# Broadleaves – An alternative to conifers in Ireland?

Jürgen Huss

## 1. The role of broadleaved tree species in Central Europe

Central Europe, originally covered mainly with broadleaves, was to a large extent reforested with conifers. Only recently a renaissance of broadleaves has begun. Before going into technical details, which might be of interest to Irish foresters, it may be noteworthy to explain the background of the original and the current forests in this part of Europe.

### *1.1 Natural forest coverage before the influence of man*

Intensive studies including pollen diagrams have been carried out, dating back to the last decades of the 18th century about the distribution of tree species in Central Europe before the influence of man became important. As illustrated in Figure 1, they led to the following results:

- Beech (*Fagus Sylvatica*) in all maritime influenced areas – i.e. the

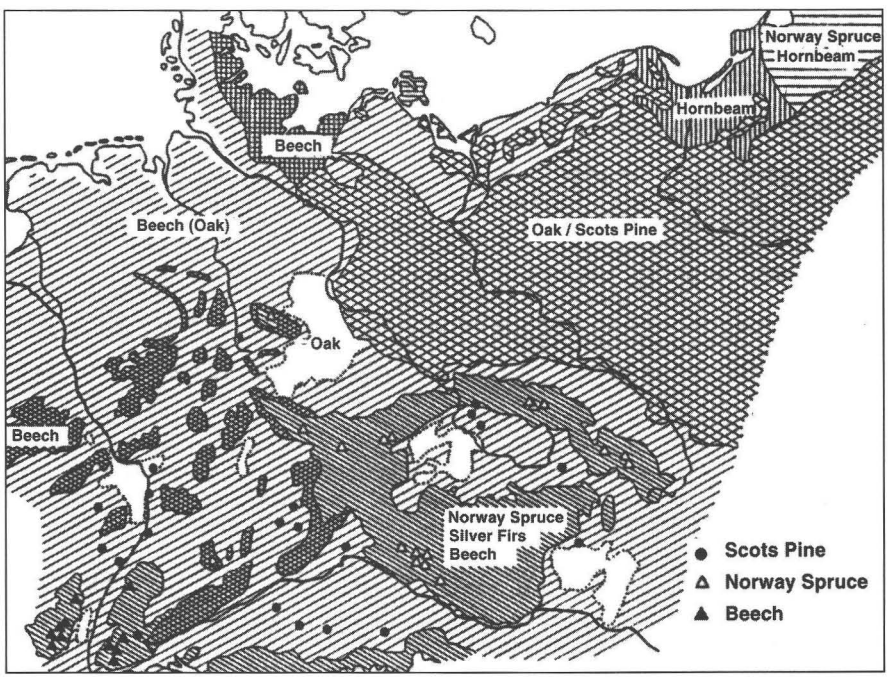


**Figure 1**
*Natural regions of forests in Central Europe before intensive interference by man.*

western parts of Central Europe – was by far the dominant species. It covered most of the lowlands, the hilly and mountainous regions up to elevations of around 1800m, in the Alps. Only in periodically flooded areas alongside rivers, on dry rocky or poor sandy soils, in the moors and in the rain shadow of some mountains did it lose its competitive capacity. The same happened in the East. In the more continentally determined climate of for instance Eastern Germany, Poland, Hungary, and Russia, beech was replaced by mixed forests of oak (*Quercus* spp.) and pine (*Pinus* spp.). Beech was only left only in "islands" in mountain regions, such as the Carpathians.

- Pedunculate oak (*Quercus robur L.*) prevailed in the riverain forests, often mixed with ash (*Fraxinus excelsior*) elm (*Ulmus* spp.), and hornbeam (*Carpinus betulus*). It was frequent also on typical pseudogleys with high watertables and in the more continental regions, as mentioned already. Sessile oak (*Quercus petraea*) evidently lived mixed with beech on dryer and warmer slopes in the low mountainous regions, sometimes in very dry areas mixed with ash, wild service tree (*Sorbus tormindlis (L.) Crantz)*, field maple (*Acer campestre* (L.)), wild cherry (*Prunus avium* (L.)).

- Sycamore (*Acer pseudoplatanus* L.) and maple (*Acer spp.*) – sometimes mixed with beech – had their niches partly on rocky ground and in wet slopes in the mountains.

