if the Society is to continue to play a significant role in the development of the sector in the next fifty years then it must adopt a higher public profile than in the past.

Alistair Pfeifer

Building a National Resource Fifty Years of Irish Forestry

J. Durand

The text of the 1992 Augustine Henry Memorial Lecture given by Dr. Jack Durand to a public meeting at U.C.D. Belfield, March 1992.

Mr. Chairman, Ladies and Gentlemen,

There are, I think no less than four good reasons why a lecture such as this should be held at this time.

The first is to honour Augustine Henry. As first Professor of Forestry in Ireland, he deserves honour for that alone. But his reputation as a pioneering plant collector in China before the end of the last century, his forthright advocacy of a properly generous scale of planting and the use of the then barely known North Western American species, his pioneering work on tree breeding and his joint authorship with Elwes of their classic *The Trees of Great Britain and Ireland*, have all won him acclaim. It was apt that the Society some years ago and in the presence of his widow, unveiled a memorial stone and planted a group of trees to honour him at Avondale, the cradle of Irish Forestry. Irish Forestry was always closest to his heart – he was Irish through and through, as his biographer Sheila Pim said in *The Wood and The Trees*. The Northern Ireland Forest Service similarly honoured his memory in his native Ulster.

The second reason of the four is to honour the founding of the Society which took place 50 years ago, under the leadership of Dr. Mark Anderson, then Director of Forestry and who was the first President of the Society and the editor of its early journals. But more of that anon.

The third reason is to participate in National Tree Week, organised by the Tree Council of Ireland. The Society of Irish Foresters, with over two dozen other groups involved in trees in one way or another, formed the umbrella grouping some years ago to further trees and tree-growing.

And finally, the fourth reason is one which has always been paramount in the aims of the Society, to advance and spread the knowledge of forestry in all its aspects.

Fifty years is in or about a common rotation length for many species of forest trees and it's a convenient point for gaining some perspective. Were we to go back 100 years, we would in fact be back to the very start of State Forest planting. This was a generously conceived, but hopelessly located,

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famine relief scheme based at Carna in West Galway on peat-covered granite outcrop within sight and sound of the rages of the Atlantic. It failed utterly as a planting scheme and discouraged further attempts until changed circumstance arose in the early years of this century.

I say only a hundred years ago – because a century is a short time in the life of a national or forest tradition. Trees as we know are the biggest and oldest living things but we do not yet know how big or tall our greatest trees will become or how long they will live. The debt forestry owes to the private estates in this country cannot be overstated and this aspect is yet another example. Giant Redwoods, Sequoiadendron, growing at Powerscourt and Curraghmore and not yet a century and a half in age, are still increasing in girth and height and bid fair to readily outdo 50 metres in height. This is to quote just one noted species. And it is a story which is still unfolding. Forestry is indeed very young in this country.

We need not dwell on the well known story of the purchase by the infant Department of Agriculture, of Avondale and the start of forester training there in 1904. It was ironic that government intervention was producing foresters when there were no state forests and private estates were falling asunder under the cumulative Land Acts. But anyway, within a few years, some few thousand pounds becames available each year after a report by a Departmental Committee in 1908. By the time the ravages of the First World War had passed, with its heavy demands for timber, the State Forest area at the time of the Treaty was about 7000 ha in the Free State and 1500 in Northern Ireland. Planting was going ahead at 500 ha per year. It may have been timid and belated but nonetheless a real start had been made.

By the 1930s, after recession and economic pressure on farm produce and world-wide unemployment, there was a greatly increased planting programme of 2500 ha in the Free State and 400 in Northern Ireland. It was a time when landowners were flocking to sell land at depressed prices and many of the best current forest properties were acquired in those years.

Then came the Second World War and a setback in planting, particularly in the 26 counties, due to difficulties of obtaining seed abroad, as well as in many other ways. At the other end of the forest time scale, forestry was once again calling on private woodlands to supply timber for both building and firewood. Because of the demand, standards in sawn timber dropped and native timber acquired a bad name when compared with the prewar choice selection from Baltic countries. It is only in recent times that standards of quality and uniformity of supply have been establishing a reliable reputation for native softwood supplies. And the setting of such reliability is an essential step before entering on a determined export drive – something which is already dawning. The harmonisation of forest production forecasts with processing developments for best national interests also require continued energy and liasons.

But to return to our starting point, the early 40s were times when manual effort was literally that. In the felling of quite substantial trees, not only would they be felled, using a bowsaw or a two man cross cut saw, but the extraction of the tree from stump to roadside would also be done by hand, or sometimes by horse – that friend of man and especially of forest worker – even occasionally still used today. There was no such thing as chain-saws, and tractors were almost unheard of.

To illustrate the rounds to which forestry went, Tom Moloney, a founder member of the Society and now over 80 years old, has told me of being forester at Glencree when the War began. As part of the Emergency Firewood schemes, he was sent to Croneybyrne Wood, Rathdrum to produce firewood from oak and birch. He was given two small portable sawmills and the services of Avondale trainees to augment his labour force but was given only a coupon ration of a gallon or two of petrol a month for the sawmills. In order to power the engines, a metal retort was supplied to him to produce charcoal – making about a hundredweight, say 50 kilograms of charcoal, from a full load of closely packed billets of timber, say a tonne, by controlled combustion in the retort. When ready after a 24 or 30 hour combustion, the charcoal could then be transferred to a separate gas producer unit and ignited, from which a gas pipe led to the carburettor of the sawmill engine. Using a drop of petrol the engine was readily enough started but making a judicious switch at just the right moment to the gas, was tricky. During the period the Germans dropped a bomb in the wood and it was said locally that Hitler had becomes worried about the Croneybyrne war effort!

Despite the difficulties of wartime, planting continued although restricted. This was a time when even tyres for bicycles – the common transport for foresters and men, were in short supply. The first outing of the Society was based at Clonmel in Summer 1943 for ease of rail communication – and even trains were unreliable in frequency and often bereft of steam due to poor coal and damp turf.

The Society was formed with the primary objective of serving professional foresters and was originally intended for the 26 County area, or Éire as it was called, but it was soon extended to embrace the entire country. In its history, the Society has had much to do with Northern Ireland forestry and has numbered four Presidents from the North. The easy contacts, North and South, are something of which the Society is justly proud – this was exemplified by an incident when the John F. Kennedy Arboretum was being established and native specimens of trees were sought from national forest services abroad. The British Forestry Commission called on the Northern Ireland Forest Service, assuming that a joint offer would be made and were informed that they in Belfast would themselves arrange this matter with their "fellow Irish foresters in Dublin".

The first annual meeting of the Society was held in February 1943, by which time numbers had grown from 31 foundation members to over 100 foresters and 21 associates. By comparison, there are 650 members today. That first meeting was addressed by Arthur C. Forbes still fit and well, having retired 12 years previously. Forbes was a remarkable man and to him above any other is the philosophy and work attitude of the State Forest Service due, I think. If Avondale is the cradle, Forbes is the father of Irish forestry. Coming to Ireland from Newcastle College in 1904 as Visiting Expert, to examine Avondale and propose a working plan, he was to take employment in the post of Forestry Expert in 1906 and began implementing his own plan and then was successively Senior Forestry Inspector, Chief Wood Procurement Officer during the '14-'18 war, Assistant Commissioner during the two years when British Forestry Commissioners funded the State Forestry programme, again Senior Inspector and finally first Director of Forestry. He retired in 1931 and was then offered the post of lecturer in forestry at U.C.D., where Tom Clear, later professor and also for decades the Secretary and Treasurer of the Society, was one of his first students. Forbes' students were privileged to learn from one who had begun his Irish forestry career with only part of a table in Agriculture offices as his work space and saw his creation grow into a sturdy effective body. It was he who shouldered the risk of trying such as Sitka spruce and Lodge pole pine, while not being so bold as to cast aside the old species of European larch, Scots pine and beech and oak, on which his earlier forestry would have relied. It was apt that Forbes was honoured in being created first honorary member of the Society, an honour sparingly bestowed, there being only ten recipients, to the best of my knowledge.

The three most recent honorary members were the late Sean McBride together with H. M. FitzPatrick and O. V. Mooney. H. M., that much admired man of forestry is a link with those early names, in having studied under Henry and having worked for many years under Forbes and also under Anderson. O. V. Mooney, a founder member like Anderson and like FitzPatrick, was to become in time first head of forest research. He has always been a staunch upholder of forestry and has been a well kown ambassador for Irish Forestry.

Like Forbes, Anderson displayed an oustanding physical and, mental energy. During his years as Director from 1939 to 1946, he showed a familiarity with plantations and problems which belied the effects of expansion and wartime restrictions on travel. He resigned to take the post of Assistant Director of the British Commonwealth Forestry Bureau at Oxford and subsequently became Professor of Forestry at Edinburgh in his native Scotland.

As the war ground on, with its tedious restrictions and personal hardships, thought was given here as is Britain, to post war forest policy. Advocates, such as Tom Clear, then lecturer in forestry at U.C.D., urged a greatly expanded programme of 8000 hectares a year. Sean McBride, always a strong advocate of planting and at that time about to launch a new political party, set sights even higher and became identified with a 40 year programme of 10,000 ha per year to make an estate of 400,000 hectares.

The actual programme was proceeding at a fraction of this rate until McBride had his way – almost but not quite – in 1948, when he was a member of a newly elected Coalition Government. As Minister for External Affairs he inserted his forest target as a paragraph or two into the general omnibus government proposals submitted by him to the European Recovery Programme. It was a policy thus decided and imposed on the Department concerned without any prior assessment or planning which had then to be considered. Although McBride's targets were immediately compromised and reduced, the planting rate was greatly extended year by year and reached the 9800 ha figure in 1960.

By using figures for areas replanted and subsequently also including figures for private planting in the total figure of planting, McBride's dream of a 400000 hectare target of new planting was never adopted, even though circumstances have subsequently brought this figure well into sight.

However modefied, the greatly increased expansion was radical and caused many changes. Acquisition spread in earnest to West of the Shannon and on to extensive blanket peats. The percentage of new planting in the West trebled within ten years, and more than half the total State planting was being consistently done in eight western counties. Such concentration in terms of age and area is not in the nature of sound planning for sustained programmes of work or output. It was a determined response to achieve a target almost exclusively defined by area planted and while a tribute to the forester in being able to establish crops on previously avoided areas, many of the plantations are suspect on economic grounds, and physical stability through a rotation period is also a doubtful probability.

The mass plantings were made possible by the scale of acquisition and by new techniques in drainage and ploughing. The purchase of no less than 21 heavy plough units and tractors in 1951 heralded the rapid change. The ploughs turned a single or double ribbon, making a corresponding deep furrow which acted as a drain. Other types of plough were fitted with deep tines and did excellent work in breaking soil pans which were a feature of many coarse-soiled, acid, upland areas. So now the forester was going further out on the bog and higher on the upland than ever before.

The reluctance of the roots to penetrate other than along the upturned ribbon of peat ploughing, raised questions of stability for such areas, leading to refinements in ribbon orientation and in time also to an attempt to form broken runs of ribbon, rather than continuous lengths. These drawbacks and the difficulties foreseen in felling and extracting an eventual crop of timber over this terrain, caused, this standard approach to be questioned over the years and further refinements, such as tunnel ploughing to avoid the gross physical profile, while still providing good drainage, were introduced.

The replacement of ploughing on flat area by machine mounding, creating a pattern of drainage at the same time, was another change.

The fifties and sixties saw the change in forestry from being labour intensive to the use of more and more machinery, together with work study and later method study and the forest workforce reduced from a peak of over 5000 in 1956 to 2000 today. H. M. FitzPatrick in one of his publications in the fifties truly said in his pungent introductory sentence "All one needs to get started in forestry is a spade". It can still be true but equipment has become increasingly sophisticated, and costly of course, over the years. In noting the change, it is only fair to pay tribute to a body of forest workers that served forestry so well. So many of them cared for the forest with a devotion and intelligent interest that has contributed much to the development of the plantations and a tradition of service.

In moving from being an undertaking primarily concerned with planting, to a timber producing and selling agency, forestry has had to adapt. The recruitment of engineers in the 1960s was due to the need for a network of road layouts which in time had to adapt to the economics of off-road haulage and the tonnage and truck sizes allowed on public roads.

A major step in developing sophistication of forestry was the creation of a Research Section in 1957. In time it was in a position to advise on an extremely wide range of conditions from soils to crop structure and on forest diseases.The first inventory of volume and production estimates was completed. Research also became an important listening and contact point for awareness of developments abroad. Up to then contact and experience abroad was open to only a limited few and an invaluable contribution made by the Society in those early years was in providing a forum for exchange of experience and for the acquisition of knowledge. On day outings, formal meetings and on Annual Study Tours, members studied and discussed techniques and results. Beginning in 1949 with a visit to Wales and followed by visits to Scotland in '51 and subsequent tours to Germany and Denmark and many subsequent foreign tours, the Society gained greatly from such contacts and introduced members to foreign experiences which would not otherwise have been available. Groups from other countries likewise began to visit here and gave of their experiences and suggestions.

The Journal of the Society has become a prime record for Irish Forest experience and innovation and many items of work undertaken in forest management or forest research were first published in its pages. It was widely circulated abroad on subscription to institutes and libraries and thus further contacts were made and strengthened. Such contacts and limited English led to an occasion when Cecil Kilpatrick, then President of the Society of Irish Foresters and coincidently President of the Irish Deer Society, received a letter from India addressed to him as "President of Ireland"!

The mid-fifties saw the creation by Malachy Sharkey, of the first integrated forest company, Irish Forest Products. Proudly proclaiming its activities as ranging from seedling to sawdust, its forest and sawmill activities were absorbed in time into the Woodfab-Smurfit operation. I remember Mr. Sharkey's emphemistic reference to the sale of standing timber by the State as a "lucky dip", offering little towards rational forward planning by sawmills for sawlog quantities. At that time and for many years thereafter, sales were by periodic sealed tender, this so called lucky dip. Recent years have brought more refined and less haphazard methods, of ensuring a reasonably even supply of timber on to the market and at competitive prices, which nonetheless allow for an inducement to more efficient sawmills.

During the mid-sixties, responsibility for wildlife was assumed by State forestry and in time a Wildlife Act, covering conservation and management of flora and fauna was sponsored in 1976. In recent years the Office of Public Works has assumed these responsibilities. At the same time, the public representing an increasingly urban population were resorting to the forest for recreation. In place of being discouraged from entering a forest for fear of fire or other unstated risks, the public were invited and, following a path in recreation as in wildlife, already explored and imaginatively trodden in Northern Ireland, many facilities, ranging from a simple picnic site to quite elaborate developments, were provided and hugely enjoyed.

1970 was marked as European Conservation Year. In one reference in the journal I noted it had become conversation year – I wonder was it tongue in cheek on the part of the recorder – or perhaps a skeptical editor! To encourage a wider awareness of nature and conservation, the Society inaugurated a large number of forest walks and these were very popular with the public and were continued for many years.

In moving along over the years, many of the once familiar terms such as chains, straight and square, yards, feet and inches, Petrograd Standards and Hoppus feet, quarter girths, acres – English and Irish, hundredweights, stones, pounds and ounces as well as guineas, half crowns and shillings, cubic feet and gallons – even pints – although the term is still much used colloquially – have yielded to modern and more convenient metric units.

Changes in style and control of the forest programme also took place over the years. In the early 1950s the professional forester lost his position of authority and influence with the political head of his department and became subordinate to general Civil Service administrators. Only a change in personalities was necessary to bring this about, the legislation under the Ministers and Secretaries Act from the early years of the Free State being the supporting power. Henceforth the forester became an advisor, which led to many anomalies where responsibility for managing resources of great value in labour, materials and machinery lay with the forester but yet he could not purchase even a trivial piece of expendable equipment without approval, nor sign even the simplest letter of advice going to a landowner.

In the resolution of questions related to forest policy and management, the Society, composed after all largely of State employed personnel, was understandably but regrettably loath to speak out on such matters. The absence of a clearly expressed forest policy was not given prominence as one would expect and it was left to the independence of such as Profesor Tom Clear, notably, and later two editors Dr. Jack Gardiner and Dr. Ted Farrell, all three, academics and therefore removed from the Civil Service, to draw attentions to anomalies or absences in policies. It is noted for example, that it was Professor Frank Convery who initiated the discussion of the apparent failure in Civil Service structures in managing the forest estate in the late 1970s, which led in time to the Trade Union of forest officers publicising their criticisms. The subsequent exposure of the question, led to the Review group which in turn influenced the creation of the structures we know today. The Society's submission to the Review Group, while giving well reasoned suggestions on policy under several headings, does not address the changes if any in management structures it would see as desirable.

The impact of the creation of Coillte Teoranta as a commercially orientated, limited, State company has been the most dramatic change in State forestry since its beginning. Now entering on its fourth year and trading against a background of difficult sale conditions, Coillte aims to become self-funding in all respects after taking account of European Community grants and to be nationally self-sufficient in softwood by 1996. It is striving to broaden its potential revenue base and to pursue the creation of rewarding downstream industry. These next years will be critical in setting a pattern of results and a historic basis of comparison for assessment. Forestry is an undertaking where mutual support – indeed synergy – between business and biology is necessary. One can't have one without the other and in walking that very fine line the critical path of best advantage, so ill defined at times even in hindsight – will Coillte's story be recorded.

The availability of European Community funding for certain Coillte operations as well as funding for private planting and related work has given a remarkable boost to forest operations. This year the greatest ever planting programme will be completed when Coillte's total is added to that of private individuals and companies. The great expansion in private ownership is having a dramatic impact on the spread of ownership and is drawing widespread financing into forestry from entirely new sources. It augers well for variety and innovation in management and in vibrancy in Society deliberations and attitudes from which the entire industry stands to gain. The recently announced and greatly increased planting grants and farm premium payments will no doubt draw in a better type of land and lead, one hopes, to a better spread of species and away from an undue and potentially hazardous reliance on a very limited number of species. Expansion of planting brings with it also a wider need for care in avoidance of risks to aspects of conservation and enviroment, including landscape.

