The Oceanic Forest[1]

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YOU have invited me to talk to you tonight about the oceanic forest—the concept, its execution and the pattern of the forests of the future in our islands.

Let me start by making perfectly clear the basic principle of the oceanic forest. The principle is this:

> *Every tree selected to grow on to the final crop shall be enabled to develop its full potential growth throughout the rotation of the forest.*

There is one vital corollary to this principle. The oceanic forest must be inherently stable.

This principle and its corollary are fundamental to the oceanic system. They are radically different from the German ideas and ideals of traditional forestry upon which British and Irish practice is based. The more you think about it, the more revolutionary it will appear for it affects every forest operation from the selection of parent stock to the final clear fall of the forest itself.

Introduction

On the 16th September 1961 Hurricane Debbie struck Ireland, and its tail ploughed into Argyll and the Western Isles the following night. In Ireland sixteen people were killed and much of the productive forest over 40 feet in height went down. At my own home in County Tyrone it was impossible to get out by road until we had been released by explosives and chainsaws.

For me this was the moment of truth. I realised that day that it is impossible to grow profitable commercial conifer forests in our islands by traditional methods of silviculture for the simple reason that before the forest becomes financially rewarding it will have become unstable.

In the years following the hurricane the clearing up process went on and I had the opportunity to observe about me on private estates and in government forests not only the scale of devastation but also with the keenest interest to see and ponder on the nature of the trees which had escaped destruction. It was about this time that I met the forester instructor at our Northern Ireland training school, Basil Wilson, without whose continual advice, originality of thought and wide experience, the oceanic system would never have come to life.

1. Addresses given to the Society of Irish Foresters, Dublin, on 13th Feb. 1976.
2. Mountfield Lodge, Mountfield, Omagh, Co. Tyrone.

We considered in every possible case why certain trees or stands—concentrating on sitka spruce—had survived. They were usually vigorous trees; they were often in mixed stands where the sitka dominated; but they had two things in common—they had deep crowns—that is their centres of pressure were low; and in every case these deep crowned trees had developed correspondingly strong, wide and firm root systems. To go back to our corollary—they possessed the ingredients of inherent stability. This was the origin of the concept of the oceanic forest.

There are also certain vital requirements from the commercial aspect which are more important than ever before. The timber crop must be as valuable as possible while the rotation is as short as possible. We have set out to devise a sound scientific silvicultural practice which will give the best timber we can grow with the greatest depth and surface area of crown on the trees individually and on the forest as a whole. We are confident that this is the way to obtain the maximum financial return from our forests, and to ensure that the whole of our investment will not be at risk by windblow. As is so often the case in nature, that which is most efficient is also the most aesthetically pleasing. The oceanic forest is beautiful as well as profitable.

This lecture falls naturally into two parts: First—The origins of our forest philosophy—the reason that Britain adopted traditional continental practices, despite our different climate, different species and quite different rates of growth. Second—The Oceanic theory of forestry. A description of the silvicultural methods we have evolved to suit our forests to the oceanic climate in which they grow; to protect them from the hazards as well as to reap the rewards of life on the shores of the Atlantic ocean.

Historical

Botanically speaking, it would be true to say that our era, as far as the islands of Britain are concerned, begins with the bare earth and rock which was left behind as the ice retreated after the last glaciation. Geologically this is a very short span of time—no more than 12,000 years. The descent of the ice cap historically divides us in our day from all that went before. By means of pollen analysis we claim a true record of the sequence in which the land was recolonised with vegetation. The lichens and mosses were followed by the grasses and shrubs, the birches, the alders, the willows and junipers. We know how the pine and oak forests gradually spread over the country, but how remarkable by their absence were the firs, the spruces and the larches among the conifers and the wide range of continental hardwoods which today we look upon as though they were truly indigenous to our islands. We know well the climatic cycle in which our vegetation flourished, and the timings of the changes which, coinciding with the first great clearances by man, gradually transformed our well-wooded countrysides into the barren mountains which are today accepted as the traditional landscape for most of the uplands of Britain and Ireland.

Lying as do the British Islands at the western extremity of the Eurasian land mass, it is useful first to compare and contrast our circumstances with those of the western seaboard of the North American continent, being the only other territory similarly situated in the northern hemisphere and, as we all know well, the home from which the majority of our forest trees originate. As the ice disappeared and the time came for the recolonisation of Britain, its new plant life had of necessity to move northwards and westwards, that is in a direction contrary to the prevailing winds. Furthermore the species themselves were continental in their origin and their inherited characteristics. It was therefore necessary for them not only to swim against the current as it were, but at the same time to adapt themselves to the very different climatic conditions to be found on the stormy and sunless Atlantic fringe. So it was, as we know, that while the various indigenous continental coniferous species of Eurasia were able to move northward behind the retreating ice, few succeeded in crossing the narrow waters westward to Britain. Thus, apart from Scots pine, and the insignificant family of junipers, the gymnosperms had to wait for the conscious efforts of man to re-establish themselves in our islands.