- Conifers such as silver fir (*Abies alba (Mill.)*) were commonly mixed with beech in the southern mountain regions such as the Vosges, Black Forest, outer borders of the Alps and Bavarian Mountains as well as in the boreal zones of Scandinavia and Russia.

Norway spruce (*Picea abies (L.)*) was generally found only in small proportions in the more continentally influenced mountainous areas but became predominant in the inner Alps and the East European Mountains as well as in the boreal zones of Scandinavia and Russia.

Pine – also of little importance in West and Central Europe — lived on extremely dry mountain slopes and rocks, as well as alongside moors. It also had only a chance occurrence in continental and boreal zones.

There is almost no dispute today, that at least two thirds of all forest coverage was with broadleaves. Conifers were only of some importance in the mountains and in the east, where they were generally mixed with broadleaves.

*1.2 A short history of forest development*

Since the stone age lowland forests, especially those on loess, have been gradually cleared by man, quite systematically by the Celts and Romans. There is some evidence, that oak has been particularly favoured for more than three thousand years, because of its value as construction timber and mast trees.

Today's forest distribution was established in the middle ages between 800 and 1300, when more or less all arable land was cleared, leaving a forest cover only in the mountains, bogs, and on very poor ground.

It took another 500 years until most

of the remaining forests had been heavily degraded by uncontrolled selective cuttings, by the excessive grazing of millions of cattle, sheep and goats, by litter extraction, and by the enormous need for fuel wood and charcoal. The later two were the only energy sources available to meet the high demand in households, salt and other mines and, of course, of the porcelain, glass, iron and textile industries founded by the many princely states in the 18th century.

Beech was the main casualty in this development. Oak and some other easily sprouting species such as ash, elm, hornbeam, wild service tree were being favoured where coppice forests have been built up in the hilly regions.

Little artificial regeneration was undertaken. Pine sowing, however, had taken place as early as the 14th century around some cities and industrial centres, where the forests had been heavily degraded, and oak planting was carried out to some extent in similar areas.

Nevertheless at the end of the 18th century broadleaves still prevailed.

For more than 150 years since around 1800 a remarkable reforestation and forest conversion work has taken place resulting in pure stands of Norway spruce, which are today almost 40% of European forests while Scots pine (Pinus sylvestris (L.)) are roughly 30%. Conifers, therefore now cover more than two thirds of today's forests.

The various reasons for this forest conversion include the following:

- The difficulty in establishing climax forests on open ground,
- soil degradation,
- expected financial return,
- need for softwood for industrial use instead of fuel wood, and
- easy handling of conifers.

Even beech forests are now mainly pure because shelterwood systems and late thinning regimes have been widely used, disadvantaging the other broadleaved species, which, without exception, demand light.

*1.3 Adverse effects of coniferisation and simplification of the forest structures*

At the end of the last century, many of the conifer plantations had reached the pole and small stem size stage. From then on hazards like storms, snowfalls, ice and different insect attacks started to put pressure on these plantations leading to average damage levels of 30% more than the allowed annual cut. In March 1990 hurricanes swept through southern Germany and parts of Switzerland, Belgium and France, leaving behind the sorry statistic of about 100 million $m^3$ of windblown and broken timber.

*1.4 Reasons for a renaissance of broadleaves and mixed stands*

Beech, oak and mixed stands may sometimes also be affected by storms. Nevertheless, damage was always at lower levels, at approximately ten percent. There is consent today, that conifers have too often been planted on wrong sites, shallow pseudogleys being the most inappropriate soil types. Moreover, wrong provenances have been used to a remarkable extent. Low thinning, mostly carried out too late and at low intensities reduced the stability in forest ecosystems. Norway spruce stands mixed with beech proved,

however, to be especially resistant.

In order to reduce these forest risks, endeavors have increasingly been made in the last twenty years to stabilize the endangered young stands by using more adequate thinning methods. Moreover better adapted provenances are generally used. In particular, mixtures with broadleaves or total conversion from conifers to broadleaves are favoured in order to reduce the risks. Fortunately, this tendency towards more broadleaves is supported by the following developments:

(1) Heavily degraded soils now, after more than a hundred years of forest coverage, have partly recovered. This is presumably due to the fact, that the humus layers and biological activity have been restored, soil compaction has decreased resulting in better root penetration, and nitrogen input, as a result of emmission of pollutants, has at least partly compensated for the tremendous nutrient export by litter extraction. Where not planted, broadleaved trees and some shrubs are reinvading, particularly the pioneer forests, such as oak into pine and beech into spruce forests.