And speaking of such hazards, it is particularly in our interests to maintain a soundly based and sensitive research arm not only to investigate future paths but also as insurance to monitor conditions and guard against possible epidemics of disease. We had very little elm in this country and its almost entire removal by Dutch Elm disease was noticeable only in its limited pockets of location, but yet everyone was aware of the thorough depredation. Our forest plantations have thus far escaped epidemic losses but in forestry, as in politics, the price of freedom is eternal vigilance. The recent threat to Kinsealy research unit and the curtailment of forest research in certain aspects are causes for unease, especially at a time when greater insurance is indicated for an increasing capital at risk. The forest industry has by now an inherent dynamism and a huge potential to be encouraged and developed. For the same reason the long hiatus in the training of a stream of foresters will soon pose the likelihood of a shortage of skilled supervision for forest properties.

In this account I have had to omit many aspects that would be of interest to various members for one reason or another. I can only express my regrets and also to say that the views expressed are my own and not necessarily those of the Society.

Sitka Spruce in the 21st Century Establishment and Nutrition

Richard Schaible

Research Officer, Forest Service, Department of Agriculture for Northern Ireland.

Summary

Historically, new plantations of Sitka spruce were established on a wide range of soil types in the British Isles by providing a raised or otherwise weed-free planting position, using manual or mechanical techniques. Some of the benefits of mechanical ground preparation can be achieved using herbicides. The application to second rotation sites of the results of research and development of mechanical ground preparation methods for afforestation is speculative. Inputs of phosphatic and nitrogenous fertilisers have been necessary on most upland sites. Strategies are available to reduce N fertiliser requirements. Productivity may decline with successive rotations on some sites due to site degradation, but is likely to be increased on others due to improved establishment methods.

1. Introduction

In common with other tree species introduced to the British Isles from the Pacific coast region of North America, Sitka spruce (*Picea sitchensis* (Bong.) Carr) is highly productive compared to native European species. The predominance of Sitka spruce in timber and fibre production has come about for several reasons. It is relatively resistant to indigenous forest pests and diseases, it can be established on a wide range of sites using relatively simple methods and it has, in general, proved responsive to fertiliser applications on sites where the availability of nutrients is limiting to growth. The timber has good fibre properties for pulpwood production, and is a versatile whitewood that can be used in a wide range of structural and non-structural applications. Underlying these factors are the historical policy commitments of our governments in favour of the afforestation of marginal land and maximum timber production.

This paper addresses the extent to which the problems of growing Sitka spruce in the British Isles have been resolved. Past developments and current uncertainties in establishment practice and the use of fertilisers are reviewed, and suggestions are made regarding prospective information requirements in the future.

2. 20th century developments

2.1 Early development

Sitka spruce was first introduced to the British Isles in 1831; up to the early 1900s it was predominantly planted on favourable sites in gardens, arboreta and small plantations, often in mixture with Scots pine (Faulkner and Wood, 1957). The discovery that Sitka spruce could be easily established on upland blanket peat using a technique imported from Belgium known as 'turfing' took place at Corrour in the Scottish Highlands from around 1908 (Stirling Maxwell, 1951). This consisted of hand cutting and distributing sods at the desired tree spacing from parallel drains about 4m apart. Excess soil moisture and runoff was removed from the afforestation area by linking turfing drains to natural watercourses by means of additional 'cross' drains. It was also found that the initial growth of turf planted Sitka spruce was increased by the application of basic slag, a phosphatic fertiliser then readily available as a by product of the iron and steel industry. This was found to be inadequate, however, where vigorous heather (*Calluna vulgaris*) regrowth on and around turfs had occurred. The proposed solution was to plant in mixture with Scots pine, which would suppress the heather and enable the development of the spruce crop.

As a result of experience at Corrour and other areas, particularly the Lon Mor, a nearby Forestry Commission experimental reserve (Macdonald, 1945), Sitka spruce quickly displaced Scots pine and Norway spruce as the favoured species for state afforestation throughout upland Britain and Ireland (Robinson, 1931; McMahon, 1945). The establishment package of hand turfing and basic slag application was to become standard practice in these areas on peat and upland mineral soils, and remained so, until mechanised methods were developed (McMahon, 1945; Zehetmahyr, 1954).

2.2 Mechanisation of ground preparation for afforestation

A comprehensive review of the development of forestry ploughing techniques in Britain is given in Neustein (1976 a, b, c; 1977). Mechanised methods of producing raised planting positions on peat and poorly drained mineral soils were developed in the 1940s in the form of single and double mouldboard ploughs pulled behind crawler tractors (Zehetmayr 1954 & 1960). These were in widespread use by the late 1950s and enabled a greatly increased rate of afforestation, including the planting of sites which had previously been considered unplantable. On the wettest peats it was common practice to carry out 'pre-draining' using deep single mouldboard ploughs, such as the Cuthbertson 'F' type plough, before ploughing for planting with shallower 'P' type double mouldboard ploughs (Dallas, 1962;

O Carroll, 1962). Large single mouldboard ploughs were also used for cross draining on peat, whereas on mineral soils this was done by backactor diggers or tracked excavators.

Research into the effects of cultivation initially concerned the effects on growth of increasing intensities of cultivation, using open furrow ploughing techniques (Taylor,1970). The main factors limiting the application of this approach were perceived as being the availability of suitable machinery and cost. Early cultivation experiments on peat showed growth was greater on the large ribbons produced by the 'F' type plough than on the 'P' type plough ribbons, (Binns, 1962; Jack, 1965). However, there was concern that rooting would be excessively restricted by the closeness of the single mouldboard plough furrows and that the resulting stands would be unstable (Zehetmayr, 1954). A commonly used compromise was to alternate 'P' and 'F' type ploughing (Dallas, 1962). In the late 1950s an alternative approach to ploughing peatland known as tunnel ploughing was developed at Glenamoy, Co Mayo (O Carroll *et al,* 1981). The technique resulted in subsurface drainage channels and continuous ribbons for planting. Its main advantages lay in greater control of the water table, deeper rooting was possible, and radial root development was not restricted. Although widely used in Ireland in the afforestation of western blanket peat, tunnel ploughing was unsatisfactory on shallow or amorphous peats and required at least a slight slope. It was also unsuitable for peats containing pine stumps (D. G. Nelson, pers. comm). Further development of the technique enabled it to be used on amorphous and shallower peats and the production of mounds instead of ribbons (E. Hendrick, per. comm). Another cultivation technique based on excavating narrow trenches, known as vault draining, was tried in Northern Ireland (W. T. Wilson, pers. comm), however potential applications of all these methods were forestalled by a reduction in the rate of afforestation of peatlands generally in response to economic and other pressures (eg Farrell and Boyle, 1990).

The mineral soil types on which some form of cultivation was considered necessary for establishment fall into two main groups: heathland soils, which are predominantly podsols and ironpan soils with a thin layer of peat, and gleys, particularly surface water gleys (Pyatt and Craven, 1978). Where the depth of organic matter is sufficient to significantly influence the planting medium, but not enough to prevent cultivation of the underlying mineral soil (conventionally 45 cm in Britain and 50 cm in Northern Ireland), these labels are prefixed with the term 'peaty'. It is important to note that on mineral soils an important function of ploughing was to reduce competition from vegetation. On drier sites it was common for trees to be planted on the side or in the bottom of plough furrows (Zehetmayr, 1960). At an early stage single mouldboard tine ploughs were introduced to heathland sites in order to rupture ironpans and improve aeration in the upper soil horizons (Zehetmayr, 1960). On some sites in Ireland it was only necessary to carry out ripping (Verling, 1967), while on a peaty ironpan site in the border region of South Scotland deep ripping resulted in reduced initial growth compared to open furrow ploughing (Quine and Burnand, 1991). Although early responses to increasing the intensity of soil disturbance were substantial (Zehetmayr, 1960; Taylor, 1970), in the longer term growth does not appear to be increased significantly (Wilson and Pyatt, 1984). Complete ploughing using the rotary mouldboard plough (Thompson, 1975) avoided most of the limitations of standard approaches to ploughing on heathland soils (Ross and Malcolm, 1982). However the long term effects of the treatment on tree growth and the nutrient economy of the site are unknown.

On surface water gleys it became clear that even shallow single mouldboard ploughing was detrimental to tree stability (Savill, 1976). Under Irish conditions mole drainage has been a successful alternative aid to establishment (Hendrick, 1989). However, as with tunnel ploughing, more care is required in cross-draining than with open furrow ploughing. In addition control of competing vegetation is more important in the first growing season because weed-free planting positions are not provided. Mole drainage appears to have considerable advantages for stability over open furrow ploughing, including double mouldboard ploughing, because radial rooting is not limited by adjacent open drains (Schaible, 1986; Hendrick, 1989). However, moling is unsuitable on peaty gleys; in these situations and in Britain the most common alternative to double mouldboard ploughing is mechanical mounding, either by excavator or using purpose build machinery.

With mechanised site preparation there was a tendency to cross drain at a lower intensity than hitherto. Ditching experiments laid down on deep peat and surface water gley soils showed that the potential for lowering the water table any further than was achieved by the cultivation systems described above was slight and would depend on development of the tree canopy and interception of rainfall (Savill *et al*, 1974; Savill, 1976). The main objective of cross drains was to tap water from springlines and plough drains, and if possible to eliminate wet areas which may become centres of instability (Pyatt, 1990a).

2.3 Nutrition

The practice of applying a handful of basic slag at planting was carried forward to establishment on ploughed sites, however the problem of early growth check in association with *Calluna* was no less apparent than on turfs. In Northern Ireland it was sometimes treated by deepening of plough furrows and placing the excavated spoil around trees (Jack, 1965). The most common counter measure on all upland soils where 'heather check' was anticipated remained to plant in mixture with Scots pine, and subsequently lodgepole pine (as seed supplies became more readily available) or Japanese larch, although more often as an insurance policy rather than to achieve a predictable result (Macdonald, 1953).

Formal nutrition research confirmed indications from investigations at the Lon Mor that ground mineral phosphate was more effective than basic slag, and that broadcast applications were more effective than placement in the planting hole or under the plough ribbon (Dickson, 1971). Useful as this information was, it did not reverse the established trend in Britain and the Republic of Ireland which was to favour the use of lodgepole pine over Sitka spruce on infertile peats (Edwards, 1962; O Carroll, 1962). In Northern Ireland the policy remained to plant Sitka spruce in anticipation of good timber yields once stands were established (Jack, 1965). The principal limitation to this appeared to be the supply of phosphate (P), even in the presence of vigorous *Calluna*. The phosphate requirement could be met by the application of 90 kg P/ha on one or two occasions (Dickson, 1971; Dickson and Savill, 1974). It is interesting to note that studies of upland blanket peat in Northern Ireland suggested that it was even more nutrient poor than at the Lon Mor (Dickson, 1962). It subsequently became apparent that, despite the provision of adequate quantities of phosphatic fertiliser, growth of Sitka spruce on oligotrophic peat in Northern Ireland was limited by the supply of nitrogen (N) within 8-10 years of planting (Dickson and Savill, 1974). The only reliable means of meeting this requirement appeared to be the repeated application of 100 kg N/ha at intervals of 3 or 4 years. In practice it has become customary to apply 150 kg N/ha at slightly longer intervals (Atterson, 1978).

It was not known to what extent N requirements would be affected by increased interception of rainfall by the developing tree canopy. On the assumption that the release of organically held nitrogen in upland peats as a result of biological activity is limited by anaerobic conditions (Adams *et al*, 1972; Adams, 1974), it was thought that a reduction in water table through increased interception should be associated with an increase in the availability of nitrogen. However, although a reduction in water table depth under Sitka spruce crops on blanket peat may occur after fertiliser application (Farrell and O'Hare, 1974; Farrell, 1985b), the effect appears to be temporary (Farrell, 1985a). Studies in Northern Ireland have indicated only small differences in water table depth under nutrient deficient, post canopy closure Sitka spruce crops compared to unplanted virgin peat (Schaible, 1992). Under less extreme water table environments conceptual and empirical models predict that, once canopy closure has been achieved, the demands of the crop for nutrients supplied from the soil becomes relatively insignificant in relation to recycling processes within trees and litter (Miller, 1981 & 1986).

Significant responses to applied potassium (K) were also found to occur on peat soils (Dickson, 1969; McIntosh 1981 Dutch *et al.*, 1990). In Ireland it has been shown that significant quantities of K are supplied to most areas in precipitation (O Carroll and McCarthy, 1973). Although there is wide year to year variation it is not normal practice to apply K early in the rotation, in contrast to practice in Britain, where up to three K applications may be recommended (Taylor 1991). One exception is the midlands of Ireland, where K application is regarded as essential for establishment on reasonably fertile fen peats (Carey, 1977). In Northern Ireland K deficiency is limiting to growth in young first rotation Sitka spruce plantations on more fertile mesotrophic peat, where the native vegetation is dominated by grasses. The normal application rate is 100 kg K/ha (Atterson, 1978).

Early growth of Sitka spruce was also found to be limited by the availability of P on various mineral soil types. In Britain these included heathland soils (Zehetmayr, 1960), and, in Ireland, podsols and ironpan soils overlying old red sandstone (ORS), and on some gleys and peaty gleys (Carey, 1977; Adams *et al.*, 1970; Savill and Dickson, 1975). On heathland soils in northern Britain and on ORS areas in south-west Ireland growth check in association with *Calluna* was persistent in spite of P application. On some sites removal of the *Calluna* by hand pulling or cutting, herbicides or shading resulted in a growth response (Weatherell, 1953; Leyton, 1955). The latter effect provided justification for the establishment of spruce/pine nursing mixtures. On ORS in Ireland the problem was related to the earlier removal of organic material for fuel, however the underlying cause was essentially the same in that the soil supply of N was inadequate.

On the poorest heathland sites the prognosis was similar to that for infertile peats, i.e. that regular applications of N-fertiliser would be necessary to enable pure spruce crops to close canopy. On many sites in the ORS region of Ireland it appeared that the growth response to applied N was even more short lived than on oligotrophic peat in the north (Carey, 1977). An alternative solution to the problem came from field experimentation in the 1960s to examine the long term effects of planting 'nursing mixtures' (O Carroll, 1978) which had been commonly used in place of herbicide for establishment for several decades. After 16 years, growth of Sitka spruce was significantly greater in mixtures with pine or larch than in pure controls. Foliar analysis showed that this was associated with significantly greater uptake of N, even though *Calluna* had only been partially suppressed. Results from similar experiments planted on heathland soils and deep peat in Britain have demonstrated that the 'mixture effect' extends to other N deficient soil types, (McIntosh, 1983; Taylor, 1985; Carey *et al.*, 1988), however it may not be apparent where growth is also limited by availability of P.

The impact of nutrition research on the productivity of Sitka spruce in Northern Ireland is demonstrated by assessments of general yield class in permanent sample plots of different ages used for forest inventory, shown in Table 1. Over three decades of planting the average yield class of plantations on peaty soils and shallow and deep peat has increased by an average of 4. These definitions refer to soils with a surface organic horizon of 5-50 cm, 50-100 cm and >100 cm respectively, which are well represented over all regions of Northern Ireland apart from the south-east. The apparent increase on gley soils may include regional effects, in particular an increase in planting at lower elevation in the south west in the 1960s, while on well drained soils mean yield class has not increased. Similar increases in yield class with decreasing age have been reported from Northern Britain (Worrell and Malcolm, 1990).

Table 1: Mean Yield Class of Sitka spruce plantations on different soil types in Northern Ireland by planting year.

Planting Years	Brown earths/ Podsols	Gley soils	Peaty Podsols	Peaty gley soils	Shallow peat	Deep peat
1950-59	19.5	16.0	13.0	13.6	10.5	8.9
1960-69	19.1	19.6	15.8	15.4	14.5	11.3
1970-	19.0	20.8	16.5	16.0	16.0	14.2

3. Current uncertainties

3.1 Establishment of the second rotation

Potential problems with the establishment of the second rotation were discussed in papers given at a symposium of The Society of Irish Foresters in 1979 (Malcolm, 1979; Hendrick, 1979; Moloney, 1979). However, evidence from surveys of establishment success in the second rotation has suggested that initially the main problem has been in achieving an adequate stocking (eg Tabbush, 1988). Since by definition trees were previously satisfactorily established on second rotation sites, the source of this problem is the failure to recognise differences in the site brought about by growth and clearfelling of the first crop, or as stated by Malcolm in 1979, failure to exploit the increased variability of second rotation sites.

The initial problem in establishing plantations and achieving stocking targets on second (and subsequent) rotation sites is due to the reduced availability of planting microsites. Planting is made difficult and arduous by the residues from harvesting (Nelson and Dutch, 1991) and tree roots. The distribution of residues will depend to a large extent on the harvesting process, but can vary from a low relatively uniform cover to non-uniform piles or well defined bands which have been compressed by the passage of extraction machinery. If the previous crop was established on hand spaced turves raised planting positions will not be available. Where the remains of plough ribbons are available for planting it is difficult to maintain modern spacing specifications, which are normally wider than the original ploughing specifications. Moreover windthrow in crops established on plough ribbons usually results in peeling of the combined root plate-plough ribbon mass (Savill, 1976) and this creates particularly difficult conditions for replanting, where the choice of alternative microsites is limited by the area occupied by the old plough drains. The reduction in area for planting is exacerbated further by the need to plant away from the edges of stumps to avoid unduly restricting radial rooting in areas of moderate to high wind-risk (Quine *et al*, 1991).