Throughout the early history of the British people there were adequate supplies of timber for the needs of the sparse population. The requirements were for structural uses and for fuel, and later on there were large demands for the production of charcoal. The first significant establishment of man-made conifer forest took place in the middle of the 18th century at the hands of the Dukes of Atholl in Scotland and were of larch. Although Norway spruce had been introduced two centuries earlier, no spruce forests had been planted. By this time the mercantile fleets of British ships were bringing in to our ports exotic timbers of a quality and in a quantity which satisfied the needs of our craftsmen and structural engineers and, moreover, more cheaply than could possibly have been grown in Britain. On the mainland of Europe, however, demands could not be met by seaborne transport and a forest industry evolved suited to the climate, the tools and the needs of a continental environment. Without going into detail, the requirement in Europe for the man-made coniferous forests was for light poles of high form factor suited to growth on the often steep hillsides, to tushing by horse and conversion by the village sawyer. The need for the heavier structural timbers was met by hardwoods.

Thus over the centuries the continental conifer forest and its associated industries developed in a form exactly suited to its climate, its terrain and the utilisation of its produce. The character of the forests themselves has become familiar to every student of forestry, and indeed to every traveller on the mainland of Europe, and is accepted as the classical standard of good management. We shall return to this presently.

The steps which led to the development of coniferous forest in Britain were entirely different. As we have seen, there had been no demand for home grown softwood timber but there had arisen in the colonial empire a need for skilled advice on the management of vast equatorial forest regions across the world. A school for the training of these forest advisers had eventually been set up at Coopers Hill, and a distinguished German forester Wilhelm Schlich from the Indian forest service was appointed as its principal. To cut a long story short, in 1906 the first faculty of forestry at a British university was inaugurated at Oxford with Schlich as its first professor. Sir William Schlich, knighted in 1909, found himself recognised as the leading forester of his time and his published works became the bible of early 20th century silviculture. It is worth remembering however that Schlich had no first hand knowledge of sitka forest, and indeed very little experience of conifer forest in oceanic conditions

Schlich's books are the epitome of classical German forest philosophy and technique. When in the aftermath of the First World War the Government decided to form the Forestry Commission, it was to Oxford and Schlich's Germanic tradition that Lord Robinson (the Commission's first chairman) looked for the staff and the advice so urgently needed to launch the new national enterprise. But the strategic demand for the production of pit props as an insurance for our power supplies from coal, free from the threat of blockade, demanded a growth rate which could not be met by any continental species. Sitka spruce alone could meet the challenge. For this reason the initial plantings of the Forestry Commission, above all the Kielder Forest, were of Sitka spruce designed to grow the narrow continental poles which the nation must have for the mines. And for this reason also the Germanic continental forestry philosophy became, and has ever since remained, the accepted background of the Forestry Commission. But (and here is an astonishing fact) the principal species chosen by the Commission had been Sitka spruce, an oceanic tree from the distant Pacific shore of North America. And here in our wild and wet Atlantic seaboard this oceanic tree was introduced and treated exactly as if it were

Norway spruce growing in the heartland of Europe. There were no major trials; there was no experiment. As long as the produce of the new forests was mining timber, it mattered little. However, the demand today is not for pit props but for the whole range of utilisation from structural timber to pulping material. The produce of conventional silviculture is inappropriate to that demand.

I said at the beginning that this talk fell into two parts. In concluding the first part I want to look for a moment at Sitka spruce, the species, its origins and its characteristics. In the study of this tree must lie the solution to the problems of management which confront us all as we seek to found a flourishing forest industry for the 21st century.

Sitka spruce

I have not been able to trace the whole fascinating story of Sitka. What we know is of great interest but leaves vitally important questions unanswered. To the best of our belief Sitka survived the last ice age on the coastal margins of California and Oregon—and perhaps Washington also. Exactly what happened on the Queen Charlotte Islands is uncertain, though it is conceivable that some seed, but no trees, might have survived there. Sitka was always and has remained a coastal species. Together with its companions such as Douglas fir and Tsuga, it reafforested the coast in the wake of the ice. It fought for its place in the climax forest and extended its range northward along 2,000 miles of seaboard. Its territorial range, however, is oddly restricted. It seldom thrives more than 40 miles from the sea, and is never entirely at home more than 350 metres above sea level, irrespective of latitude. We cannot here and now digress into these and other unusual attributes of Sitka, but they must form part of our silvicultural studies. Its response to light, for example, in that part of the spectrum which favours its powers of conversion are of prime importance. The full spectrum of uninterrupted sunlight appears to be abhorrent to it.