In this regard foresters have a great friend and supporter, the jay – whereas roe and red deer tend to foil these endeavours.

On favourable sites ash, sycamore and maple are now germinating intensively as never before observed. Some people even complain about "ashification" or "sycamorisation" in some areas. Also, when not disturbed by roe deer, rowan is spreading in higher elevations and birch in the lowlands. The successional sequences thus clearly show the ecological return to forests dominated by broadleaves.

(2) Nature conservationists argue for the conversion of pure conifer into mixed stands dominated by broadleaves, which should be structured as naturally as possible. There is now a switch from fundamentalists to "realos", who accept the compromise between natural and commercial forests realising, that people in the industrialised countries can hardly close their forests to utilisation while the tropical rain and the boreal conifer forests are being destroyed in order to supply their markets. In any case, mixed forests with a proportion of broadleaves and the structure of semi-natural production forests are now the general target at least in the public forests, which consist of state and community owned forests and total about two thirds of all forests.

Because of these arguments grants are given for the establishment of either mixed broadleaved and conifers or pure broadleaved plantations by the German government and the EU. Reforestation with pure Norway spruce on the contrary is not subsidised.

That is the reason why private forest owners have also begun to take interest in broadleaved regeneration.

(3) The demand for high quality timber from broadleaves is increasing as the tropics are less able to supply the European market sufficiently. Prices for high quality oak, beech, ash, sycamore and cherry timber have, therefore been rising for some years in comparison with coniferous timber prices. Moreover, some species such as cherry, wild service, red alder recently have become the new whizz kids. This development is illustrated in Figure 2.

(4) Most production forests in Central Europe now show an even age class distribution and thus have reached more or less a sustained yield basis.

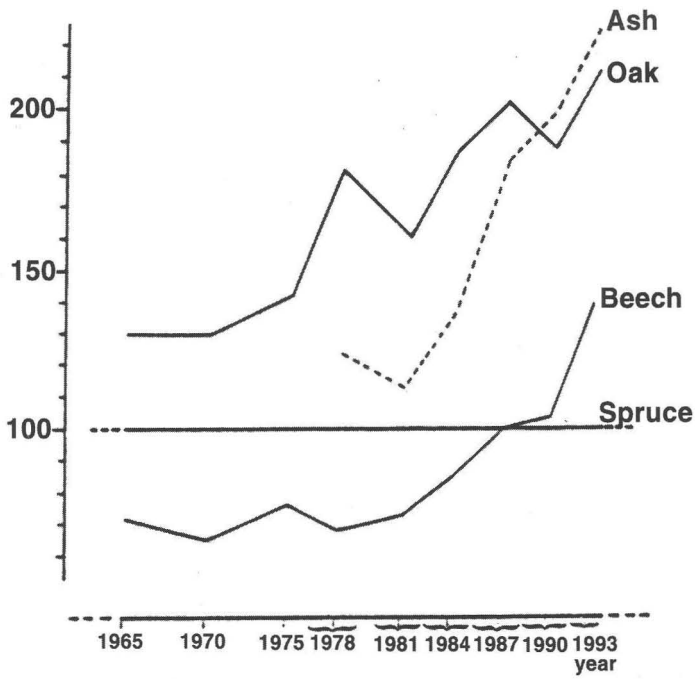


**Figure 2**
*Development of prices of ash, oak and beech timber as compared with spruce (=100%) between 1965 and 1993 (according to data from the state forest service of Baden-Württemberg/ SW-Germany).*

Under these conditions the annual profit is the difference between income from timber sales and costs for planting, tending and administration. Planting etc. are therefore not regarded as investments, which must be calculated with interest.

Some calculations based on data from the forests of some German states show that oak production proves more profitable than Norway spruce, whereas pine and beech are loss making. Beech, however, is now improving (see Table 1).

## 2. General Silvicultural Goals and Principles for Broadleaves

Apart form details specific to the different species, there are some general principles, which should be recognised in order to make broadleaved species management successful.

*2.1 Site classification*

One of the main problems in increasing the proportion of hardwoods is the high site quality demand of most of these species. They prefer more or less loamy sites, well drained with a good rooting potential and sufficiently rich soil. Except for birch, rowan and aspen, broadleaves are therefore no alternative to Sitka spruce and lodgepole pine on peaty ground, on podsols, pseudogleys or on poor sandy or gravely soils. Most of the hardwoods, moreover, are not pioneers and therefore do not grow well when heavily exposed to wind and frost.