Protection requirements are probably the most important secondary factors influencing establishment success of Sitka spruce in the second rotation. The outstanding protection requirement is against damage caused by the insects *Hylobius abietis* and *Hylastes* spp, which utilise tree stumps and dying roots for breeding. Replanted trees are vulnerable to attack, however the amount of damage sustained can vary widely between and across sites. Other protection requirements will vary widely and will not be significantly different in character from those of first rotation plantations. Some losses may also occur due to competition from the vigorous regrowth of vegetation. If the regrowth includes scrub or coppice replanted trees are also vulnerable to fraying damage. However the vegetation coverage of clearfelled sites is seldom uniform, and this complicates weed control.

A general response to dealing with the difficulty of establishment has been to upgrade plant handling and insecticidal protection measures (Tabbush, 1988; Stoakley and Heritage, 1990; Mason, 1991). However given the uncertainty attached to the risk of damage from *Hylobius*, a risk assessment procedure would be a useful aid to targeting protective measures. Experience suggests that plant handling methods which lead to improved vigour in the first growing season will also mitigate the effects of pine weevil damage by influencing the rate at which damaged tissues are replaced.

Strategies to increase the availability of planting microsites involve treating residues and the provision of new raised planting positions, using purpose built machinery or excavators with specially designed buckets (Nelson and Quine, 1990). Residues may be moved slightly to allow placement of mounds, pushed into windrows, or burned, although the latter may lead to *Rhizina* infection, with possible undesirable consequences (Seaby, 1977). Provision of raised planting positions makes planting easier and minimises weeding requirements, however it still may be difficult to achieve stocking targets without including an element of direct planting, because of stumps and the mounding drains themselves. On heavy mineral soils mounds do not always improve survival (eg Nelson and Watterson, 1992). On better drained mineral soils scarification provides better access to planting microsites through residues and some cultivation. Optimum strategies will clearly be site specific.

3.2 Natural regeneration

Natural regeneration of Sitka spruce may often occur on clearfelled sites, however there is, as yet, no basis for predicting its occurrence or abundance (Clàrke, 1992). Where it is prolific some form of treatment is required; densities in excess of 300,000 stems/ha have been recorded in Northern Ireland forests. Mechanical respacement before thicket stage is ineffective without treatment of cut stumps with herbicide to prevent regrowth, while delaying the operation can result in loss of diameter increment. On some sites the option of mechanical respacement may not exist because of extreme nutrient deficiencies brought about by competition. Chemical control of Sitka spruce regeneration is possible using the herbicide imazapyr (Nelson, 1990), however this is not a suitable method of preliminary respacement before a later mechanical selection. In spite of the respacing requirement it is possible that under some circumstances use of natural regeneration may result in lower establishment costs.

3.3 Maintaining productivity on N deficient sites

With the benefit of hindsight, much of the pessimism of the 1970s regarding the future N-fertiliser requirements of Sitka spruce on deep peat in Northern Ireland appears to have been unjustified. A similar prognosis has been made regarding the requirements of crops growing on low level blanket bogs in the west of Ireland (Farrell and Boyle, 1990). In northern upland peatland forests 2-4 applications of urea have been sufficient to achieve and maintain closed canopy conditions in most pure spruce crops, although on some experimental sites annual growth is still dependent on applied N after five applications, even though closed canopy conditions have existed for a number of years. With hindsight this might be a reflection of the preference for site uniformity and absence of slope in the laying out of experiments. However the suggestion is that in very high water table environments, such as flat peaty sites, it becomes less likely that nitrogen requirements for the maintenance of stand conditions will ever be met by litter breakdown, even after repeated application of N-fertilisers. Under these circumstances even the potential of species mixtures is questionable.

On infertile mineral soils the application of sewage and other sludges can be effective means of supplying nutrients (eg Wolstenholme *et al.*, 1992), and may be an alternative to the application of urea.

3.4 Nutrient deficiencies in second rotation stands

Results from fertiliser experiments on clearfelled sites in the Republic of Ireland and upland Britain (Hendrick 1979; Taylor, 1990) suggest that fertiliser applications at planting are unnecessary for most second rotation Sitka spruce, if growth in the first rotation was satisfactory. On some old red sandstone sites however, responses to applied P were significant, while on heathland sites in Britain it is suggested that nitrogen deficiency could be expected in pure crops. It has been suggested that fertiliser requirements on deep peat will be reduced, compared to the first rotation, because of physical changes brought about by the previous crop. These include irreversible drying and cracking, and are more likely to occur under crops with significant amounts of lodgepole pine (Pyatt and Craven, 1978; Pyatt, 1990b). Growth data from a cultivation experiment on shallow peat in Northern Ireland (Schaible and Dickson, 1990) suggest that nutrient availability will influence growth in the second rotation on some upland peats after about five years from planting. In this experiment the availability of N and P was increased by draining and providing raised planting positions; borehole studies indicated that the effect of the drains in lowering the water table was minimal, suggesting that the origin of the nutritional advantage lies in the mineralisation of the spoil generated by drainage, as suggested by Savill *et al.*, (1974). Intensive cultivation and the planting of spruce/pine or spruce/larch mixtures are treatments which will be fully explored in the second rotation on deep peat. The planting of mixtures is also recommended for replanting heathland sites (Taylor, 1990), although on nutrient poor sites a second rotation of mixtures may require management to ensure that the availability initially of P and subsequently of N and K is adequate.

Where harvesting systems involve the concentration of residues some redistribution of nutrients is inevitable. Studies of the effect of harvesting residues on nutrient availability suggest that in the short term nutrient release from litter decomposition is of greater significance than release from residues (Carey, 1980; Titus and Malcolm, 1991; Fahey *et al,* 1991). Studies of nutrient release on a peaty gley clearfelled site in Northumbria indicated that while losses of N and P were unlikely to give concern, losses of K were substantial. Nutrient inputs to litter from slash were significant and the possibility that banding of residues could lead to uneven growth in the longer term was not discounted (Titus and Malcolm, 1992). In a review of recent studies of the possible effects of harvesting residues, or 'whole tree harvesting', (Nelson and Dutch, 1991) it was concluded that there is little evidence to suggest that this practice will result in nutrient deficiencies in the second rotation except on poor sites. In Ireland this might include soils derived from old red sandstone (Carey, 1980) and oligotrophic blanket peat. If this is the case the redistribution of residues to a more even coverage before planting or early fertiliser application would be desirable practices on these site types.

4. Looking Ahead

4.1 Establishment

It has been accepted that research to develop methods of establishment that enhance crop stability is of great importance to forestry on soils with impeded drainage. On gley soils in Ireland there are indications that this has been at least partially successful (Hendrick, 1989), while on peats future uptake in terms of new planting is limited. The application of the results of cultivation research to second rotation crops will be problematic because of the presence of stumps, root plates and residues, and on some soils, because of changes brought about by the previous crop. In this context mounding is essentially a mechanised method of turfing and scarification a mechanised equivalent of screefing. For many decades of new planting these treatments were considered necessary either to provide local drainage, or to increase available moisture and provide a local and temporary reduction in competition from vegetation. If the latter role is fulfilled by the use of herbicides, the requirement for either raised or depressed planting positions on mineral soils is open to question, unless the site is prone to waterlogging or drought in the first few months from planting. Neither option is likely to enhance conditions for root development compared to direct planting, and hence neither will offer the prospect of improved stability. In addition, the practice of mounding by excavator and forming parallel drains may create problems for establishing third rotation crops on mineral soils, depending on drain width and mound volume. However, apart from eliminating or minimising weeding requirements, there is also evidence that cultivation may reduce pine weevil damage (Orlander *et al*, 1990). On surface water gley soils in Northern Ireland a technique of ripping has been successfully applied which does not result in the shearing of root plates and widespread disruption of surface drainage (Schaible, 1992). It may provide a means of increasing the stability of second rotation stands on wet mineral soils. On peaty sites much will depend on the degree of shrinkage of the organic horizon (Malcolm, 1979). On shallow peaty gleys it may be possible to introduce subsurface drainage channels into the mineral soil for the second rotation, while on peaty ironpans it should be possible to rupture pans where this was not done prior to planting the first crop. It remains to be seen whether it will be possible to introduce subsurface drainage tunnels to clearfelled deep peats. Clearly there is a wide range of site preparation options to use on clearfelled sites, each with a particular set of advantages and disadvantages depending on site conditions determined by soil type, the rate of revegetation and protection requirements.

Compaction or rutting damage of mineral soils is sometimes caused by timber extraction machinery, in spite of the use of residues and small poles to bed extraction routes. Whilst the area affected is generally small in proportion to a felling coupe, this type of damage is distributed linearly and is often continuous, and therefore may have a disproportionate effect on the stability of the successor crop. In the clearing of windthrown areas the supply of brash for bedding extraction routes is reduced, and ground conditions are often wet to begin with. Under these conditions it is difficult to avoid ground damage and the potential exists for a reduction in productivity in second and subsequent rotations through slow establishment, reduced growth and poor stability. Little work appears to have been done to investigate remedial measures on surface water gley soils where the implications for stability may be the most serious.

4.2 Nutrition

It is likely that the nutritional management of upland forests will evolve to take account of cheaper and more environmentally benign materials and practices. Some of these, such as the use of cultivation on organic soils, the planting of mixtures and the use of sewage sludges, have already been discussed as practical possibilities, while others are largely experimental. The application of high (7.5-15 t/ha) rates of ground limestone to deep peat (Dickson, 1984) has been shown to enable the mineralisation of organically held N. It will be technically far easier to apply on clearfelled sites than on virgin peatlands by utilising timber extraction routes. Liming of peat also enables the establishment of alders in the milder western half of Northern Ireland (Dickson, pers. comm), which may then fix atmospheric nitrogen for the use of Sitka spruce planted in mixture, or possibly as a successor crop. Likewise the use of other nitrogen fixing species such as lupins or *Ulex gallii* is potentially useful on heathland soils on ORS in Ireland (O Carroll, 1982; O'Toole *et al.*, 1984).

4.3 Environment x nutrient interactions

Acid deposition and other forms of atmospheric pollution may affect Sitka spruce plantations in ways which have not yet been experienced in Ireland or upland Britain. The effects will be difficult to interpret as pollution events are weather related and episodic in character, and may interact strongly with previous or subsequent climatic conditions. The effects on trees may be mediated through changes in insect populations and in the susceptibility of trees to insect attack, particularly the green spruce aphid *Elatobium abietinum* (eg Warrington and Whittaker, 1990). Defoliation of trees disrupts established patterns of nutrient cycling and temporarily affects growth. On wet sites recovery may be limited because of changes in soil moisture resulting from reduced interception of rainfall. Predictions of global warming and climatic instability suggest it would be advisable to consider the fact that most upland Sitka spruce plantations are growing on soils which are poorly buffered against drought and acidic deposition, and which are potentially susceptible to irreversible changes.

5. Conclusions

Although productivity on some sites may decrease with successive rotations because of site degradation, this will be balanced by increases on other sites resulting from improved establishment methods. Speculation on future developments in establishment and nutrition practices for Sitka spruce based on current and historical trends is difficult because of the potential changes to sites brought about by the first rotation and changes in climate and atmospheric inputs. Tangible differences between past and future practices will be in the degree of within and between site variation that will need to be accommodated as a result of the effects of previous rotations, and in the degree of choice of treatments available to the manager. Consequently systematic application of silvicultural treatments will be less satisfactory than prescriptions based on site appraisal, recognition of predetermining site factors, and an understanding of interrelationships between these factors and the mechanisms involved. This approach would enable decisions affecting the establishment, nutrition and stability of forest crops to be derived from first principles. It is essential if past experience is to be used successfully to deal with future challenges.

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Future Options for the Genetic Improvement of Conifers

Part I: Current and Near-Term Technologies

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Summary

Natural forest ecosystems are less productive than their theoretical net productivity rates. This difference between actual and theoretical productivity can be lessened by silvicultural methods, including genetic improvement. This paper summarises current and near-term (within 5 years) technologies including early selection, flower stimulation, vegetative propagation and crop ideotypes and describes how these are used to reduce the time required to breed and put into use genetically improved material.

Introduction

Compared to the long history of man's use of forests, techniques to breed and select trees with desired growth rates and qualities are comparatively recent developments. Although the basic goals of tree improvement programmes are reasonably clear (increasing yield, production of a high quality product and reduction of production costs) the way to accomplish these objectives is rather unclear (Faulkner, 1987). Most of the current concepts of tree improvement can be traced to work in Scandinavia in the the early 1950's. These methods have served us well for the last 40 years and have resulted in significant gains in the potential productivity of our forests. Unfortunately, due to the long time required to breed and test new genotypes (25 to 35 years in spruce), new methods are needed to reduce the length of time required to improve forest tree species.

The purpose of this paper is to review current methods of tree improvement, and then to examine techniques that will be used in the near future (next 5 years) and suggest how these techniques will affect tree improvement programmes. Part II of this paper will attempt to look further into the future and will discuss technologies that will affect tree breeding in 10 to 20 years and beyond, including molecular biology and genetic engineering.

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Productive Potential of the Forest

Before a discussion of what improvements have been accomplished in breeding forest tree species, it is important to understand the theoretical potential productivity of forests and to determine what levels of improvement might be possible. Such an attempt was made in 1983 by Farnum and co-authors when they calculated the theoretical maximum primary net productivity for two major softwood species in the United States, Douglas-fir (*Pseudotsuga menziesii*) and loblolly pine (*Pinus taeda*).

The theoretical maximum primary net productivity rate is calculated by multiplying the rate of photosynthetic efficiency of a species by the amount of photosynthetic light absorbed by photosynthetic tissue. Then the respiration rate is subtracted, an adjustment is made for temperature and rate of inorganic nutrient uptake and the loss of material due to mortality, shedding and consumption by insects and mammals. This calculation results in a theoretical productivity rate for most land plants of 55 Mg/ha/year (1 Mg= 1 million grams or one metric ton). For temperate conifers this figure is estimated at 45 Mg/ha/year (Farnum *et al.*, 1983).

There is a difference between the mean annual yields (actual observed yields) and the theoretical maximum productivity rate of about 2.5 times. This means that in theory the mean annual yields for temperate conifers should be about 18 Mg/ha/year. In reality natural Douglas-fir and loblolly pine stands produce about 5.7 and 3.6 Mg/ha/year respectively. The difference between the theoretical maximum primary net productivity and the observed mean annual yield is the rate of improvement that should be our target. Farnum and his co-authors have suggested 25 and 30 Mg/ha/year as targets for improvement in Douglas-fir and loblolly pine respectively.

The major way to decrease the gap between these two numbers is by increasing the photosynthetic efficiency of the species which will result in increased growth. The rate of photosynthesis in conifers is about ½ that of most other plant species, possibly because they represent an early form of land plants. Among the ways to improve their efficiency would be by increasing site occupancy, thinning to reduce mortality, improved cultural practices such as fertilisation, avoidance of water stress and by selecting for certain biological processes that can be made more efficient by genetic manipulation. Farnum and his co-authors have presented data to illustrate the mean annual yield of natural stands (base case) for both Douglas-fir and loblolly pine and the effect of silvicultural treatments and genetic improvement on yield (Table 1). Clearly there is a large opportunity to increase the productivity of our forest land through silvicultural treatments and genetic improvement. However, while new silvicultural treatments will undoubtedly improve forest productivity, genetic improvement is a cumulative process whereby a certain increase in the level of improvement results with each new generation.

Table 1: Productivity Increases Attributable to Intensive Management of Douglas-fir and Loblolly pine. From Farnum *et al.*, 1983

Douglas-fir

Treatment	Max. Mean Annual Yield (Mg/ha/yr)	Cumulative Increase (percent)
Natural Stand	5.7	–
Silvicultural Treatments		
Plantation Establishment	7.2	30
Nitrogen Fertilizer	8.8	50
1st Generation Genetic Improvement	9.7	70
TARGET	25.0	340

Loblolly pine

Treatment	Max. Mean Annual Yield (Mg/ha/yr)	Cumulative Increase (percent)
Natural Stands	3.6	–
Silvicultural Treatments		
Drain and plant	7.0	90
Bedding	8.6	140
Preplant Phosphorous	10.5	190
Nitrogen Fertilizer	11.8	230
1st and 2nd Generation Genetic Improvement	14.3	300
TARGET	30.0	730

Current Tree Improvement Methods

Briefly, these methods depend on the selection of superior individuals from essentially "wild" populations. Natural variations in physiological, morphological and chemical characteristics serve as the source of variation utilized in genetic improvement. The easiest and cheapest improvement method depends on the selection of the proper species (native or exotic) and provenance. Further refinement can take place by selecting trees with superior characteristics ("plus" trees) to become part of a breeding population. Comparative "progeny" tests are established with their offspring on uniform sites in several locations. Seedlings of unselected parents are used as a check or control. Periodically the heights and diameters of the individuals in the progeny tests are measured and compared with the check or control seedlings. After a period of time, which is traditionally ⅓ of the full rotation age of the species (10 to 20 years), the performance of the progeny will reasonably predict the progeny performance at maturity. Trees which consistently perform above the check or control seedlings can be identified. These individuals then become part of the production population. Although height and volume growth are typically the major desired characteristics, other factors include stem form, branching habit, pest resistance and wood properties (Table 2).