The object of looking at Sitka in this way is that we should approach the establishment of Sitka forests in Britain with completely open minds as a scientific problem to which we are seeking an optimum solution. It is probable that Sitka evolved south of the ice in a climatic environment more akin to Britain today than to its present home on the Pacific coast. It has adapted itself to the changes in latitude and climate which allowed marked provenance variations to develop. There is, however, no reason to suppose that having selected the best provenance for our purpose we should not by our skill and ingenuity grow Sitka to timber at least as well as it grows in its homeland and very much better than we are growing it in

Britain today. In passing, it is worth remembering that the majority of all the Sitka existing is to be found in Alaska, yet the Alaskan provenances are not suitable for growing in the British Isles.

The Oceanic Forest

And now we come to the concept of the Oceanic Forest itself. It is contained in a principle—a principle which favours the maximum growth of the final crop stems. We are dealing with strictly commercial production of timber. We decide what is the individual tree we want to have, in other words the optimum stem volume for the species. This is derived from the pattern of growth as well as from our handling equipment and from the capacity of the automated sawmills of today and tomorrow. We then estimate how many of these optimum stems can grow on any given area—or, put the other way round, how much space each tree must have to develop the required volume. We then determine the management regime which will produce the crop with the maximum economic efficiency, that is, the method which gives the highest return on the capital employed.

I feel that at this point the clearest explanation of the oceanic theory can be obtained by contrasting the continental and the oceanic systems, the one with the other. In its essentials, the continental system sets out to grow as many trees as possible on any given area. Rotations are long, but there is a prospect of profitable thinnings at regular intervals from about the twentieth year onwards. Crowns are restricted from the moment of closing canopy and the lower branches are progressively shaded out. Crowns are subsequently inadequate to sustain the volume growth of which the forest is capable. Timber is grown slowly with narrow but irregular rings. Centres of pressure and centres of gravity are high, while root activity is impaired, therefore the forest tends to become unstable and liable to windblow from an early age. This method of management gives continuous employment, but it is extravagant of labour.

In contrast to this familiar regime, the oceanic system sets out to follow a principle. That is that every tree selected to grow on to the final crop shall be enabled to develop its full potential growth throughout the rotation of the forest. Selection takes place when crowns are still intact. Crowns must thereafter be preserved of sufficient depth to ensure that in those species where this is possible, uniformity of ring width is developed throughout the timber length and throughout the duration of the rotation. Thus the volume increment approximates to the maximum of which the species is capable. This may be referred to as the "rate for the site". The density of the crop on the ground is derived directly from the required timber tree diameter. The length of the rotation is determined by the time taken to attain this diameter. The centre of gravity of the stems and the centre of pressure of the crowns are decisively lower than in the continental method, and root systems are fully developed, resulting in stable, windfirm forest. This method of management entails no labour between the operation of selection and the final clear fall. It is therefore economical of manpower.

The foregoing summary defines the underlying difference between the two concepts. All are familiar with the traditional continental method and great efforts have been applied during five decades to make it work under British conditions. Why and in what respects, therefore, has it failed? It has failed primarily in two ways.

First economically: yields in relation to investment have been inadequate. Another facet of the same defect has been that rotations have been too long to carry the discounted cost of land usage, establishment and maintenance over so many years.

Second silviculturally: the continental system produces a forest which is inherently unstable in our wet and stormy oceanic climate. In other words, a forest which *could* grow fast enough to be profitable will almost certainly become unstable and liable to windthrow before it shows an economic return.

These two simple statements illustrate the weakness of the continental system in Britain. If yields are raised more than marginally in our characteristic environment, our forests will blow down. The reason is clear: in the areas of high rainfall where our most productive forests grow, rooting tends to be shallow. If combined with a high centre of pressure this *must* result in instability.

The economic failure of the continental system may be stated in silvicultural terms thus. In the early stages the traditional crop is too dense. By shading the lower crowns of the strong, the weak deprive their superiors permanently of their vital vigour. As the final crop approaches maturity, there are neither sufficient stems standing, nor is the total area of crown adequate to use the resources of the ground to the full, while the individual crowns are incapable of maintaining the growth potential of each respective tree.