In Germany for instance around 20 million poplars were planted in rows or small groups within or by the side of agricultural fields after the Second World War. Unfortunately, they developed poorly or failed totally as most sites were too acid, wet or cold.

Site mapping – taking into account site quality as well as exposure to climatic stress – therefore will be indispensible in order to avoid future failures.

*2.2 Choice of suitable provenances*

Careless collection primarily of conifer seeds from obscure sources in the late 19th and early 20th centuries and transport by railway across Europe led to poor growth and damage by fungi as well as abiotic damage. The first strict law controlling the collection of seeds, plant production and sale of plant material introduced in 1934, was one of the responses to this problem in Germany. It was later revised several times and adjusted to European regulations. As most broadleaves had been regenerated naturally not much attention was paid to them. Only recently have regions of origin been distinguished.

For several broadleaved species such as birch or aspen, no clear ideas exist about whether they show provenance differences or not and whether these should be taken into account in practice. I believe therefore that provenance trials should also be established as soon as possible in Ireland. Unfortunately, it will take a long time to gain results from them. In the meantime, however, some information may be gathered from single trees and groups, which grow by chance throughout the country.

Moreover, it will be necessary to guarantee an indisputable supply of plant material for the forest owner. Unfortunately, in spite of strict legal regulations in Germany intentional deception by nursery companies in the early eighties occurred even in recent times, which has led to the government closure of some of these nurseries.

Some examples may illustrate the problems experienced:

- It was discovered that oak seeds were collected in Rumania as pig fodder and sold as high quality material from Northern Germany.
- I found some information in the forest office of Burglengenfeld/ Upper Palatine that in a pine stand, which was used for a thinning experiment, sessile oak had been sown which had been bought from a seed supplier in the early sixties. In the seventies I recognised many of the young oaks in the understorey as being Turkey oak (*Quercus cerris* (L.)) from south-east Europe.
- Some plant breeding experts from the state forest administration some fifteen years ago discovered, that all nurseries, which produced cherry transplants, had been provided with seeds by jam factories. Thus huge amounts of cherry plants have been brought into the forests, which are not suited to the specific site conditions.

Some progress had been made, however

- Seed orchards for cherry have been established — almost at the last minute — in order to save the genetical potential, and to supply the forest enterprises with adequate plant material.
- Red alder can now be supplied one hundred per cent from seed orchards.
- A great breeding program was started with birch some ten years ago, aiming at improving the often poor local strains.

- Some German state forest services have been collecting oak and beech seeds for their own use for the last twenty years. However, they are sometimes obstructed by politicians and the nursery lobby. Today's general world wide philosophy is, that private persons and companies perform better than the state organisations and therefore public activities should never compete with private ones. However, many irregularities have not been accounted for.

In any case great attention should be paid to the choice, breeding and control of the suitable provenances.

*2.3 Production of high quality timber*

As previously mentioned, hardwood prices have been increasing for some years as compared with conifers The recent development of beech timber prices illustrates the changes in the market. The prices of some species like alder have also been pushed up, but this may be a short term trend.

Nevertheless, hardwoods like oak, ash, walnut, chestnut and elm have been maintaining a high price level for a long period, and as mentioned before, there is some evidence, that this may continue in the future. Lime, birch and poplar are less valuable, but when suitable for veneer, fetch reasonable prices. This trend may continue in the long run.

Hardwood production is only profitable if good quality timber production is correlated with stem dimensions, branchiness, straightness and colour. The first three criteria are strictly bound to silvicultural treatment, i.e. early choice of crop trees, favouring of crown development and pruning.

Figures 3 and 4 show an example of the prices for beech and oak depending on quality class and dimension.

Moreover it should be kept in mind that big stems are less expensive to fell and to transport per volume unit.

*2.4 Protection of broadleaf plantations*

Because of the lack of seedbearers, broadleaves are generally regenerated artificially. This can be done by sowing if the soil surface is suitable. In Germany some experience has been gained form the sowing of beech, oak and birch, which are lightdemanding or intermediate species and much more sensitive to competition by ground vegetation than species like Sitka and Norway spruce.