Table 2: Douglas-fir traits under genetic control. From Silen, 1978

Strong Genetic Control
Graft incompatibility
Cone Production
Moderate to Strong Genetic control
Stockiness
Terpene Composition
Spiral Grain
Animal Resistance
Survival
Moderate Genetic Control
Stem Diameter
Stem Straightness
Tracheid Length
Percent Summerwood
Frost Resistance
Insect Resistance
Cotyledon Number
Weak to Moderate Genetic control
Total Height
Branching
Weak Genetic Control
Dry Weight
Percent Heartwood
Wood Permeability
Fertiliser Response

Scion material from "plus" trees selected in "wild" populations is grafted onto rootstocks to establish a collection of selected germplasm or a "clone bank". Seedling progeny or grafted scions of plus trees which have demonstrated their superior qualities in progeny tests are used to establish seed production areas or "seed orchards". The natural cross pollination between these individuals within the orchard produces seed with the improved characteristics. Seed orchard site selection is important in order to encourage early flowering and good cone yields. Despite this, many seed orchards (especially seedling seed orchards) are slow to produce practical amounts of seed. Sitka spruce typically requires 15 to 20 years to flower from seed and may need to be 30 to 35 years old before they begin to produce seed in commercial quantities.

Unfortunately, the products of most tree improvement programmes have, as yet, to be put into large-scale use in our production forests. This is because by its very nature the selection, breeding and testing of trees is a long-term activity. In some pioneer species such as pine, which flower early, a breeding cycle may require as little as 7 to 8 years. Subclimax and climax species such as spruce, are among the slowest to reach sexual maturity,typically requiring 15 to 20 years to flower from seed. Combined with a 15 year progeny test period, one breeding cycle in spruce may require 25 to 35 years. Thus TIME is the greatest limiting factor in tree improvement.

Using these methods, varying levels of genetic improvement have been achieved with most major conifers of economic importance in Europe. With increasing costs for both the establishment and continued operation of these long-term tree improvement programmes, geneticists have begun looking at ways to both shorten the breeding cycle and increase the availability of this improved material. This requires the development of a new set of techniques that will allow a reduction in the time required to get improved material into production forestry.

Near-term Technologies

Early Selection

Originally it was believed that about ⅓ of the rotation age (10 to 20 years) was required to be able to identify superior individuals. Studies with Sitka spruce have shown that at least 6 years of field growth (8 years from seed) are required before differences between progeny can be seen (Samuel and Johnstone, 1979; Gill, 1987). Researchers, however, have been attempting to reduce this period still further.

Work by the Forest Commission on Sitka spruce in the early 1970's (Herbert, 1971) attempted to identify superior families early by growing them in a glasshouse. Initially there appeared to be a correlation between height growth in the glasshouse and field growth rate, but these could not be confirmed in larger trials and the method was later abandoned (Samuel and Johnstone, 1979; Faulkner, 1987). It can be argued that the technology has improved so much in the last 20 years that these type of studies with Sitka should be repeated, especially in light of recent results with other species where good correlations have been found (Waxler and van Buijtenen, 1981; Williams *et al.*, 1987; Pharis *et al.*, 1991). Recent work with loblolly pine has suggested that even under well controlled conditions, the poorest families can be identified and eliminated from progeny tests, thereby reducing progeny test establishment costs (Lowe and van Buijtenen, 1989).

Flower Stimulation

The long time required for some conifers to begin flowering has encouraged basic research into the flowering process in trees. Stress has been known for many years to stimulate flowering and seed production. More recently studies on plant growth regulators have led to the recognition that certain forms of gibberellic acid can stimulate flowering in many members of the pine family (pines, spruces, hemlocks, Douglas-fir). Treatment with gibberellins, either applied as foliar sprays of more effectively as stem injections combined with water stress, induced by root pruning, warm temperatures or stem girdling, will stimulate flowering in conifers. It can be useful in making seed production more reliable, especially in young orchards. In some species even sexually immature seedlings can be induced to flower. Work on flower stimulation in Sitka spruce has been summarized by Philipson (1987).

These methods have been applied to both potted grafts as well as large field grown trees in seed orchards. Flower stimulation techniques are now at the stage where we can consider the development of indoor or potted seed orchards in regions, like Ireland, where climatic conditions are not conducive to regular flowering (Figure 1).

Depending on the species, large quantities of genetically improved seed will generally not be available from these indoor orchards, because trees must be of a limited size to fit in a greenhouse. Regular production of small quantities, multiplied through vegetative propagation, will, however, supply improved plants in commercial quantities.

Vegetative Propagation

Man has been vegetatively propagating horticultural plants since Roman times. Only through vegetative propagation is it possible to faithfully reproduce selected individuals with desired characteristics. Reproduction by sexual means results in segregation of genes and creates variation in the offspring.

Vegetative propagation can be accomplished by grafting, air layering, the rooting of cuttings or by tissue culture. Grafting, air layering and rooting of cuttings are together known as "macropropagation" because a relative large (macro) piece of the plant is used in propagation. In contrast, tissue culture or "micropropagation" involves the removal of a small piece of the plant, anything from a small piece of the stem or bud down to, at least in theory, a single cell and placing it into culture under controlled conditions of nutrition, temperature and light. Micropropagation will be discussed in more detail in Part II of this review.

Vegetative propagation of forest trees is not a new idea. Japanese cedar (*Cryptomeria japonica*) has been propagated by cuttings in Japan since the 1400's. One of the earliest reports of the vegetative propagation of a forest tree species in Europe was Norway spruce (*Picea abies*) propagated by cuttings in Germany in the 1840's.

Currently it is estimated that worldwide as many as 65 million conifer

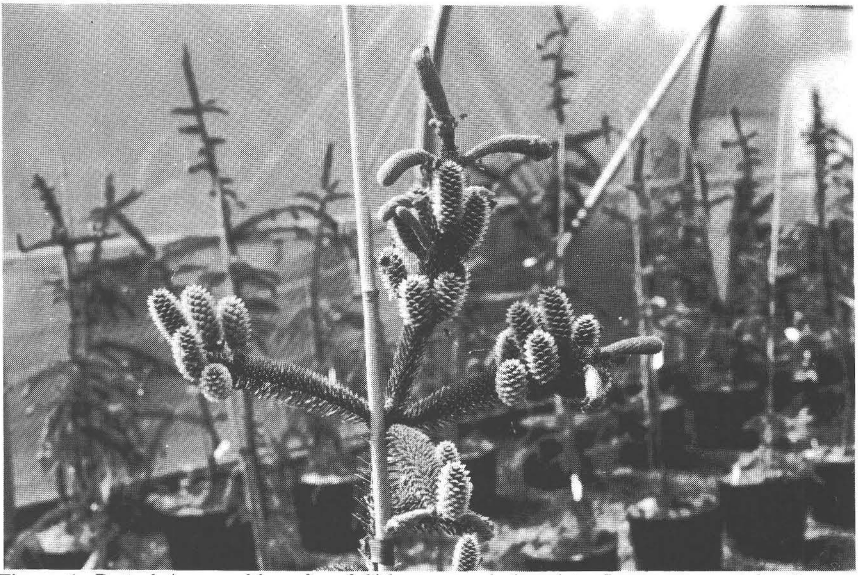

Figure 1. Potted 4 year-old grafts of Sitka spruce induced to flower as a result of warm temperatures, water stress and injection with gibberellic acid.

propagules are produced by rooted cutting production systems (Ritchie, 1991). Presently between 150,000 and 170,000 rooted cuttings of selected clones of Sitka spruce are rooted for clonal testing in Ireland by Coillte's genetics research section each year. Plans call for this to increase to about one million rooted Sitka cuttings per year in the next several years (Figure 2). Probably the most well developed commercial programme is the Forestry Commission's Sitka spruce programme. Because only limited amounts of "the best" genetically improved material are available as seed, vegetative propagation is used as a way to multiply this limited supply. In Sitka spruce one seed can produce 500 rooted cuttings in 2 cutting steps spread over 6 years (John and Mason, 1987). Because of the amount of time and labour involved, rooted cuttings typically costs 2 to 3 times the price of seedlings (Mason, 1989). The selling price of genetically improved rooted cuttings in 1990 was UK£ 190/1000 compared with UK£ 75/1000 for unimproved bare-root seedlings. Current production rates of Sitka rooted cuttings in the U.K. are between 2 to 3 million per year.

The rooting of conifer cuttings depends to a great extent on the age of the plant from which the cutting is taken. The older the donor plant, the more difficult it will be to root. Different species lose the ability to root at different rates. Douglas-fir cuttings, for example, can be rooted quite easily from a 1 year-old seedling, but beyond that age the rooting frequency decreases rapidly. Sitka spruce cuttings can be rooted from donor trees up until about

Figure 2. Plastic tunnel containing 100,000 Sitka spruce cuttings under mist during the rooting process.

6 or 8 years old. After this, not only does the rooting percentage decline, but the incidence of plagiotropism (growth as a branch rather than as an upright shoot) increases. The propagation of "tested" genotypes offers the greatest genetic gain, but testing requires 6 to 8 years which increases the chance of problems with poor rooting and plagiotropism. This has led to an interest in techniques to slow, or delay, aging in woody plants.

The position on the crown from which the cutting is collected may be important in rooting success, with cuttings from the lower part of the crown tending to root best. Several techniques such as pruning close to the ground (hedging) or the repeated use rooting of cuttings as donor plants (serial propagation) may have the effect of slowing aging of the donor plant or clone. These treatments do not stop aging, they only delay it. Repeated grafting of scions of mature trees onto seedling rootstock has been suggested was a way to return a mature individual to its juvenile (high rooting frequency and no plagiotropism) state which is known as "rejuvenation". The effectiveness of this process varies with the species studied and requires further proof of "rejuvenation". For example if tissue from a selected superior individual could be returned to the juvenile state (high rooting percentage) but it continued to grow at the slower mature growth rate, it would not be of very great commercial interest. In vitro techniques rejuvenation (discussed in Part II of this review) are also reported to return mature genotypes to their "juvenile" state.

Crop Ideotype

In the past, the main focus of tree improvement was on growth and wood production. Other factors such as dry matter accumulation/stem unit, cell wall thickness, fibre length and ratio of spring to summerwood have been mostly neglected. Faulkner (1981) likens this to cattle breeders who selected for the width of the forehead and symmetry of horns while they neglected milk production and butterfat content. Tree breeding has demonstrated that it can make improvements in the growth and form of forest trees, but is this really what is needed? Now is probably a good time to devote some time to thinking about the concept of crop ideotypes and what type of trees we actually want to breed. The idea of selecting for generally adapted progeny to grow well on a variety of sites, under a range of climates, using current site preparation and forest management techniques of fertilisation and thinning may need rethinking. A limited number of small sub-lines should be considered for special purposes (disease resistance, high wood densities, water and nutrient use efficiency, etc.) but only if they are economically viable.

The concept of identifying the "ideal" tree form is not new, but it is an idea that has probably not received the attention it deserves. Gordon (1975) suggested three approaches for increasing forest tree yields. The first approach would be to change the nature of the photosynthetic process in trees. The only way this would be possible would be with the techniques of "genetic engineering' (discussed in Part II). The second approach is to change the shape of individuals so that they would efficiently occupy the space allocated to them and be less competitive under intensive cultural conditions. Cannell (1982) argued that progeny testing methods actually select for genotypes that are either "isolation" ideotypes that grow well as widely spaced individuals or as "competition" genotypes that grow at the expense of their neighbours. Whether selection for either of one of these two ideotypes seriously affects stand productivity over the rotation has yet to be studied. The idea of establishing a forest with a type of tree that will be able to be grown to full rotation with minimal or no thinnings has been developed in Finland. This is the ideotype of the narrow crowned spruce. This tree has long, pendulous branches that concentrate their photosynthate into the main stem rather than branch wood. Its narrow crown also allows for more trees to be planted per hectare, thus producing more wood per unit area (Figure 3). This ideotype is selected to produce a tree with improved stem quality in a shorter period of time with reduced thinning or pruning costs (Pulkkinen *et al.*, 1989: Pulkkinen and Poykko, 1990). It is also supposed to be better at resisting wind damage, an idea that might be useful in Irish forests. In Sitka spruce sparsely branched clones were found to allocate high proportions of their dry weight matter to stems (Cannell *et al.*, 1983). The authors suggested selecting for tallness and sparse branching as a way of selecting for efficient stemwood producers.

Gordon's third option for increasing forest yields is selection for optimal internal allocation and utilization of photosynthate, nitrogen and nutrients. Evidence exists that such genotypes are possible in Sitka spruce (Cannell *et al.*, 1983). Sheppard and Cannell (1985) reported clonal differences of 10 to 30% in the amount of dry matter accumulated per unit of nutrient taken up. Since publication of these observations, little further work seem to have been done in this area.

Future of Tree Improvement

Tree improvement is a collection of techniques that are used to accomplish an overall strategy. Some of the techniques have been around for some time while others are relatively new. The techniques are like pieces of a puzzle. Their position in the puzzle will allow us to reach the overall strategy to improve a forest tree species. The "classical" methods of tree improvement such as selection, testing, breeding and seed orchard establishment are well established and understood. They have served us well and resulted in the development of a successful seed orchard system.

Conventional seed orchard methods initially appeared to satisfy the demand for genetically improved material in amounts large enough to supply commercial demands. This has proven to be true, especially for pine species. Similar work with northern non-pine species were not so successful, mainly because of the long time required for flowering. With increased interest in genetically improved material, together with demands for reducing costs and time required by conventional tree improvement programmes, new strategies have been developed.

An initial attempt was made to try and reduce the size, and thus the cost, of seed orchards. The bi clomal and meadow orchard were attempts at this (Sweet and Krugman, 1978). Flower stimulation, originally developed for use on large trees was adapted for use on potted, grafted trees. Unfortunately the amounts of seeds produced by the miniaturized and potted orchards was not enough for commercial use. Some means of multiplying the seed was needed.

Shortly afterwards, in a paper by Smith *et al.*, (1981), the use of micropropagation was proposed as a way to "vegetatively amplify" the small amounts of seed produced by the meadow orchard. However, at that time the technique was unable to produce the required number of plants at a competitive price.

At about the same time, the use of cuttings collected from seedling stock plants as a way to avoid problems in trying to root cuttings from mature, tested individuals led to the development of efficient seedling rooted cutting propagation systems (Gill 1983).

The combination of flower stimulation methods applied to potted, grafted material for the production of controlled crosses of superior families,

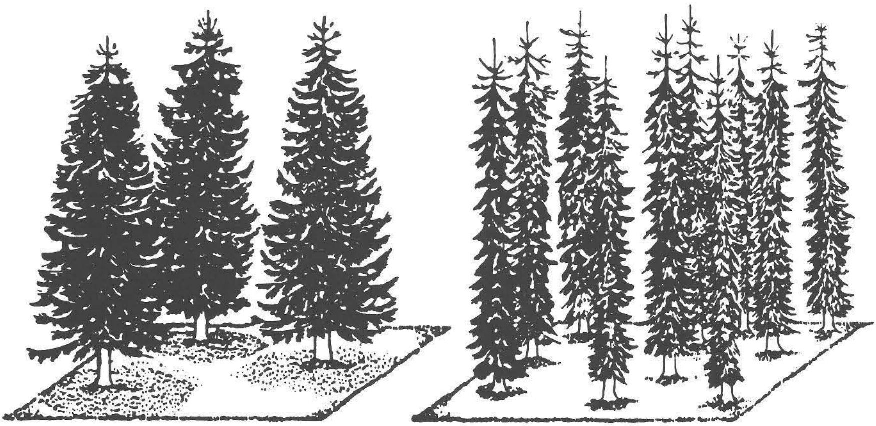

Figure 3. Hypothetical comparison of narrow crowned trees (right) with a stand of normal crown form. Individual tree yield of narrow crowned trees may be smaller, but because more trees occupy the same land area yields are higher than normal crowned trees (From Pulkkinen et al., 1989).

followed by vegetative propagation may be the solution to large-scale production of improved material without a large, expensive, slow to produce seed orchard. It also allows for a large amount of flexibility because material in a potted orchard can be added and deleted more easily than in a conventional orchard. Rooted cutting methods might be replaced by micropropagation, specifically somatic embryogenesis once it has been tested and improved. Micropropagation may be used as a first stage of multiplication for the production of stock plants so that the high production costs of micropropagation can be spread over a large number of rooted cuttings.

Early selection methods will allow a way to reduce costs in another expensive component of the tree improvement process, progeny testing. These techniques will not replace field testing, but will permit the early elimination of poor genotypes from progeny testing.

A combination of early selection, flower induction and vegetative propagation by rooted cuttings would be able to reduce the time required to produce genetically improved material.

Conclusions

It is inevitable that due to current world economics, much of the world's wood in the future will come from plantations of pure species or more productive exotic species. Thus more wood must be produced on less land. Not only will it be necessary to use the best silvicultural management practices but it is also essential to use the most appropriate species, selected and bred for the required end uses.

Calculations of theoretical production rates provide evidence that there are opportunities for continued improvement in most forest tree species. Selection and breeding will continue to provide a powerful tool in the continued improvement in production rates in a species. We will not be limited by ideas and techniques because geneticists working with agricultural and horticultural crops face the same problems. Fortunately for them, they do not have to work under the long periods necessary for breeding and testing woody species. Undoubtedly some of the technology developed for non-woody species will be inapplicable to forest species, but of the technology that is relevant it will certainly require a much longer period for the fruits of this work to reach commercial fruition.

Perhaps tree improvement has reached the first plateau in its development. As Faulkner (1981) described it" ...the use of the broadsword to crudely reduce the breeding base to a manageable size, then to use a scalpel to refine existing and develop new techniques..." for continued improvement.