By what conceivable means then can a significantly higher yield be obtained in a windfirm forest? For those interested in the purely technical reasoning behind the oceanic method, the total effective area of crown in relation to the number of stems brought to the final crop in the forest is much greater in the oceanic than in the continental method. Timber is predominantly composed of carbon. Since this carbon is wholly obtained from carbon dioxide in the air through the stomata of the leaf, it is the essence of the oceanic method of silviculture that it can provide that extra area of leaf—and therefore of stomata—which ensures that a much larger volume of timber can be grown on any given site, and above all remain windfirm.

The traditional idea has always been that the conditions which determine the yield of a forest are to be found on the ground and that the limiting factors to the yield of a species in the forest lie in the region of the base of the tree—fertility, soil texture, water, microbiology and the root structure of the tree itself. (How often it is quoted that no more can be taken out of a site than the ground gives.) In fact, the very contrary appears to be the case. The limiting factors to growth of our evergreen conifers are to be found in the crown, and the critical stomatal intake of carbon dioxide. We can influence the area of the base by cultivation, fertilisation, and by preserving the ecology of the forest floor. Here are to be found the vital ingredients of healthy growth, but not the essential constituent required for the process of conversion to timber—carbon, from atmospheric carbon dioxide. Unless the crown carries a large enough leaf area, the all important carbon cannot be absorbed in sufficient quantity to satisfy the ability of the tree as a whole to convert its intake to wood. We may be unable in any significant way to influence the concentration or availability of CO_2 in the atmosphere, but we can decisively influence the capability of the forest to absorb what is present. The oceanic techniques are designed to increase the total leaf surface of the crown of every stem contributing to the final yield by as much as four times that resulting from traditional practice. This is the virtue of the oceanic system.

The Oceanic System in practice

Turning now from theory to practice, we must ask ourselves three questions about the Oceanic System of forestry. Is it (1) Possible; (2) Practicable; (3) Profitable.

To take these in turn.

1. *Is it possible?*

The short answer is of course "yes".

It is possible to select final crop trees early in the rotation and ensure that they are given the opportunity to develop their full growth potential. Whether the ideal "rate for the site" as defined earlier in this lecture can be sustained is important as a target in striving to obtain the maximum yield, but in any case the crop must grow on to attain the planned production. The planned yield I have suggested for Sitka is 750m^3 per hectare. The measure of success is the number of years this will take. The total production from Sitka on a site attaining Y.C. 24 will reach this figure by continental management in 32 years, *but* half of the total will have been squandered in unprofitable thinnings whose production will have damaged the final crop beyond repair.

2. *Is it practicable?*

Can the oceanic system be operated as a normal forestry process, by trained men with an average level of supervision? Again the answer is "yes".

The method we have adopted is practical and effective, but other and better techniques may be evolved in the future. Let us see what is implied in adhering to our principle, taking Sitka as our example. Saw timber fetches the highest prices, so let us consider first the sawmiller's ideal log. It is a stem of breast height diameter of 36 cm running to a 12 cm top, with a volume of three-quarters of a cubic metre. Its green weight will be of the order of 750 kg. This log can be extracted and transported at minimum cost for volume, and is thereafter suitable for fully automated conversion. As far as possible produce from the forest should not exceed these dimensions by more than 15% nor fall below them by more than 20%. This, then, is the required tree which will fetch the top price in the market today, and for as far as it is possible to look into the future. It gives the forester a good all-purpose target, exactly within the capacity of his skills to produce, but leaving little freedom for errors. On an average site this stem can be grown in thirty years without difficulty.

To extract the full return from the site, what then is the maximum number of stems which can be carried on a hectare of forest? Or translated into other terms, how much space does the individual tree in the forest require in order to develop its full potential as defined in the foregoing terms? The answer to the question obviously offers scope for discussion and individual judgment, and during the further evolution of the oceanic system experience may cause estimates to be revised. Observation and measurements in our north western regions suggest that 10 square metres per tree, or 1,000 trees to the hectare, is near the mark. If this be accepted for the time being, let us review the steps which must be taken to attain this result.

(i) *Selection*

The planting stock most suited to our foremost areas of establishment comes from seed of Queen Charlotte Islands origin. Extensive observation reveals that no more than 50% of this stock possesses the vigour to give an economic return in the forest. *Furthermore, that elite* 50% *can only manifest itself in the forest, after planting, on the site where it is destined to grow to maturity.* It must be from this starting point that the design of the new highly productive Sitka forests will spring. No tree must grow to timber unless it belongs to that selected vigorous half of the best stock we can plant. Since some uniformity in spacing of the final crop is desirable, a degree of latitude in choice must be allowed. Thus on every hectare some 2,500 trees must be planted to offer in the region of 1,250 for selection. From these, 1,000 well-placed stems can be chosen. The timing of selection is important. It should be as late as possible having regard both to the discounted cost of the process of selection itself and to facilitating the actual choice of the most vigorous stems. The moment before the closing of canopy is most favourable. If it is left later it is both difficult to see clearly and physically the going may be very hard. If too early, errors in choice may be made and the truncated stumps may prove to be over-competitive.