Broadleaves normally are more often attacked by mice (short tailed mice) and deer, roe deer being by far the greatest hazard to young broadleaves on the continent. That is why fencing is generally a necessity. Fencing, however, is very expensive and not always effective, as for instance wildboar open up holes in the fence, which will be used by the deer afterwards. Fences are also frequently damaged by branches or trees which have been knocked down by storms, creating openings for deer. Experiments are in progress to test the suitability of bigger sized saplings of $>1.5$m to overcome these problems. Planting techniques would also then need to be altered. In the presence of red deer, individual protection of each sapling by poles and meshwire would be necessary for some years.

*2.5 Mixtures*

When regenerating mixed stands it has to be determined how the species involved may coexist and compete in the future. In case of expected "equiva-

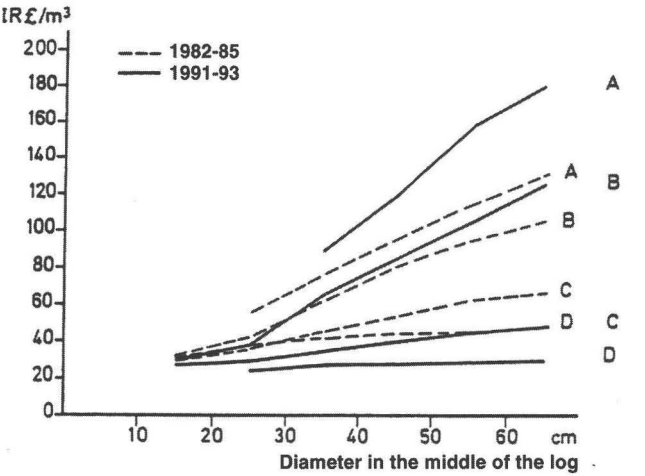


**Figure 3**
*Prices of beech timber as dependent on stem dimensions and quality classes (according to data from the state forest service of Baden-ürttemberg/ SW-Germany).*

lent mixtures", i.e. two or more tree species will comprise the overstorey when reaching the end of the rotation period, they should be regenerated in groups. The size of each group must be at least that of the crown of a crop tree of the species concerned. This will be about 100m² for beech and oak, – 50m² for Norway spruce for example. A number of these group sizes will lead to final groups of two or more crop trees. Within these groups the trees are spaced as in a pure stand. This procedure will improve the chances of getting those species to grow evenly which might be overgrown by those that have different growth rates. For instance, the intermediate Norway spruce had suppressed beech, initially slow growing climax species on thousands of hectares in Central Europe because of insufficient group sizes. If not properly sized at the time of establishment, the groups may be later enlarged by means of tending procedures.

In mixtures of one dominant and one intermediate species, both species should, however, be evenly mixed over the whole area. For example: oak may form the upper storey and beech or hornbeam underneath it to suppress epicormic branching.

## 3. Afforestation and Regeneration of Broadleaves: Targets and Techniques

### *3.1 Techniques as related to ecological conditions*

The establishment of broadleaved stands will greatly depend on the given site conditions, such as bare ground or the availability of shelter provided by old trees. These are discussed below.

### *3.11 Afforestation on bareground*

Pioneer species like birch, aspen and pine will be able to grow in climatically heavily exposed, open areas. However, their production rate will then be reduced, and they may be of poor form. Longliving, light demanding pioneers like ash and oak will

suffer even more. Although they may generally survive, growth will be extremely poor. Climax species such as beech or silver fir are highly sensitive to late frost and drought, and on this account should never be planted in exposed areas.

I therefore would like to recommend basing afforestation of bare ground largely on successional dynamics, that means to make use of the shelter of auxiliary trees like birch, rowan, willows, aspen or pines. In case parent trees occur in the vicinity, they may regenerate freely in these surroundings. Planting crop trees may then take place after the nurse trees have reached the early thicket stage. At this point it will be necessary to open up these thickets row wise to make space for planting and to reduce shade. In the following years further thinning will be inextricably tied to the light requirements of the underplanted trees. Finally, the nurse trees will have to be completely removed, after the main crop had reached the thicket stage and made crown contact.

The nurse trees may also be sown, in order to speed up the development. Experience suggests that with birch it should be sown when the snow melts. In Ireland this will be early spring when the soil is soaked with water.