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A Study of the Impact of the European Wild Rabbit (*Oryctolagus cuniculus L.*), on Young Tree Plantations

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Summary

The relative susceptibility of seven tree species of both broadleaves and conifers, to damage by the European rabbit, (*Oryctolagus cuniculus L.*), was investigated on two newly planted sites in Co. Wicklow. The incidence and the severity of three different forms of rabbit damage were assessed using the nearest neighbour sampling technique. Four tree species were identified as being susceptible to all forms of rabbit damage that is, either to the leading shoot, to side-shoots or to the stem. These were; penduculate oak (*Quercus robur L.*), ash (*Fraxinus excelsior L.*), Sitka spruce (*Picea sitchensis (Bong.) Carr*) and Japanese larch (*Larix kaempferi L.*). Those that displayed relatively low levels of damage were beech (*Fagus sylvatica L.*), sweet chestnut (*Castanea sativa L.*), and Douglas fir (*Pseudotsuga menziesii L.*). Damage to the side-shoots of all of the young trees was found to be consistently high for all four vulnerable species. Most of the damage was slight but severe side-shoot damage did occur in ash. The incidence of leader loss was found to be high for two species, oak and ash. The incidence and severity of bole damage was most prevalent in ash.

Differences between tree species in susceptibility to different forms of rabbit damage were identified as being due to a number of interrelated factors, which were ecological, chemical and physical in nature.

Introduction

The rabbit is primarily a grazing mammal and is associated with a wide variety of habitat types (Anon.,1982; Gibb,1990). It can cause serious and sometimes devastating damage to forests (Gill,1992) and this is most prevalent in young plantations, up to eight years following planting (Springthorpe and Myhill, 1985). Changes in the Common Agricultural Policy and the large increase in private planting in recent years (O'Brien, 1990) have resulted in an increase in the range of site types becoming available for forestry in Ireland. As an increasing proportion of these sites have free draining soils, this may have accentuated the concern about rabbits as pests.

Rabbit densities have not been documented in any detail to date in Ireland (E. Grennan, Wildlife Service, personal communication), although anecdotal evidence from various sources countrywide point to an increase in the population density of the rabbit, albeit lower than that currently experienced in England (Ross and Sanders, 1987; Lloyd, 1970). It is unclear as to whether a reduction in virulence of the Myxoma virus as reported in England (Trout, Tapper and Harradine, 1986), has substantially affected the population levels in this country but this a distinct possibility. Young forest plantations are preferred habitats for rabbits. A survey of 173 forests in 1985 showed that rabbits were present in 93% of these areas with damage being reported in 42% (Hannan, 1986). Actual damage to trees was confined to the youngest plantations. Severe damage, (characterised by 20% or more of trees suffering damage), constituted a sizeable proportion.

Rabbits damage trees in two ways: by browsing (that is by nibbling shoots and buds) or by stripping the bark (Anon., 1982; Springthorpe and Myhill, 1985). Browsing young trees is by far the most serious form of damage and its incidence is highest in winter and in spring (Hannan, 1986). The selectivity of rabbits, demonstrated by their tendency to drop damaged shoots, is thought to be related to their role as grazers (Gill, 1992). In general, the effects on the subsequent growth and development of trees as a direct result of rabbit browsing are not known (Ratcliffe, 1989), although in some cases, multiple leaders may develop (Staines and Welsh, 1984), thereby reducing the value of trees destined for structural timber. The inherent capacity for trees to recover following injury has not been examined in great detail (Burdekin and Radcliffe, 1985), although saplings of many broadleaved species have demonstrated their capacity to sprout repeatedly after being pruned back by browsing (Miles and Kinnaird, 1979). In addition to this, it is known that certain species, such as Sitka spruce can withstand a greater degree of leader browsing than either Douglas fir, Japanese larch or any of the broadleaves (Melville, Tee and Rennolls, 1983).

Work on Norway spruce (*Picea abies*) has shown that heavy browsing of lateral branches in one year, leaving the leading shoot intact, significantly reduced the rate of vertical growth over the following eight years (Pepper and Hewison, 1989). On the other hand, for young pine seedlings (*Pinus radiata*) in Tasmania, economic loss was demonstrated only in the case of very severe browsing to the leading shoot (Nielsen, 1981).

Unpublished data compiled by the Forestry Commission has indicated that almost any species of tree may be damaged by rabbits, especially where the number of rabbits is high (Gill, 1992). Craig (1871) was the first author to record browsing preferences by rabbits. However, little work has been carried out in this area to date and information on browsing preferences is generally poor. Craig showed that both rabbits and hares preferred oak species, larch, spruce and Scots pine to birch. Plant secondary substances in the bark of birch plays an important role in this preference by hares, nutrient conditions will influence the choice (Votila, I., J. Tahvaninan and M. Taavitsainin, 1993). There is little information on the role of plant secondary metabolites as natural feeding deterrents for rabbits, as opposed to hares (Ianson and Palo, 1991;). Later in 1946, Allman gave anecdotal evidence for browsing by hares of Corsican pine (*Pinus nigra*) in preference to Lodgepole pine (*Pinus contorta*) or to Scots pine (*Pinus sylvestris*) (Allman, 1946).

It is against this background that this study was carried out. The main objectives of the study were:

1. To evaluate the relative susceptibility of seven different tree species to browsing damage by rabbits.
2. To determine the extent and severity of the different forms of damage identified for the seven tree species.

Materials and Methods

The field work was carried out on two sites in County Wicklow during the period October to December 1992. Both sites were within 15 km of the coast, and at moderate elevations but differed in layout and species composition. Site one is at Kilpoole, at 90m above sea level and was planted in March/April 1992 with common ash (1.6ha) and Sitka spruce (2.4ha). Site two, situated at Carrigmore and Ballinclare, near to Glenealy village is 80-90m above sea level and consists of 16ha of mixed broadleaves and conifers, also planted in 1992. Seven tree species were examined for evidence of rabbit damage; oak (*Quercus robur L.*), ash (*Fraxinus excelsior L.*), beech (*Fagus sylvatica L.*), sweet chestnut (*Castanea sativa L.*), Sitka spruce (*Picea sitchensis (Bong.) Carr*)., Douglas fir (*Pseudotsuga menziesii L.*) and Japanese larch (*Larix kaempferi L.*). Rabbit damage to ash and Sitka spruce was studied on site one and the damage to the other five species was studied on site two. Approximately half of the oak trees and all of the ash trees on site two had tree shelters, 45 cm in height. The presence of tree shelters on ash trees on site two prohibited any contrast of results for ash on both sites. Approximately half of the oak and all of the ash on site two were protected by tree shelters, 45 cm in height. However, these shelters were not erected until two months after planting. Therefore, upon examination of the trees in October it was concluded that all of the damage occurred in May/June 1992 and that the shelters provided adequate protection against subsequent attack. Damage that occurred before erection was assessed.

Damage was quantified using the nearest neighbour survey method (Melville *et al.,* 1983). This involved the systemic selection of a number of points throughout each species plot. At each of these points a

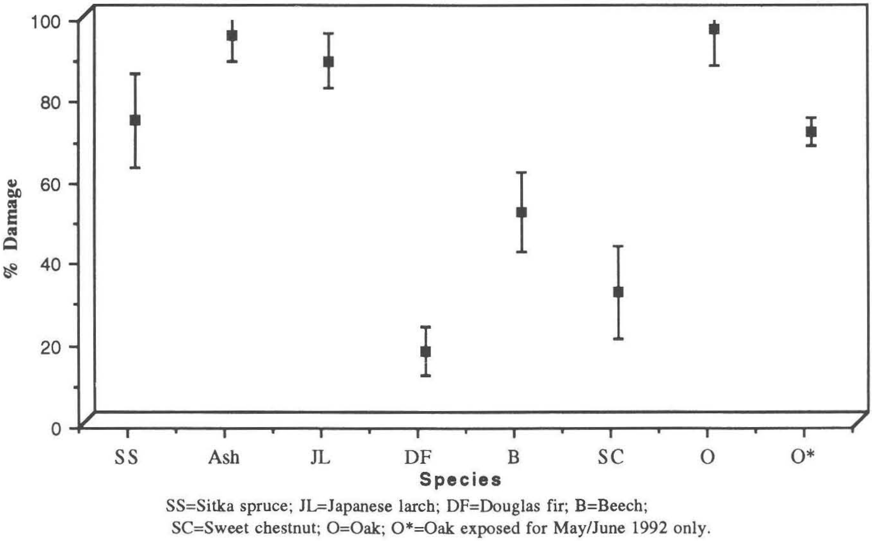

Figure 1. Percentage damage for the seven species examined in the two study areas. (Vertical bars represent 95% confidence limits of the estimates.)

predetermined number of trees was examined for damage. The trees which formed a cluster were chosen objectively and independently of any damage. In this study the sampling cluster size was chosen to be six and thus for an accuracy of 10% at the 95% confidence level, it was necessary to sample at least 100 trees. Sampling points were spaced systematically throughout the plot and reached simply by walking the required distance D. This distance was calculated after Melville *et al.*, (1983) as follows:

$$D = \frac{\sqrt{A \times 10{,}000}}{n}$$

where D = the distance between points (metres)
A = the area of the plot (hectares)
n = the number of points allotted.

Thus, the distance between clusters was the only between plot variable and this was directly proportional to the plot size under investigation. The larger the area being assessed, the greater the distance between clusters. All of the plots were sampled in proportion to their size.

Each tree within the cluster was examined for damage and the tree height recorded. If damaged, the tree was further inspected for the type and severity of damage. The categories of damage into which the

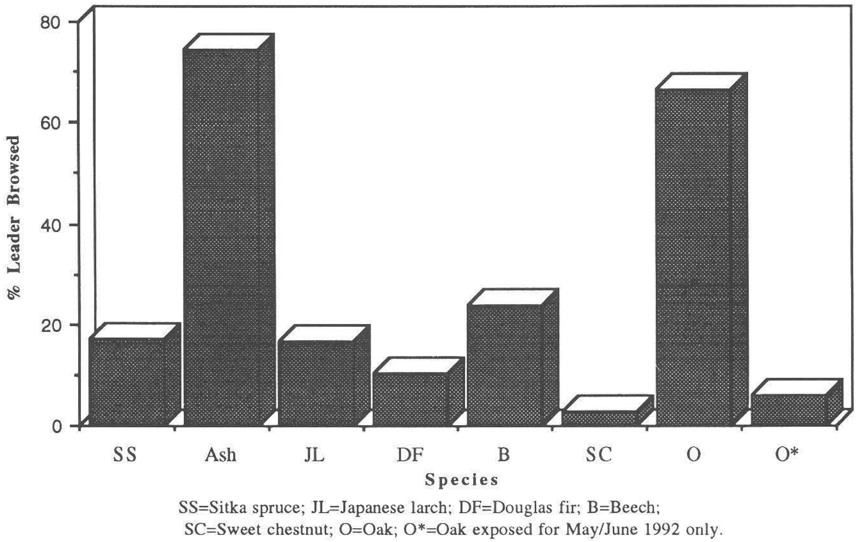

Figure 2. The percentage damage to the leading shoot for the seven species examined in the two study areas.

trees were grouped were not mutually exclusive and were as follows: 1) leader browsed, 2) side-shoot browsed and 3) bark stripped. The severity of damage was then visually assessed and classified as either slight (0-30% removed), moderate (31-60% removed) or severe (61-100% removed).

As vulnerability to browsing damage is related to the amount of other browse available (Kinnaird, 1974; Miles and Kinnaird, 1979; Springthorpe and Myhill, 1985), the presence or absence of herbicide immediately surrounding each tree was recorded. The presence of tree shelters and shoots on the ground beside the damaged tree was also noted. For each cluster, the vegetation cover within the vicinity that is, within $10m^2$ of the centre point of the tree cluster was assessed as being either low (less than 10cm in height), medium (10-25cm in height), or high (greater than 25 cm in height), and the dominant plant species present were noted also.

Rabbit population numbers are difficult to estimate to any degree of accuracy (Kolb, 1985). The density of pellets per hectare has been used to estimate the population of rabbits in a warren (Leach, 1989). Maximum breeding populations have been estimated at 13 individuals per hectare (Lockley, 1964). However this is complicated by the fact that pellets can be left anywhere within the range of the rabbit [100m (Cowan, Hardy, Vaughan and Christie, 1989) to 500m from the burrow (Gibb, 1990)], or concentrated in latrines on the boundaries of its territory (Leach, 1989). An alternative method for gaining an index of the population was investigated by Kolb. This involved utilising the number of burrow entrance holes but was also found to be unreliable, due to the variability in the number of entrance holes relative to other features. The number of scrapes per unit area may be a useful aid in gaining an index of population in young plantations due to the availability of edible roots near to the surface (Downes, 1993) but this is a function of the quality and availability of other preferred plant species. Clearly, the practice of applying herbicide around each tree would encourage scraping and indeed browsing.

A rough index of the rabbit population density on each tree species plot was determined by systematic plot sampling of rabbit pellets and scrapes, based at each sampling point for tree damage. The number of pellets in a plot of $10m^2$, centred on the tree cluster sampling unit was counted. A count of one to 20 pellets or less than two scrapes constituted low rabbit activity, while 21 to 40 pellets (two to four scrapes) and 41 to 60 pellets (five to eight scrapes) were deemed to show medium and high rabbit activity respectively. Very high rabbit activity was shown by a pellet count of greater than 60, or more than eight scrapes, and distinguished from high rabbit activity by the presence of burrows and forms on the site itself (Harting, 1986). This systematic sampling was considered to be reasonably accurate for the relatively small areas under investigation in this study.

Results

A total of 828 young trees were sampled in this study of browsing damage by rabbits. The percentage mortality was approximately 3% for species such as ash, Sitka spruce and beech and no mortality was recorded for all other tree species studied. Mortality was unrelated to browsing damage. Mean tree height for damaged and undamaged trees, as well as their percentage reduction in height (measured during the assessment in October 1992) are shown in Table 1. Oak, ash and Douglas fir all displayed a relatively large reduction in height (30%), while for sweet chestnut and "sheltered" oak the reduction in height was just 3% (Table 1). The proportion of young trees which suffered from any form of rabbit damage is shown in Figure 1. The four most vulnerable tree species were oak, ash, Japanese larch and Sitka spruce. The accuracy of estimates of is shown by the vertical error bars, the percentage damage levels lie within these ranges. Beech, sweet chestnut and Douglas fir all displayed relatively low levels of damage. Douglas fir was the least susceptible to any form of rabbit damage, with an incidence of just 16.7%. Leader loss was of economic significance for two species, ash and oak (Figure 2). The trend for total overall damage was similar to that of side-shoot damage (Figure 3), although we see a different pattern emerged for stem damage (Figure 4).

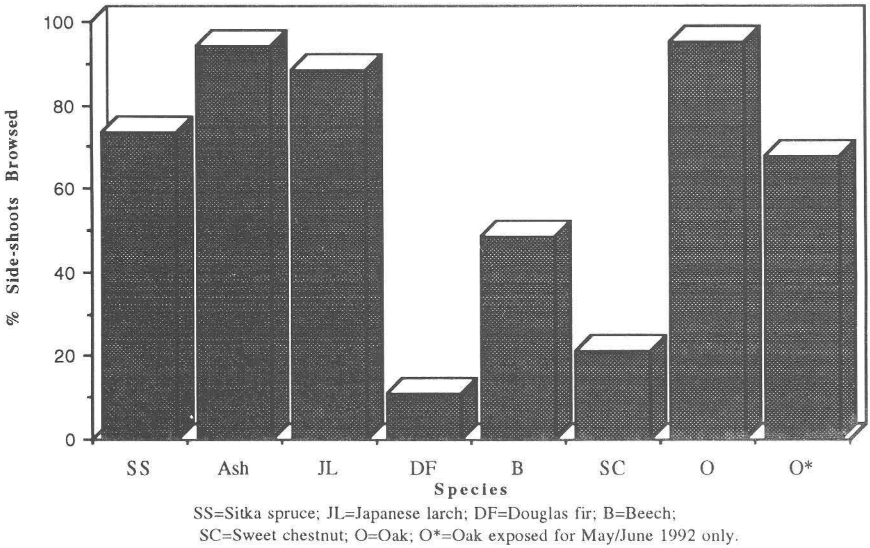

Figure 3. The percentage damage to side shoots for the seven different species in the two study areas.

Table 1: Mean values for undamaged and damaged tree heights, in cm and the percentage reduction in height, for seven tree species examined in the two study sites.

Species	Mean undamaged tree height (cm)	Mean damaged tree height (cm)	Mean reduction in tree height (%)
Sitka Spruce	55.2	42.5	23.0
Ash	51.3	34.9	32.0
Japanese Larch	80.4	68.0	15.5
Douglas Fir	0.5	41.1	32.7
Beech	57.2	49.6	13.3
Sweet Chestnut	92.3	89.6	2.9
Penduncculate Oak	66.0	63.7	3.4
Pendunculate Oak*	66.0	40.9	38.1

The tree species which suffered the highest level of leader loss were ash and oak, at 74.3% and 66.7% respectively (Figure 2). Levels of damage were less than 20% for the other five species, with Douglas fir proving to be

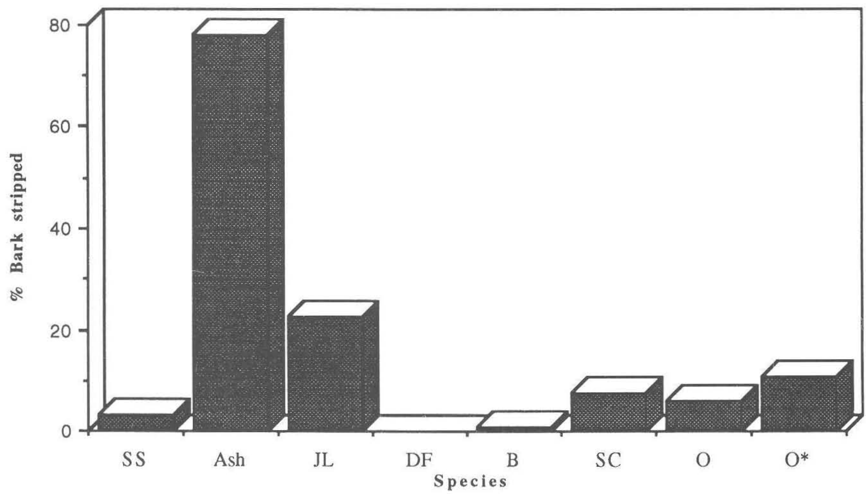

Figure 4. The percentage damage to the stem for the seven species in the two study areas.

the least susceptible of all, with leader damage of just 10%. However, these results were not fully repeated in the proportion of trees which suffered from damage to their side-shoots. The incidence of this form of damage was relatively high in ash and oak as well as in Sitka spruce and Japanese larch (Figure 2). Values for beech of almost 50% for this form of damage are a cause for concern. In contrast, with the exception of ash in particular and, Japanese larch to some extent, the incidence of stem damage by bark stripping was generally low (Figure 4). Almost 80% of ash trees were found to suffer from stem damage, for Japanese larch the incidence of damage was just over 20%.