(ii) *Treatment of Un-Selected Trees*

It is again fundamental to the oceanic process that those stems which are destined to be eliminated should contribute towards, and not detract from, the development of the final crop. To this end much thought and trial have been directed, but further experiment will continue. It is firstly essential to simulate and then to preserve a fully forest environment. The more rapidly the ground is covered the better. Therefore no unwanted tree should be destroyed by the act of culling, but each must in its due time be allowed to die naturally. The whole micro-biological life of the forest floor must conform to the natural processes of death and decay. The abrupt destruction of large numbers of root systems such as is suffered by the action of conventional thinning is highly disruptive of the very mycorrhizal association of fungus and root which we are seeking to encourage. Again, the sudden opening of the forest floor to light causes a faster breakdown of debris, resulting in a denial by bacterial action of readily available nitrogen to the surviving trees.

There may be a variety of treatments which will satisfy all the requirements, and experiment will arrive at the correct solution. One method has proved to be a practical forest operation, comparatively moderate in cost—that of lopping the tops from unwanted trees at between one and two metres above the ground. If it is correctly executed, it is the only silvicultural operation carried out until the forest is felled some twenty odd years later. There is no brashing, no pruning—and therefore no expenditure on maintenance apart from ensuring from time to time that drainage remains in good order.

(iii) *The Rotation and the Yield*

Having specified the stem to be grown and the space that each tree needs in order to obtain the optimum dimensions, the process of selection ensures that the most vigorous trees and they alone grow on for the final crop. Adopting the estimate of 10 square metres as being the average area that every crown must have to obtain sufficient light and air for the production of $0.75m^3$ of timber, one fully stocked hectare will yield $750m^3$ at the end of the rotation. Sitka forest will, for example, be classified as a "28 year", a "30 year" or a "35 year" etc. forest, this being the anticipated time to yield, in each instance, the $750m^3$ which has been stipulated. Existing yield classifications and the associated tables based on statistics of the continental system are not relevant to forest grown by the oceanic method and can be confusing. A calculation of basal areas and current annual increments at the culmination of the oceanic rotation gives results which may seem exaggerated by conventional standards. I ask you to remember that the timber production of the oceanic forest derives from the total crown, and that provided the leaf surface is there, the increments are within the capacity of the species.

3. *Lastly, is the oceanic system profitable?*

Referring to the spruces, it is the object of management to bring the short rotation crop to a volume of some $750m^3$ to the hectare. There are no returns from thinnings. A high proportion of the final crop is available for the sawmill.

By any means of assessment the oceanic system is very much more profitable than traditional practice. The value of a hectare of $750m^3$ of Sitka on 1,000 stems at today's prices is about £8,000. Or, if you prefer this expressed in imperial measure, we will expect £1m. return on every 320 acres of fully productive oceanic forest. It is our belief that we can attain this return in thirty or so years.

Conclusion

In conclusion I will bring together in a few sentences the elements which comprise the concept and the execution of oceanic silviculture.

Objective

The aim of the Oceanic System is to grow the maximum volume of the most valuable timber in the shortest possible time, preserving stability throughout the rotation.

The target volume for Sitka spruce is to grow $750m^3$/hectare. The time taken is a measure of the quality of the site and the skill of management.

The Method

Theory: Decide before operations start what is the optimum stem of timber to be grown in the forest. Observe how much crown space each tree requires to produce this standard stem in conditions of optimum growth. Calculate the maximum number of stems which can be grown to the optimum volume on a given area of ground.

The (mathematical) product of the number of trees multiplied by the average individual volume gives the total standing volume of the crop at rotation.

When this volume is reached, this is the period of maximum financial return and the forest is ready to be felled.

Practice

Establish the crop to ensure a quick and successful get away. As canopy closes, select the "dominants" to the number determined, spacing them as uniformly as can be readily achieved. Eliminate crown competition from the remainder without causing their death.

Leave the forest alone—for twenty years or so. When the planned volume is attained, clear fell.

My last words must repeat the oceanic principle: "Every tree grown to the final crop in the forest shall have developed its full potential growth". The rewards can be rich, and the forest beautiful.