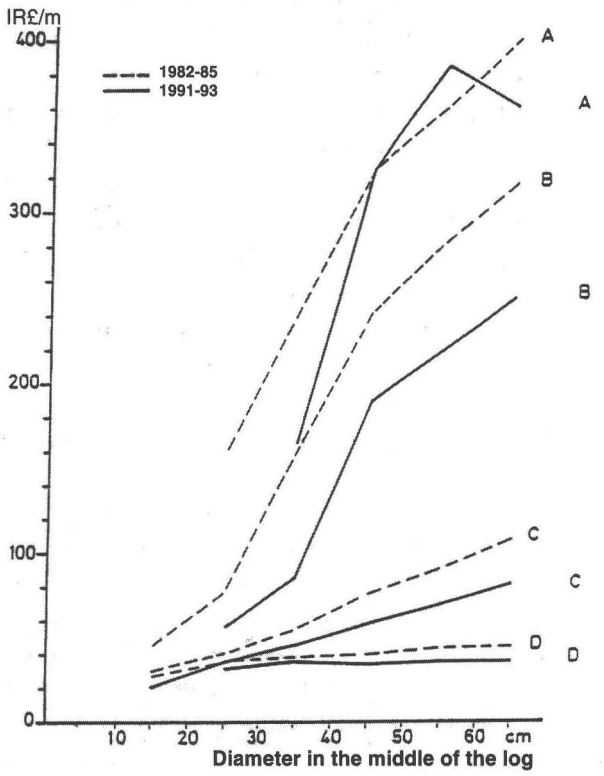


**Figure 4**
*Prices of oak timber as related to dimensions and quality classes*

These experiences with "snow seedings" have been successfully revived recently since the dearth of large forest areas in East Germany due to pollution, and in storm damaged areas.

We at the Freiburg Silviculture Institute started experiments on hurricane damaged areas in 1991 by planting birch and aspen in wide spacings to establish shelter for oak and beech.

Worldwide there is also a tendency to make use of the auxiliary trees as an intermediate cash crop. High breeding stock of birch, aspen, balsam and other poplars is regarded as suitable for this

purpose. The nurse trees are then reduced providing slight shelter in the thicket stage, and those overstorey trees which do not seriously compete with the main crop trees will be retained.

Models of this type should be examined much more intensively not only in the tropics and subtropics but also in temperate zones in order to develop economic systems especially for small property owners.

In Central Europe pine plantations very often acted in the same way after they had been underplanted with beech, Norway spruce, Douglas fir or silver fir or when broadleaves like oak, beech or hornbeam invaded naturally — accelerated by the jay. At the end of the pine rotation period, the old pines were carefully and successively extracted, leaving a complete young stand of mainly beech or oak, which can be managed like any other normal stand of this type.

*3.12 Restitution of broadleaves in existing forests*

As has been emphasized before, any shelter will be helpful for the first regeneration phase in existing forests. The more lightdemanding the commercial species like oak and ash are, the more the shelter should be opened up with the remaining shelter trees having been removed successively after ten years at the latest.

In Central Europe underplanting of beech under spruce is by far the most important example. Beech under pine is frequent, and oak under pine is going to become important.

Unfortunately, shelterwood treatments in older Norway spruce stands often result in a destabilisation of the overstorey and may lead to greater storm damage. I therefore doubt that conversion of Sitka spruce stands into broadleaves will work in this way.

In many cases planting in gaps will be a good alternative. Gaps of not more than about half a hectare are still climatically protected by the surrounding older trees. They still provide effective protection against water stress caused by low humidity, winds and high radiation as well as against early or late frost. Gaps will be created again and again by storms accidentally. They can also be cut into existing broadleaved stands voluntarily in order to make use of the sheltering effect as well as to regenerate those parts of a stand which are of poor quality.

*3.2 Techniques to establish broadleaves*

A detailed description of only the more important silvicultural criteria in this field would fill a large part of a silvicultural text book. The following statements are limited therefore only to the particulars really noteworthy:

Natural regeneration may be encouraged by means of soil preparation when seedbearers exist in the vicinity. Most seeds germinate better on mineral soil than on humus layers or in ground vegetation. The use of various machinery, that opens up patches or strips on mineral soil, may therefore be favourable. Aspen normally will need prescribed burning of slash and raw humus in order to germinate and grow successfully.

- Soil preparation is also helpful for planting also, especially if raw humus layers occur. In Germany drillers are increasingly used in order to facilitate the planting process, to loosen the soil and to apply fertilisers to the planting hole.