The incidence of damage to "sheltered" oak trees that is, the damage which occurred prior to sheltering was surprisingly high and approached that for unsheltered oak trees on the same site (Figure 1). For this species, most of the damage was in the form of damage to the side-shoots (Figures 3 and 5), with as much as 40% of this being moderate damage. As might be expected the period of exposure to rabbits would be directly related to the extent of damage; leading shoot damage was almost 70% in unsheltered oak (7 months exposure), while nearby sheltered trees suffered only 6% damage (Figure 2). Interestingly, this situation was reversed for the extent of stem damage, with sheltered trees having more than twice that of unsheltered, although both the magnitude and severity of the damage was decidedly lower overall (Figures 4 and 6).

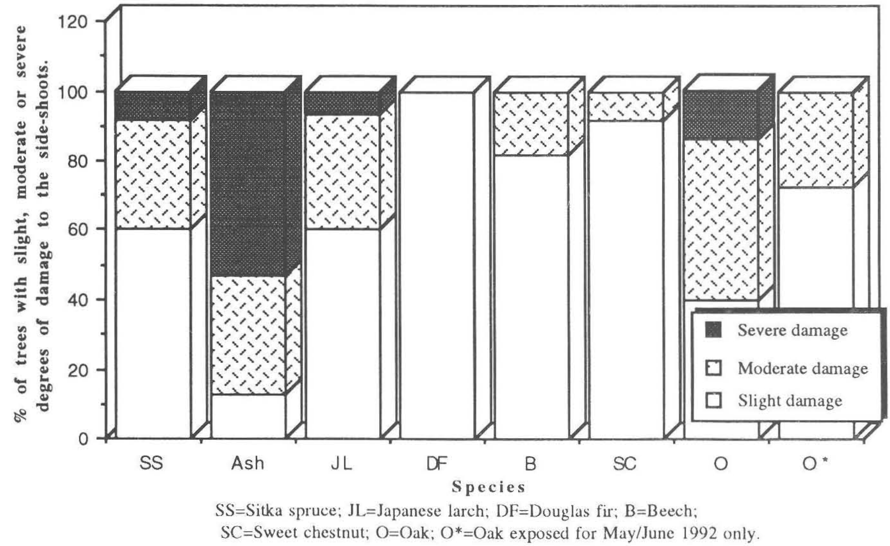

Figure 5. The severity of side shoot damage for the seven species in the two study areas.

Almost half of young beech trees suffered from damage to their side-shoots while 23.8% had the leading shoot removed. Beech had one of the lowest level of stem damage of all of the seven species studied, at less than 2%. Furthermore, all of this damage was classified as being slight. Sweet chestnut, with a moderate level of overall damage (31.4%), also had a relatively low level of side-shoot damage, at 21.3%. Less than a tenth of sweet chestnut trees suffered from bark stripping and the incidence of leader damage (6%) was the lowest of all seven species examined.

The percentage of trees which suffered some degree of damage was relatively high in two out of the three conifer species examined. Eighty eight point two percent of Japanese larch trees were damaged and 73.5% of Sitka spruce trees were similarly affected. The contribution of side-shoot and leader damage to the overall damage level was approximately equal for both of these species. In Douglas fir the percentage of trees which suffered any degree of damage was just 16.7%, with the incidence of leader and side-shoot damage falling to values as low as 10% and 11% respectively, with no stem damage being recorded.

Figures 5 and 6 show a classification of the degree of severity of damage for those trees which suffered side-shoot damage and stem damage, respectively. Of the seven species examined, ash was most vulnerable to severe rabbit damage. Over half of the side-shoot damage which occurred

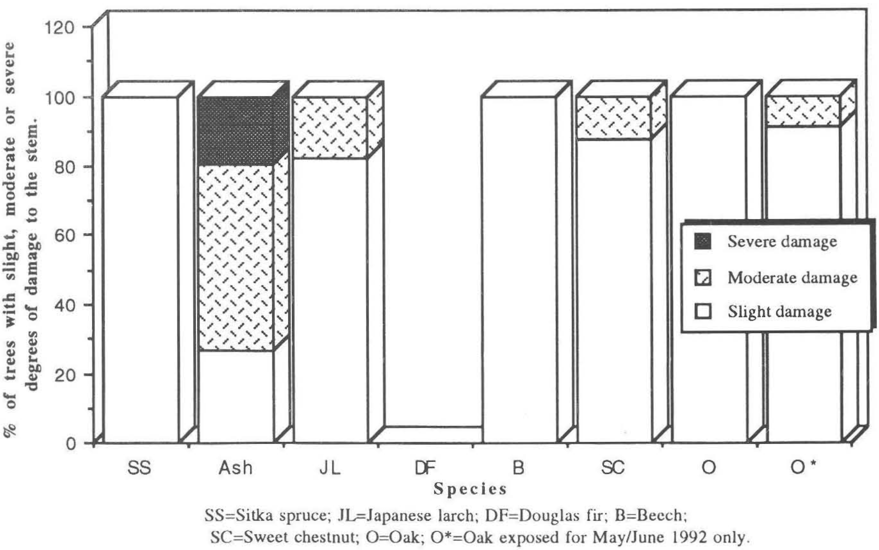

Figure 6. The severity of stem damage for the seven species examined in the two study areas.

was severe. In addition, 20% of stem damage was severe but a further 50% was moderate. Conversely, in the majority of cases both forms of damage to the other species was slight. However, Sitka spruce, Japanese larch and oak did display moderate side-shoot damage in 30% of cases (Figure 5). The incidence of moderate stem damage was generally lower and occurred in Japanese larch, sweet chestnut and oak (Figure 6).

The extent of overall damage was not related to rabbit activity levels. However, rabbit activity was found to be correlated with certain forms of damage, such as bark stripping and severe side-shoot damage.

Discussion

The overall levels of damage which were found confirms the suspicion that the majority of young tree species can become damaged by browsing (Gill, 1992), with side-shoot damage proving to be the most important form of damage by rabbits. Certain species, such as ash and oak are preferred for browsing and these can become damaged in a relatively short period of time (Gill, 1992; Lanier, 1976), even when rabbit population levels are relatively low. The distinctive preference for species such as ash, oak, and Japanese larch shown in this study confirms early reports from Scotland (Craig, 1871).

Although there were four species identified which had a relatively high rabbit damage, much of the damage to Sitka spruce and to Japanese larch was slight and to the side-shoots. In addition to this it is known that Sitka spruce can withstand a greater degree of browsing than many other species (Melville *et al.*, 1983). Coniferous species are generally less vulnerable and the damage inflicted is not generally economically significant. Thus, the two species at greatest risk from rabbits are ash and oak. Little work has been carried out so far on the economic significance of this forest pest. The lack of information on the ability of trees to recover from browsing damage makes any calculation impossible. With the sole exception of ash, the incidence of stem damage in these young trees was low and suggests that this form of damage is not important in young plantations. Side-shoot damage appears to be a common form of damage even on non-preferred species, while leading shoots were often targeted on preferred tree species. Tree shelters proved to offer a satisfactory level of protection against leader damage in oak trees.

The extent of overall damage was not related to rabbit activity levels, but this was not thought to be a reflection of the situation in general. The size of the plot examined was too constrictive for any study of rabbit ranging behaviour. The distance from cover has been shown to be related to damage of winter barley (Cowan *et al.*, 1989), with the majority of rabbits staying within 20 m of the field margin. Ecological factors such as competition, availability of preferred species as well as various physical site variables may well be more important in tree plantations. However, rabbit activity was found to be correlated with certain forms of damage, such as bark stripping and severe side-shoot damage. These relationships are indicative of the situation in early summer, when population levels were relatively high. Shooting and poisoning activities on both sites caused a temporary reduction in numbers during the summer months and this may have effectively controlled the rabbit population and reduced the incidence of leader damage. However, we cannot rule out other, more complex ecological interactions which are likely to influence the selection behaviour of these animals. For instance, the relatively high incidence of side-shoot damage to oak trees in May and June may have been due to the unusually dry conditions that prevailed for those two months in 1992 (T. Keane, Meteorological Service, personal communication). A reduction in the availability of other more lush vegetation at this time could result in the selection of side-shoots, in order to provide sufficient water.

The degree of severity of damage to the leading shoot was not scored, due to difficulty in distinguishing between damage classes. Basically, the removal of a leading shoot is an "all-or-none" response, i.e. once the uppermost tip is removed, multi-leader development is likely. There is no evidence to suggest that there is a relationship between the length of leader which was removed and the extent of multi-leader development

(J. Fry, personal communication). Therefore, leader damage was simply classified as having a score of either 1 (leader removed) or 0 (no damage). With the exception of sweet chestnut, the inter specific differences in mean tree height were too slight to permit any meaningful comparison between rabbit activity and mean tree height.

Unlike deer, (Hannan, 1986), the species preferred for browsing by rabbits were not preferred for bark stripping, although susceptibility to bark stripping by rabbits may be related to the age of the tree (Gill, 1992). Several reasons have been cited for bark stripping; the shortage of other food, the need for vitamins or minerals otherwise deficient, (Miles and Kinnaird, 1979) or for the sugar content of soft tissues as in the case of the grey squirrel (Kenward, 1982). Damage to side-shoots was consistently high in species with high incidence of rabbit damage, while leader damage was restricted to just two species, ash and oak. Results from "sheltered" oak trees suggest that the side-shoots may be the first line of attack in preferred tree species but this requires further corroborative evidence. Furthermore, preferences for older shoots may become more apparent in older trees, as was found for hares (Ianson and Palo, 1991; Tahvanainen *et al.*, 1985) and this requires further investigation. The relatively low incidence of leader damage in sweet chestnut was due to the height of these trees when planted out in March/April 1992. All were greater than 60 cm in height and therefore could not be comfortably reached by the rabbits (Springthorpe and Myhill, 1985).

The factors which govern the selection of material for browsing are complex and the underlying principles have not been examined in any detail for rabbits (Miles and Kinnaird, 1979; Gill, 1992). Population size, habitat variables and the presence of certain resinous material (Moss, 1973), or secondary metabolites (Gill, 1992) have all been identified as possible contributory factors. The determination of the role of secondary metabolites as possible anti-browsant compounds, as carried out for hares (Ianson and Palo, 1991; Tahvanainen *et al.*, 1985), would be an important step forward. It may be possible that tree species such as oak, ash, Sitka spruce and Japanese larch may contain similar types and levels of these compounds. Preferences for older as opposed to younger shoots may become apparent in older trees.

In addition to this chemical factor, other important ecological variables have been identified, all of which are interrelated to a greater or lesser extent. These include the level of rabbit activity and future potential for an increase in numbers, habitat type, whether the site has been clear felled in the past, the amount of other browse available, the availability of suitable cover for the rabbits on the site as well as distance from areas of high rabbit activity to the site (Downes, 1993). In addition, there are various physical factors to be considered, such as soil type, the control methods (if any) used on the site and the time of year and weather conditions (Downes, 1993). Further work may clarify the exact ecological, physical and chemical mechanisms involved.

Recommended Control Measures

The importance of adequate assessment of the site at least three months prior to planting, in order to prevent subsequent damage occurring cannot be emphasised strongly enough. Assessment of the numbers of rabbits which are present on, or very close to a proposed site is not sufficient on its own, without an estimate of the future potential for recolonisation from neighbouring land (Springthorpe and Myhill, 1985). Waste material, such as large piles of tree stumps and brambles, if left on the new plantation create ideal habitats for rabbits and should be cleared. Species vulnerability as well as plot size are important considerations in deciding on preventative measures such as fencing or tree shelters. Therefore, any pre-planting assessment plan is certainly likely to substantially reduce any costs that might be incurred as a result of serious rabbit damage and is strongly recommended.

Conclusions

Rabbits are capable of causing severe damage to young tree plantations in relatively short periods of time even when population numbers are relatively low. Oak, ash, Sitka spruce and Japanese larch were identified as being vulnerable to rabbit damage, although there were differences in the form and severity of damage for these species. Sweet chestnut, beech and Douglas fir all suffered relatively low levels of damage. Damage to the side-shoots was consistently high for all four vulnerable species, but the incidence of leader loss was highest for oak and ash. Serious stem damage was found in ash. Ash was the most vulnerable tree species by far, with a high incidence of all three forms of damage, a large proportion of which was severe in nature. In contrast, Douglas fir was the least susceptible to damage by rabbits and any damage which occurred was slight.

It is clear from this study that measures to understand the relationships that exist between the nutritional ecology of the European wild rabbit and the health of young forestry plantations will substantially reduce the economic losses incurred in the future. Such information is essential for future planning and management programmes, particularly in view of current high rates of planting and the diversity of site types.

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Effects of Weed and Grass Control on the Establishment of *Fraxinus excelsior L.*

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Summary

Fraxinus excelsior L. was planted at Johnstown Castle, Co. Wexford in a loam to clay loam soil which had previously been used for intensive beef production. Weed control, using glyphosate, was practised on part of the site for three consecutive years, the rest remained untreated.

A marked increase in tree height and quality occurred in the treated plots. It is suggested that vegetation competing for moisture, rather than nutrients, was the main reason for the poor growth in the control plots.

Introduction

Ireland has approximately half the livestock numbers that it's grassland is capable of carrying (Lee and Diamond, 1972). Because of E.C. restrictions it is unlikely that, in the forseeable future, there will be sufficient livestock to utilise the existing grassland efficiently. It is therefore critical that alternatives to grassland be found. The climate and soils are such that tillage crops are unlikely to provide a viable alternative land use on a national scale. At the moment 6.5% of Irish land is under forestry (Fitzsimmons, 1987) and this percentage is rising at a rate of 0.25% per year.

Since the foundation of the State forestry has, by and large, been confined to the poorer soil types. The introduction of grants and premia by the Government to the private sector has vitalised interest in forestry among farmers and the choice of land available for tree planting has widened significantly. There is a considerable interest now in planting broadleaves on good quality lowland, that was heretofore used for intensive grassland agriculture (Culleton and Bulfin, 1990).

Competition by grasses and herbaceous weeds in young plantations can seriously reduce the survival and early growth of the trees and lead to an extended establishment period. Grasses, especially, can compete vigorously for light, nutrients and in the lowlands and drier uplands, for water (Williamson and Lane, 1989). Weed control is therefore recognised as highly desirable in the establishment of newly planted trees (Davies, 1987). Soil moisture deficits become greater under grass and weeds than under bare

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Figure 1. Difference between treated and control plots are readily distinguished. Glyphosate treated plots on right.

ground because a vegetated cover can loose moisture more rapidly and for a longer time before soil moisture potential limits transpiration. Relatively little moisture evaporates from bare soil before a layer of dry soil forms, restricting further evaporation loses (Marshall and Holmes, 1979).

Insley (1988) suggested weed control under broadleaves is required for a longer period than for conifers because of their slower establishment phase. Roberts and Chancellor (1986) reported on the large number of seeds normally present in the soil of intensively managed lowland soils. There is a need to quantify the effects of weedgrass control on the establishment phase of hardwood trees on fertile lowland sites.

Material and Methods

Twelve hundred saplings of *Fraxinus excelsior* were planted on an imperfectly drained loam to clay loam soil at Johnstown Castle, Co. Wexford in April 1989. A description of the trees at planting is given in Table 1. The land had previously been used for intensive beef production from grass, using up to 200 kg N/ha, and carrying a stocking rate of 2000 kg/ha of stock at turn-out in spring. The sward prior to planting consisted primarily of *Lolium perenne*. The P and K levels were 12 and 150 mg/kg, respectively. Soil pH was 6.7. The entire sward was burnt off completely three weeks before planting with glyphosate.

The trees were planted at a 2m spacing within and between rows. There were 40 rows of 30 trees per row. Complete weed control was maintained in the first 20 trees of each row, by spraying with glyphosate three times per year, in late April, mid June and late September in 1989, 1990 and 1991. In the last 10 trees per row there was no weed control and there were no other differences between treatment of soil or trees subsequently. In November 1991, tree mortality and tree performance were assessed in both treatments. Each tree was also graded into good, medium or poor quality. This was determined by eye and was based on a combination of factors i.e. presence/absence of apical bud, tree shape and general appearance of healthy growth. Leaf samples from the middle of the crown of a range of trees in each treatment were collected in July 1991 and analysed from N, P, K, Ca and Mg as outlined by Byrne (1979).

Table 1: Description of Saplings Planted in April, 1989.

	Height(cm)	Width(mm)	Quality
Mean (S.D.)	73 (20.4)	9.7 (1.88)	42% good
Minimum	26	49	52% medium
Maximum	170	16.0	8% poor

Results and Discussion

While every effort was made to plant trees that were uniform in appearance there were differences in height, width and grade in trees at planting (Table 1). Complete weed control was maintained, although at each spraying operation a different species of weed tended to appear. The constant spraying insured that these weeds were not growing sufficiently long to compete with the trees for light, nutrients or water. This observation of constant and severe weed infestation on highly fertile ex-agricultural land has been reported previously by Roberts and Chancellor (1986).

In the no weed control plots grasses, rather than weeds, were the dominant species present. *Lolium perenne* and *Agrostis tenius* returned rapidly after the spraying prior to planting and grew vigorously in each growing season. Small numbers of broadleaved weeds, mainly *Rumex* species were also present. The effects of this luxurious grass growth severely restricted the performance of the trees. Mortality in trees was higher than in the complete weed control plots (Table 2). It was observed that the tall grass tended to pull down the saplings to an almost horizontal position, from which several were unable to recover. Minimal weed control, like trampling around each tree could lesson these problems. The effects of grass growth on tree growth and width were enormous. The trees in the no weed control plots were 34% and 37% of the heights and widths respectively in the complete weed control trees. It was observed over the three year period that there were considerable amounts of apical bud death and dieback in the no weed control plots. It was also observed that after the weeds had choked the young saplings new growth came in the following year from an auxiliary bud near ground level. While many plants survived, the quality of the surviving trees were very much reduced (Table 3). Moffat and Williamson (1991) agreed in that they reported that tree establishment was seriously compromised unless weed control was practiced on lowland fertile sites.

Table 2: The accumulated effects of weed control in *Fraxinus excelsior* growth after three growing seasons.

	Complete Weed Control	No Weed Control
Moratality%	4	15
Height(cm)		
Mean (S.D.)	220 (31)	75 (26)
Minimum	95	18
Maximum	320	135
Width(mm) at 30cm		
Mean (S.D.)	27 (5)	10 (4)
Minimum	12	5
Maximum	38	18

Table 3: Quality of trees in weed control and no weed control plots (percentage of total monitored).

	Good Quality	Medium Quality	Poor Quality
Complete Weed Control	30	40	30
No Weed Control	2	30	68

The reasons for the difference between treatments is not immediately apparent. The chemical composition of leaves harvested in July, 1991 from both treatments is given in Table 4. While there was some evidence of lower mineral content in the no weed control trees, the differences were not large. It is difficult to imagine growth being retarded by nutrient deficiency in such high fertility soils.

Table 4: Chemical composition (g/kg) of leaves of *F. excelsior* taken in July 1991.

	N	P	K	Ca	Mg
Complete Weed Control	3.0	.23	.82	1.7	.79
No Weed Control	2.6	.20	.74	1.4	.74

Marshall and Holmes (1979 and Tabbush (1984) reported that drought can restrict tree growth and suggested that trees in bare soils will suffer less drought stress whenever evaporation exceeds rainfall during the summer. Table 5 summarises data on rainfall and soil moisture deficits during the growing seasons on 1989, 1990 and 1991. There was a severe soil moisture deficit for most of the establishment year. There was also low rainfall in 1990. This suggests that lack of moisture may have been the main reason for the lack of growth in the no weed control plots.

Table 5: Climatic parameters in 1989, '90 and '91.

	1989		1990		1991	
	Rain (mm/day)	S.M.D. (mm)	Rain (mm/day)	S.M.D. (mm)	Rain (mm/day)	S.M.D. (mm)
April	4.1	0.8	0.7	30.8	3.0	11.7
May	0.2	51.8	1.2	72.1	0.4	48.3
June	2.1	77.5	27	59.6	3.1	62.5
July	0.7	91.1	1.4	49.7	2.1	62.9
August	2.5	78.0	1.3	82.9	0.9	62.9
September	1.2	58.2	1.3	78.2	3.8	73.9

The results from this trial, suggests that weed control is vital for the rapid establishment of *Fraxinus excelsior*. A trial that was planted in 1990 at Johnstown Castle is examining degree of weed control in more detail. The results after the first season's growth suggests that weed control in the immediate environs of the tree may result in better growth rates than either no weed control or complete weed control. Results of this trial will be published in more detail in due course.

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Mark Anderson – Scottish Forester[1]

Address given at Banchory, Aberdeenshire, on 23rd October 1981 by Professor Charles J. Taylor on the occasion of the 25th anniversary of the Silvicultural Group, R.S.F.S.

[1]Reprinted (slightly abbreviated) from *Scottish Forestry*, Vol. 36, No. 4, 1982, by kind permission of the Editor.

If there is need to find an epithet to apply to Mark Louden Anderson I am sure the one that is particularly apt, and which he would have approved, is "Scottish Forester." There was never any doubt of his being a Scot, sometimes in the extreme, and his concern for forestry can be called a passion.

Mark Anderson was born in April 1895 and died in September 1961, just four years before he was due to retire from Edinburgh University's Chair of Forestry. His father was the Parish Minister of Kinneff in the Mearns.

The young Mark suffered a double tragedy when only about twelve years old. His father, cycling downhill, was killed by being transfixed on the shaft of a cart. Six months later Mark's mother died. The orphan then went to the Manse at Menstrie at the foot of the Ochils, where his cousin was Minister – cousin by relationship but more like an uncle in age. It is probable that the five years Mark spent at Menstrie created in him an attitude which he was to carry with him, to a greater or lesser degree, all through life and which caused him to feel that some people were trying to do him down or thwart him. It was most unfortunate that he had this complex because it did tend to influence the way he treated some people who really deserved better for they would have been very co-operative if they had been given the chance. What brought about this was Mark's conviction that the Minister did not accord the same treatment to him as he did to his sons; and so Mark felt subordinated to them.

Mark left Alloa Academy in 1912 but with a grudge because he was sure that he should have done so as dux but was denied the honour allegedly by a master who had taken a dislike to him. He had intended studying Chemistry at Edinburgh University but enrolled in the B.Sc. (Forestry) degree course.

On leave from the army not long before the end of the war Mark married Mabel who came from Menstrie. There were two sons and a daughter of the marriage. Lt. Anderson was demobilised in December 1918 and convinced Mr Stebbing that he could complete the remaining year of his degree course in the two terms that were left of the 1918-19 session. This he did successfully and on the fifth anniversary of graduating B.Sc. (Forestry) he added the D.Sc. for a thesis on tree form. He did it in the minimum time allowed for the higher degree and it was the first such award in Forestry.

Mark Anderson joined the newly created Forestry Commission and although he did some splendid work it did not bring the amount on happiness and satisfaction he should have enjoyed. The two principal reasons were the frustrations he met by not being allowed to try out ideas he put forward, and his intolerance of some people, particularly some who were senior in rank. His ability and his vision made him a man before his time or, rather, in advance of many of his colleagues. He was a research officer but so often he felt he was denied a proper hearing, or his listeners failed to understand him because their attitudes were insufficiently scientific. He preached soil, nutrients and root systems but, to a certain extent, was ignored. He pioneered deep ploughing of peat at a time when it was fraught with even greater difficulties than are now experienced because in those days horse-power literally meant what it said. In the 1920s he tried hard to persuade the Forestry Commission to appoint a tree geneticist. It was more than 20 years later before such a post was created. On the matter of personalities it is no secret that Dr Anderson and the executive head of the Forestry Commission did not get on together. This was a very great pity, for both were eminent men but for different reasons. It would seem that Dr Anderson never missed a chance to disagree with Sir Roy Robinson or to be rude to him, directly or indirectly. Indeed, it was with some glee that Professor Anderson told me of an incident when he was watching cricket in the Parks at Oxford, Sir Roy, in passing, said, "I didn't know, Anderson, that you played this game." The rather biting reply was, "Yes, and the war game, too" – a somewhat unnecessary allusion to Sir Roy not having served in the armed forces in World War I. In retrospect, this was even more cruel, for Lord Robinson's only son was killed in World War II while serving with the Royal Air Force.

It was mainly as a result fo feeling frustrated in the Forestry Commission by not being allowed to do more scientific work that caused Dr Anderson to resign in 1932 and go to the Republic of Ireland, first as Chief Forestry Inspector and then in 1940 he became Director. It seems that this was a happy period in his life as he had the opportunity to use his initiative. It was his intention when World War II broke out to return to Britain to join up. Whatever upset this plan is not known because he did not take up his appointment as Demonstrator in the Department of Forestry of Oxford University until 1st December, 1946. He remained at Oxford until 1951 when he succeeded Professor E. P. Stebbing in the Chair of Forestry at Edinburgh University. He occupied this post with distinction until his death ten years later.

Professor Anderson encouraged research studies in shelter, climatology, soil microfauna and investigations into the natural oak woodlands and he instituted experiments connected with the transformation of regular to irregular high forest, associated with the Check Method management. In a later period, the transition of the Department of Forestry to the wider scope conferred on it as the Department of Forestry and Natural Resources was made easy because of the standard to which it had been brought under Professor Anderson's regime.

Professor Anderson's students had two different views on his qualities as a teacher. They found him a poor lecturer because he read his lecture with bowed head and when he used the blackboard the writing was so small and lightly done that it was difficult to read. In addition, the lecture was rather concentrated and read fast. When a member of his staff mentioned to Professor Anderson that his students found some difficulty in getting down his lectures, he replied, "It doesn't matter as it is all in the books" – which was not so! On the other hand, Professor Anderson's students very much appreciated him as a teacher in the forest. In a very easy, natural way he became the great teacher through whom students learnt to observe, make logical deductions based on observation and their own learning and only then try to come to a decision. As a teacher in the forest he was at his ease and was an inspiration to all who accompanied him.

It was a self-appointed mission to try to raise the standard of British forestry that led Professor Anderson into other things. He was the initiator of a meeting held in Aberdeen in 1925, called to consider his proposal to institute a forum in Scotland where scientific forestry could be discussed. The outcome went beyond his original idea for it was the birth of the Society of Foresters of Great Britain, now the Institute of Foresters. It was a great pity that Mark Anderson did not play the part in its activities that one would have expected of him and this lack of active participation was largely due to the membership being divided into two categories – and division in such a body was repugnant to him as his objective was equal status among all the members. Indeed, he was so antagonistic to the class of Fellow that he never aspired to it because he regarded it as an empty title, where elevation to it was essentially on a time basis and not necessarily on merit. In those days there can be no denying that Professor Anderson had good reason for such an attitude which was also shared by some other foresters until the Institute did impose more realistic qualifications connected with its Fellowship. It is sad that the Institute of Foresters never in his life-time officially recognised this forester, virtually its founder, who did contribute so much for the benefit of forestry and of foresters. The award of its medal was made posthumously – a tardy recognition.

A similar objective caused Professor Anderson to found the Silvicultural Group of the Royal Scottish Forestry Society 25 years ago. He hoped it would involve members in discussion of scientific forestry, and so the original membership was by his invitation. I am sure that if Professor

Anderson had lived to celebrate this, its silver jubilee, he would have been very satisfied with what the Group has achieved and is continuing to do.

Mark Anderson was concerned at the great dearth of English language authoritative books on forestry. From his own pen he produced *The Natural Woodlands of Britain and Ireland* (1932) and *The Selection of Tree Species: an ecological basis of site classification for conditions found in Great Britain and Ireland* (1950), with a second edition in (1961). He wrote numerous articles and pamphlets and was always willing to address meetings on forestry topics. Various people tried to persuade him to write a book on nursery practice and afforestation, but he declined saying that such a book would soon be out of date as continuous progress was being made in these techniques and much more would take place. But a major literary contribution that Mark Anderson did make to English speaking foresters was through his command of some European languages. He spoke excellent French and translated from German, Russian and Scandinavian texts. It is interesting to recall that he began to study Russian in the trenches in World War I. This rather typifies the man who was never idle. In one or two respects he was sometimes stubborn over his translations. For example, when it was pointed out to him that his English translation of Knuchel's book on management had no index, he said it did not matter because readers should be so conversant with the text that an index was unnecessary! When he gave me the proof copy of a translation from German to check, I had the nerve to point out that in some places the English text was cumbersome as it was more a transliteration than a translation. All I got was "That's what it is in the original"! So my attempt to try to have a long Germanic sentence split into short, neat English ones came to naught. I found this a very surprising attitude for a man whose spoken and written English was impeccable. However, English speaking foresters are grateful for Mark Anderson's translations which have provided for us such useful works as Tamm's *Northern Coniferous Forest Soils* (1950), Knuchel's *Planning and Control in the Managed Forest* (1953) and Köstler's *Silviculture* (1956). There are also many translations on a variety of subjects including litter dacay, humus, root systems, nutrition, forest types, shelterbelts, group selection and femelschlag working and the check method of management.

There is also his monumental *A History of Scottish Forestry* which involved him in a great deal of work and was begun when he was at Oxford. Even in this his stubborn trait was shown in that he did not produce the kind of typescript that printers demand. He did all his own typing and was rather mean about it, leaving an inch or less for a left-hand margin and none at all on the right and often trying to squeeze in a word were it to involve leaving out the terminal letter! And only single spacing was ever used! Some of the material was obtained by spending many hours in the National Library of Scotland going through newspapers of the 18th and 19th centuries in particular. But with all the very numerous authorities quoted in the text, Mark left his typescript with no list of references, thus involving the editor in a great amount of searching to trace them when it came to retyping and preparing the history for posthumous publication. Having failed to find a publisher himself, Mark felt it might never be published. The fact that it was published made it a sort of appropriate memorial for a man who devoted his life to forestry.

It may be asked "How was Mark Anderson regarded as a forester and what did he achieve?" He was certainly held in very high esteem by Continental foresters. In Belgium, Turner gave him a lot of credit for the method used there in the transformation of pure Norway spruce stands into mixed stands of Norway spruce – silver fir – beech. Mark Anderson was very much in harmony with the French in their practice of natural regeneration and in not being in too much of a hurry to achieve a worthwhile objective. He always wished he could have seen something of Swiss forestry take on in Britain in appropriate circumstances, particularly the selection system, *femelschlag* and the check method of management. His maxim was akin to "Study nature, follow her if you can, but guide her where need be and record what is done and achieved." At the same time he realised that natural regeneration is not always possible, and so he conceived his spaced planted groups. In these he had an unalterable belief in small groups made up often of three or more species in pure cells, and he used the technique in transforming even-aged stands into uneven-aged ones. Some of the deficiencies in detail were seen by some of us when the method was put into practice in Glentress, Dalmeny and elsewhere but he would not deviate, and so it was not till after his death did we get the chance to vary the application by using larger groups, each containing one or two species, and without cellular structure. This modification was based on trying to visualise the ultimate structure of a group selection forest and to consider its management.

Unfortunately Professor Anderson was not appreciated as much as he might have been in British forestry. He disliked large areas of but a single species, especially when it was an exotic, and he felt more use should have been made of indigenous or European species. His love of the oak was well known. He would have given greater application to the selection system as he felt there were quite a number of situations where this silvicultural system was more appropriate than some systems applied to pure even-aged forests. Thus Professor Anderson did not conform with what might be called the general practice of British forestry. However, he was appreciated by those who did share his friendship, by those who benefited from his teaching, whether this was in a direct or indirect form, and by those who met him as a fellow forester, especially in that environment he loved most – the forest. Indeed, it was in the forest that he was at his best and happiest. On the other hand, he too often plunged his knife into the Forestry Commission, and especially some of its officers. He had the true forester's long view whereas, in a general way, he felt that the Forestry Commission was too often short-sighted. There were times when he accused the Forestry Commission of not taking a firm enough stand, but Professor Anderson would not make any allowance for the over-riding influence of politicians. He did not believe in compromise but perhaps he might have achieved more had he departed, even slightly, from what was a firmly entrenched attitude.

Some of you knew Mark Anderson to a greater or lesser degree. Others know him only by name and reputation. I am most grateful that I was able to spend quite a lot of time in his company during the last seven years of his life. During that time I think I obtained quite a good understanding of the man. I certainly benefited from my fairly close association with him. Mark was probably at his best in small company because he was really a shy man and abhorred formal occasions, particularly when they involved large gatherings. He was a man who, although respectful to people, made no attempt at class distinction. Punctuality was one of his obvious characteristics. He led a very simple life, almost a frugal one. His creature comforts were very few and could be fairly described as only the essentials. He worked himself hard and probably did not properly heed his heart attack, with its first warning during a tour of French forests in April 1955, and so he died early. He was a staunch Scot and a passionate forester and so I learnt much form him about Scotland and forestry. He did try to help people but he would not tolerate slackers and those who were incompetent. In his inaugural professorial address he mentioned "efficiency, ability and integrity," and these are three attributes which, combined, describe Mark Anderson, Scottish Forester.

Trees, Woods and Literature, 16[1]

[1]The last previous item in this series appeared in *Irish Forestry, Vol. 33, No. 2, 1976.*

Next morning, at daybreak, Serioga took an axe and made his way to the woods. A chilly, dense, continuous mist, as yet unillumined by the sun, brooded over everything. A light was gradually dawning in the east, and its pale glow was reflected in the vault overhead, veiled by light clouds. Not a blade of grass on the ground, not a leaf in the air above stirred. occasionally a flapping of wings might be heard in the thickets, or some furtive noise on the ground, breaking the silence of the forest.

Suddenly a strange, unaccustomed sound re-echoed and died away on its outskirts. Again it was repeated recurring at regular intervals, at the foot of the trunk of one of the motionless trees. One of the tree tops began to sway strangely. A murmur arose amid the leaves, which were full of sap; a warbler, which had been perched on one of the branches, fluttered and piped twice, then spread its little tail and took refuge on another tree.

The strokes of the axe still resounded, growing more and more hollow; white splinters glistening with sap fell on the green sward, and a faint crack could be heard between each stroke. The entire trunk of the tree was quivering now; it swayed, and then suddenly rose erect again, vibrating terribly on its roots, as if with fright. Silence ensued. Then the tree tottered again; the trunk split across, and fell prostrate on the damp earth, snapping its branches and bringing down the long boughs in its fall.