- Poor plant quality often causes low survival rates or dieback of the tops as the seedlings or transplants have been brought up too densely in the seed or transplant beds. This shows that most nurseries either do not have experience on how to grow broadleaves, or just wish to make quick money.

- Intensive undercutting is essential, especially for species that form a taproot like oak or a widespread root system like ash. Rootcutting after the plants have been lifted in order to ease the planting process should be strictly avoided without exception. Shootcutting will reduce water stress immediately after planting and may be carried out in the case of slim shoots with only a few branches, and where there is no competition by ground vegetation or predictable risk by deer.

- For many years planting hoes which form inclined splits have proved suitable and are therefore common for spruce planting. However, they lead to poor root development for most broadleaves, pines and firs. Therefore increasing concern has arisen about whether or not a return to spade planting should be recommended. Planting costs will increase with this old technique. Tall transplants, in excess of one metre, cannot be planted using the traditional method because of high costs. For this reason new techniques of "excavator planting" have been tested on huge windblown areas since 1990. So far they look very promising.

- There has been much discussion about spacing in combination with plant size and condition of the planting ground. Until recently most broadleaves have been planted relatively densely as natural branch pruning is essential for their later quality. Numbers range from 6,000 – 10,000 plants per ha being the standard for oak and beech, whereas 3,000 – 5,000 plants per ha is common for ash, cherry, sycamore and maple. Much wider spacing common only for poplar hybrids with about 200 – 500 plants per ha.

Under the following conditions, however, plant density may be reduced to a greater extent:

(1) Where tall plants or saplings are used,

(2) when the young trees grow under the shelter of old ones,

(3) if auxiliary trees or pioneers like birch, rowan or aspen fill the plantation and act as competitors favouring natural pruning,

(4) when artificial pruning is carried out.

As to (1), (2) and (3) I have already explained some advantages. As to (4) artificial pruning is now generally accepted and normally practised on poplars and cherry. New experiments, however, show that it may also be applied to most other broadleaved species as long as branches are not thicker than about 3cm at the base, beech obviously being relatively the most sensitive species.

Some scientists consequently recommend to reduce plant numbers to as

low as 500 individuals per hectare, when these preconditions are realised.

- In many enterprises autumn has become planting season for broadleaves in order to reduce work stress in spring. After a pause in August roots will thrive again in September and ensure sufficient water supply before winter. In Ireland planting after leaf fall may also be acceptable.

- In Germany fertilising plantations of demanding species such as ash or cherry will become a standard practice. Fertilisers mainly consist of mixtures of calcium, magnesium, phosphorus and potash in order to compensate for soil acidification. They are generally applied directly into the planting hole.

- The protection of the young broadleaves has already been mentioned. It often has to be carried out many times and very carefully in order to ensure the success of the plantations, and therefore will usually be very expensive.

- The release from competition of ground vegetation and of nurse trees as well as from competitors of naturally regenerated species may be necessary several times before real thinning is regarded as necessary. As pioneers like birch and aspen tend to grow very fast in the first years, tending operations will be more essential the smaller the number of young trees planted per unit of area.

## 4. Critical Prognosis

Forest owners are becoming increasingly interested in broadleaved species because of improved economics, higher ecological values and physical stability and greater acceptance by the public. Their advantages as explained earlier – will however only be fully realised if the trees get the chance to grow to maturity and reach large dimensions. Rotation periods, consequently, must definitely be much higher than that of Sitka spruce. Under German conditions poplars will need a rotation period of 40 years, birch 60-80 years, cherry 80-100 years, ash 120-140 years, beech 130-150 years and oak 160-300 years until they reach their optimum. Modern regeneration and thinning regimes may somewhat accelerate the growth of crop tree dimensions, and the favourable Irish climate will also accelerate growth. Nevertheless it will take much more time to produce high quality timber even in your country than to grow small sized coniferous sawlog.

In the long run, broadleaves will be, I believe, a real economic as well as ecological alternative to Sitka spruce plantations on many sites, mainly because of the much smaller risk from abiotic as well as to biotic factors. Moreover, the higher prices per unit of timber will at least partly compensate for the lower volume production. At any rate, pure broadleaves, and mixtures with other conifers will add much to the beauty of the countryside.

All over Europe experiments have recently been started to use broadleaves such as poplars and willows for short rotation energy coppice crops – this however, is another theme for another day.

Professor Jürgen Huss, Institute of Silviculture, Forestry Faculty, University of Freiburg, Germany