The sounds of the axe and of the woodsman's footsteps ceased. The warbler piped and flew to a higher bough. One of the twigs brushed by its wings fluttered for a moment, and then all its leaves remained motionless like the rest. The trees spread their quiet branches over the vacant space, and looked even more radiant than before. The sun's first rays at last pierced through the clouds, broke forth in the blue sky, and darted over earth and heaven. The mist then floated away in wreaths, an iridescent vapour hovered over the verdant foliage, and thin white clouds sailed rapidly across the azure vault. Birds fluttered in the shade, singing wild paeans of delight. High overhead leaves full of sap were murmuring joyously, while boughs of living trees waved slowly and majestically above their fellow, cut down and dead.

From *Three Deaths*, (1858) a story by Leo Tolstoy. The translators name is not known.

The purpose of this tree-felling was to procure wood to erect a cross over the grave of an old coachman. When dying he had given his boots to a young colleague, Serioga, the axe-man in this passage, in exchange for a promise to buy a stone to mark the old man's grave.

The fact that the trees "spread their branches over the vacant space" and looked "even more radiant than before" might imply that a thinning was badly needed.

The species of ash in question is probably common European ash, *Fraxinus excelsior*.

Leo Tolstoy was born in Yasnaya Polyana, about 220 kilometres south of Moscow, in 1828. The estate – the name is translated as Ash Grove – came into the family on the marriage of his father, a veteran of the Napoleonic Wars, and was his home all his life.

After his father's death Tolstoy entered the University of Kazan but dropped out without completing a degree course. He returned home, managed the estate, read extensively and sowed wild oats in various forms. After some hesitation he joined the army and served actively in the Crimean War. He married in 1862, entering into a relationship which was long-lasting but never entirely smooth.

Tolstoy had a long literary career, beginning with *Childhood*, an account of his own early years, in 1852. His most famous books are the two long novels *War and Peace* (1865) and *Anna Karenina* (1875). The latter includes, in Part 2, Chapter 16, a diverting account of a discussion between a townsman and a farmer about the assessment and valuation of a wood which the townsman is selling. The farmer believes a rip-off is in progress.

A critic once suggested, perhaps simplistically, that anyone who thought that life in Russia was nasty under Communism should read Tolstoy's late novel, *Resurrection* (1899) and learn what it had been like earlier under the Tsars.

In 1910, aged 82, irritated by his wife's surveillance and frustrated by the contradictions in his own life, Tolstoy stole away from Yasnaya Polyana, taking with him only his personal physician. He left by train, not fully decided on his ultimate destination, but some days later, becoming seriously ill, he was taken in by the station master in a remote village. While there his wife travelled to visit him but was denied entry to the house where he lay. He died there, nine days after leaving home, and such was is fame that his final days were widely publicised. Among his last recorded words were "So this is the end!. . . and it's nothing. . . "

Readers may be interested to know that one of Tolstoy's friends was "Kern, the forestry inspector".

(Selection and note by Wood Kerne)

Letter to the Editor

The Editor
Irish Forestry

Dear Sir,

In a book review in *Irish Forestry* (Volume 48, Nos. 1 & 2) Dr J. F. Durand writes (page 54) that "Dr O Carroll's quoted reference to the Forestry Commission's entry at Baronscourt in 1920 as the first area for State afforestation in Ireland, must similarly be regarded as inaccurate when unqualified". I understand that this refers to an abbreviated quotation in a note on page 365 of the book under review.

The relevant passage in *The Forests of Ireland* (1984, page 111) reads in full as follows: "Meanwhile the Department of Agriculture and Technical Instruction for Ireland, (Dublin) set up its school for training estate foresters at Avondale (Co. Wicklow) in 1904 and acquired an area at Ballykelly (Co. Londonderry) for forestry. In 1920 the first area for State afforestation in Ireland was acquired for the Forestry Commission (headquartered in London) at Baronscourt in County Tyrone". That passage, as it stands, needs no qualification.

I might add that the correction slip, also referred to in the review, did rather more than "challenge a quote"; it corrected a damaging mis-statement.

Yours sincerely

Niall O Carroll
12 Mapas Road
Dalkey
Co. Dublin.

Obituary

CAPTAIN CHARLES B. TOTTENHAM
1924 – 1992

During the course of my professional life, I was fortunate to have been associated with the Tottenham family and particularly with Charles. This association arose from an introduction to Ballycurry Estate by Professor Michael Gorman, who was advising on grassland management on the estate in the late 1940s. Around 1950 Charles returned from a distinguished wartime service and was given the management of the woods by his father, who with his family had transferred from Mount Callan estate in Co. Clare in 1946.

Ballycurry woodlands, in common with private estate woodlands had suffered from wartime fellings and lack of systematic management. The first task was to prepare a plan based on a detailed map of the woodland area. This plan Charles followed faithfully and enthusastically, up to the time of his death, and the results of his management are a shining example of what can be accomplished on the woodlands of a private estate.

As an Associate Member, Charles took an active part in the Society of Irish Foresters from the early 1950s. He was a regular attendant at meetings and on study tours in Ireland and abroad. He was also, in later years, a member of the Council. Everyone who had dealings with him came to appreciate his directness, honesty and cheerful disposition and to admire his enthusiasm for forestry.

Amongst his pleasures was fishing and his frequent trips to his old family home in Mount Callan where his younger brother, Robert, lives. Charles was

convinced from his association with forestry that the Mount Callan estate would benefit from a positive afforestation programme. In consultation with Robert, Charles and I encouraged him to get involved in a tree planting regime. This resulted in a spectacular improvement in the potential of the estate at Mount Callan and was so successful that it has had a major impact on private forestry in the west of Ireland.

To his wife, Lucy and his children, the Society extends its deep sympathy.

T. Clear.

Society News

ANNUAL GENERAL MEETING

Minutes of the 50th Annual General Meeting
17th July 1992
G-08, Agriculture Building, UCD

Attendance

P. Carroll, P. O'Sullivan, F. Corrigan, T. Farrell, L. Furlong, M. Cosgrave, M. Cosgrave, N. O Carroll, J. O'Dowd, E. Hendrick, R. Jack, J. Fennessy, B. Fitzsimons, A. J. van der Wel, T. A. Barry, D. Little, G. Murphy, F. Mulloy, M. MacSiurtain, S. Jones, R. McDonald, R. Gallagher, M. Mallin.

Apologies

K. Hutchinson, C. Kilpatrick, D. Magner.

1. Minutes of 49th AGM

The minutes, which were published in Irish Forestry Vol. 48 (Nos. 1 & 2), were taken as read. There being no amendments, the minutes were signed by the President.

2. Council Report for 1991

The Council report was proposed by B. Fitzsimons and seconded by M. Cosgrave.

3. Abstract of Accounts

The audited statement of accounts for year ended 31st December 1991 was adopted by the meeting.

4. Results of 1991 Council Election

President: Ted Farrell
Vice-President: Eugene Hendrick
Secretary: Pat O'Sullivan
Treasurer: Kevin Hutchinson
Editor: Alistair Pfeifer
P. R. Officer: Jim O'Dowd
Business Editor: John Gilliland
Auditor: Bill Jack
N.I. Group Rep.: Trevor Wilson
Technical Councillors:
Pacelli Breathnach, Pat Carroll, Richard Jack
Associate Councillor: Lily Furlong

The results, proposed by G. Murphy and seconded by M. Cosgrave, were ratified.

5. Council Motions I, II and III

Motions I and II – Proposed amendments to the Rules and Constitution of the Society.

The President outlined the background to the proposed amendments. While the Society had always sought to represent, in a broad sense, the profession of forestry – the purpose of these amendments is to enable the Society to represent the forester as a professional. He emphasised that the proposed revisions were necessitated by the huge changes currently taking place in Irish forestry and were intended, not to regulate, but to promote the regulation of the forestry profession.

The effects of the amendments will be to tighten up membership criteria, especially for technical members, since they would give the Council the power to determine acceptable qualifications for technical membership. The Council would also acquire the power to expel technical members who are not upholding the profession of forestry. The Council will have the right to set criteria and regulations determining acceptable professional standards. It was agreed that Motions I and II would be discussed jointly but voted on separately.

Fergal Mulloy advocated acceptance of the proposals as they are timely, he felt the Society provided the most broadly based framework to judge the standards needed. Gerry Murphy expressed concern that different Councils would set different standards and queried the criteria the Council would use in deciding what are acceptable standards. The President undertook to devise a code but stressed that it was an ambitious undertaking and one which would evolve over time.

Mairtin MacSiurtain agreed that the motions should be supported but argued that the Council is guilty of a disservice to its members if the qualifications it awards are not recognised internationally. Gerry Murphy agreed, he suggested that, in order to maintain standards, all technical members would be reassessed for membership at five year intervals. The President felt that while this might be a laudable objective it was unrealistic at present.

Niall O Carroll felt that reassessment was an unnecessary imposition on members since persons holding university degrees are not subjected to any form of reappraisal.

Mairtin MacSiurtain suggested changing the wording in Article 4 (e) to "holding examinations and awarding appropriate internationally recognised certificates."

Niall O Carroll argued that the present wording was adequate since "appropriate" here implied "appropriate to the objectives of the Society" and any change would be inconsistent with Article 2.1.

The President reminded the meeting that the proposed amendments must be accepted or rejected in totality.

Gerry Murphy, supported by Mairtin MacSiurtain, stated that the Constitution reeked of insularity, instead it should reflect the international orientation of the Irish forest industry. For this reason the Society should at least attempt to award internationally recognised qualifications. The meeting accepted Niall O Carroll's proposal that Mairtin MacSiurtain and Gerry Murphy be invited to make a submission to the Council on how the issue of acceptable certification might be addressed.

There being no further discussion, the President called for a vote on Motion I and II. Motion I was passed (21 for, 0 against, 2 abstentions). Motion II was passed (22 for, 0 against, 1 abstention).

Some of the 1992 Council.
Back Row (l to r):
Tim O'Regan, Jim O'Dowd, Ari van der Wel, Eugene Hendrick, Trevor Wilson, John Fennessy.
Front Row (l to r):
Dr Niall O Carroll, Kevin Hutchinson, Dr Ted Farrell *President,* Lily Furlong, Pat O'Sullivan and Richard Jack.

Motion III – That Mr Cecil Kilpatrick be made an honorary member of the Society.

This motion was introduced by the President who read the following citation:

"Cecil Kilpatrick served in the state Forest Service of Northern Ireland where he became Chief Forest Officer. After his retirement he wrote a detailed history of forestry in Northern Ireland. As first Northern Ireland President of the Society he concentrated on regional development and on increasing the Society membership. His presidency oversaw the publication of the first edition of *The Forests of Ireland*. His approach to forestry development in the island of Ireland has always been based firmly on scientific principles."

The Motion was carried unanimously.

6. Policy Issues

The three policy statements which had been prepared by the Council were well received by the members present. The President stated that each policy statement represents, in a very concise form, the Council's view on the particular topic. Fergal Mulloy supported the initiative but argued that the Council must now promulgate them in an effective manner and to do this the Society must adopt the role of lobbyists on each of the issues raised. Martin MacSiurtain welcomed the decision to prepare these policy statements and suggested that members should submit topics for future policy statements. Niall O Carroll stated that the Council must now decide how it can publicise these policy statements most effectively. The President agreed that this should be considered at the next Council meeting.

7. Any Other Business

The President stated that if the Society is to become a more active and visible organisation it must acquire a permanent office and secretarial staff. This will be addressed at the next Council meeting. Declan Little, supported by Mairtin MacSiurtain, believed the Society needs young members if it is to have a future. Suzanne Jones advocated that the incoming Council would introduce some initiatives designed specifically to foster the interest of young members.

Meeting concluded.

Pat O'Sullivan,
Secretary.
4th August 1992

COUNCIL REPORT 1991

1. COUNCIL MEETINGS

Eight Council meetings were held during the year. Attendance by Councillors was as follows:

E. Farrell, N. O Carroll	8 meetings
P. O'Sullivan	7 meetings
L. Furlong, P. Breathnach, J. Fennessy, E. Hendrick, T. O'Regan	6 meetings
K. Hutchinson, D. Magner	5 meetings
J. Gilliland, A. Pfeifer	4 meetings
P. Doolan, A. van der Wel	3 meetings
T. Wilson	2 meetings
J. Neilan	0 meetings

2. SOCIETY MEETINGS

The Society organised a Symposium; day meetings (3) at Lees Sawmills/Goles Forest, Powerscourt Estate and Lisgoold Forest/Nursery; an evening meeting on "Global Warming" and the Agustine Henry Memorial lecture. The Annual Study Tour visited eastern France.

3. ANNUAL GENERAL MEETING

The 49th Annual General Meeting was held in the Agriculture Building, UCD on 4th April 1991. The minutes of this meeting are published in Irish Forestry Vol 48 (Nos. 1 & 2)

4. SOCIETY PUBLICATIONS

Irish Forestry Vol. 47, No. 2 and Vol. 48 (Nos. 1 & 2) were published.

5. ELECTIONS

Three positions of Councillor (Technical) for the period 1992 - 1993 were filled by election.

6. MEMBERSHIP

The Society now has 578 members enrolled in the following categories - Technical (425), Associate (115) and Student (38).

Signed: Pat O'Sullivan
Honorary Secretary
March 1992

EDUCATIONAL AWARD FUND

STATEMENT OF ACCOUNTS FOR YEAR ENDED 31st DECEMBER 1991

1990	*RECEIPTS*	*1991*	*1990*	*PAYMENTS*	*1991*
1,620.46	To *Balance from last account*	1,520.65	250.00	By Awards	150.00
150.19	To Interest	121.96	1,520.65	By *Balance*	1,492.61
1,770.65		1,642.61	1,770.65		1,642.61

I have examined the above accounts, have compared with vouchers, and certify same to be correct, the balance to credit being IR£1,492.61 which is held in the Trustee Savings Investment Bank Account 30013591.

Signed: W. C. Jack, Hon. Auditor

SOCIETY OF IRISH FORESTERS – STATEMENT OF ACCOUNTS FOR YEAR ENDED 31ST DECEMBER 1991

1990	*RECEIPTS*		*1991*	*1990*	*PAYMENTS*		*1991*
3,465.37	To *Balance from last account*		8,573.03	338.16	By Stationery and Printing		116.07
	Subscriptions received			3,513.00	Printing of Journals		6,303.00
	Technical 1991	9,457.41		1,374.45	Postage		2,034.53
	Technical 1990	1,886.47		145.01	Expenses re Meetings		468.85
	Associate 1991	2,256.00		114.94	Bank charges		128.30
	Associate 1990	396.00		874.10	Secretarial expenses		1,354.36
	Student 1991	145.00		72.85	VAT		39.07
	Student 1990	45.00		0.00	Examination expenses		—
	Other arrears	114.50		0.00	Miscellaneous		143.57
	Advance payments	408.71		888.38	Insurance premium		909.00
12,045.06			14,709.09	233.69	Affiliations		204.06
	Interest on Investments				By *Honoraria*		
	Savings at Ulster Bank		784.47			Secretary	50.00
508.83	Educational Building Society		8.38			Treasurer	50.00
267.62	To *Journal*		1,595.00		Editor	50.00	
15.73	Gains on sterling		40.88	280.00	Business Editor	50.00	200.00
25.00	Donation		49.75				
	Wood Ireland		2,000.00				
					By *Balance*		
					Current Accounts	788.33	
					Savings Accounts	14,881.95	
					Educational Building Society	189.51	
				8,573.03			15,859.79
16,327.61			27,760.60	16,327.61			27,760.50

I have examined the above accounts, have compared with vouchers, and certify same to be correct, the balance to credit being IR£15,859.79 which is held in current accounts at the Ulster Bank (IR£3,589.07 less IR£2,800.74 uncashed cheques), Ulster Bank Savings Account 08778241 and the Educational Building Society Account 11304413. There is a holding of Prize Bonds Numbers R855061/080.

Signed: W. H. Jack, Hon. Auditor

Notes to Assist Contributors

The following notes are designed to aid the speedy processing of contributions to the Journal.

1. Two copies of each paper should be sumitted in typescript, with double spacing and wide margins, correct spelling and punctuations expected.

2. Diagrams and illustrations should be clearly drawn in black ink on good quality paper. Captions should be written on the back of each illustration. Illustrations, wherever possible, should be drawn in an upright position (x axis narrower than y). The approximate position of diagrams and illustrations in the text should be indicated in the margin.

3. Tables should not be incorporated in the body of text, but should be submitted separately at the end (one table per page). Their approximate position in the text should be indicated in the margin.

4. Nomenclature, symbols and abbreviations should follow convention. The metric system should be used throughout.

5. References should be in the following form:

   GALLAGHER, G. and GILLESPIE, J. 1984. The economics of peatland afforestation. Proc. 7th Int. Peat Cong. Dublin. Vol. 3:271-285.

   KERRUISH, C. M. and SHEPHERD, K. R. 1983. Thinning practices in Australia. A review of silvicultural and harvesting trends. New Zealand Journal of Forest Science, 47:140-167.

   Forestry Abstracts may be used as a guide in the abbreviation of journal titles.

6. A short summary of the paper should be included. It should precede the main body of the text and not be more than 400 words.

7. Proofs will be sent to the senior author for correction. Proof corrections are costly and authors are requested, as far as possible, to confine alterations to the correction of printer's errors.

8. Reprints can be supplied as required by the author. The cost of reprints will be charged to the author at a standard rate per page. *Reprints must be ordered when returning corrected proofs to the editor.*

9. Submission of an article is understood to imply that the article is original and unpublished and is not being considered for publication elsewhere.

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