European Experiences with Douglas and other Conifers from Western North America

Address to the Society's 14th Annual General Meeting

By Herr Oberregierungsrat Karl Oedekoven

IT is generally known that in the 16th and 17th century all Europe suffered from a tremendous timber shortage which was mainly caused by wars, reckless exploitation and other circumstances. This time of timber shortage has found its classical description by the famous economist Werner Sombart in his impressive article. "The threatening end of capitalism". To him the timber shortage is in fact a symptom of the gradually appearing end of European culture which was called the wooden culture. It is quite interesting that Sombart associates this timber shortage with another symptom of decline namely the reckless exploitation of foreign nations and cultures which also leads to the exhaustion of wealth.

The timber shortage greatly alarmed the foresters of that time and incited them to improve tree cultivations, to develop forest management and to originate the idea of sustained yield from their national timber resources.

One of the means to produce more timber was the introduction of fast growing species. Since it was not possible to remove this penury directly they at least wanted to shorten the time that the forests needed to offer sufficient timber again. Instead of the hardwoods with slow growth like oak and beech they grew more poplar, white alder and, mainly, birch. Birch especially was grown to such an extent that this tendency was called "Betulomania". Species which promised an increase in timber production were taken even from far away. In 1638 the *Robinia pseudoacacia* was brought to Paris from North-America by Robin. Around the middle of the 18th century this tree gained importance also in Germany. At the same time the first cultivations of larch

were established which originally had its range only in the Alps and the Sudeten mountains. In this first period also in which exotic trees were favoured white-pine came in.

Pseudotsuga taxifolia.

A second and greater activity originated at the end of the 1870's from the initiative of our Chancellor Bismarck who interested John Booth of Klein-Flottbeck near Hamburg to experiment with exotic trees, especially with douglas (*Pseudotsuga taxifolia*).

There is no doubt that amongst all exotic forest trees douglas has held the leading position since these early days both in the extent of its cultivation and in its general importance on the timber market.

I, personally, had the good fortune to study this species in Oregon about 20 years ago and later in my practice as District Officer in the Harz Mountains. I had quite a few douglas stands belonging to different age classes and we have added to that area new plantations of 50,000-80,000 young douglas trees every year.

So, I hope, you will have no objection if I devote the main part of my report to douglas.

If we try to transfer the natural range of this species from Western North-America upon Europe and Africa it would cover an area from Ireland or East Prussia down to the Northern region of the Sahara and from the Atlantic to the Carpathian Mountains. From sea level we would find it up to an elevation of 9,000 ft.

Belonging to a genus of which there are only two species native to North America and only one to Oregon douglas ranks as the most important timber species of North America if not of the world. The timber has excellent qualities and a wide range of uses. The boles of forest grown trees are massive, clear and taper very gradually. In the average stand on favourable sites, mature trees are from 5 to 8 feet in diameter and 225 to 275 feet in height. Exceptional trees have been found 12 to 15 feet in diameter and more than 330 feet in height.

The gross volume of the average stand is from 50,000 to 60,000 board feet* per acre, single acres with half a million feet or more have been cruised.

In the U.S.A. where more than 3 million acres of forest land are to be reforested with this species, the seed is taken from neighbouring stands if ever possible.

But there are certain cases where this cannot be done. Therefore, a lot of rules have been developed for the selection of seed-production stands the seed of which must not be used further north or south than 100 miles. Already for each 10 miles distance to the north or to the

* 12 board feet equal 1 cubic foot.

south adjustment has to be made in choosing the proper elevation for the plantation.

If these difficulties to provide the right seed exist in the home-country of douglas it is quite evident that we are facing trouble in Europe where climatic conditions are so different. Especially the distribution of the precipitation per year varies greatly in our countries compared to Western America where we have very dry summers and where most of the rainfall occurs in winter-time. It has been a very lucky coincidence that the first large douglas plantations which were established in Germany between 1880 to 1890 originated from seed of Western Washington, whereas in the following decades Schwappach called for greater imports of seed from Colorado and other unfavourable locations. John Booth, whom I have already mentioned probably got his seed from mother-trees in Scotland which were also grown from seed of Western Washington.

Quite a few of these early plantations are still left as 60 to 70 year-old stands, thrifty and healthy, and every time that there is a good seed-year we try to use the last cone, provided that they are not in the neighbourhood of poor quality douglas stands with which they might have crossed.

As you all know we distinguish between 3 types of *Pseudotsuga taxifolia:* We know

the green or *viridis*-type
the grey or *caesia*-type and
the blue or *glauca*-type.

As all our experiments prove the *viridis*-type promises the best results for our European conditions and it might be best, perhaps, if I try to give you a summary of our experiences by going through the whole rotation of a douglas stand from the seed to the felling.

Nursery Treatment.

Douglas is one of the species that require stratification or pre-sowing treatment to break dormancy. It consists of placing the seed in a moist medium, such as peat, moss, sand, or sawdust and keeping it at temperatures from 32° to 41° F. We usually put the seed in a box filled with sand and leave it in the open all through winter.

When we finally take the seed out to the nursery in spring it is most important that the sowing is not done on heavy soil which is not at all suitable for any nursery.

Comparisons where the same seedlings were transplanted, some on heavy soil and some on lighter soil, proved that the transplants on the loose soil grew 3 times as tall as those on the heavy soil. This observation also applies to new nurseries established on clear-cut forest land where the stumps had been blasted and where thus the soil had been

compacted. And not only does heavy soil affect the growth of the trees, the needles turn yellowish and total losses will be high. To sum up I might say that the quality of the nursery stock very often stands in a reversed proportion to the quality of the soil.

Another important requirement for douglas nurseries is a comparatively dry soil. The tree is used to a dry summer in its native country, while we usually have a reasonable amount of rainfall during this season which tends to prolong the vegetation-period. This is undesirable as a rather early end of the yearly growth is important for the formation of the winter-buds.

Ideal pH of soils for douglas nurseries should range from 5.0 to 6.0. The most desirable amount of fertilizer can best be determined by local experimentation. Too heavy doses, though, might be dangerous. The young seedlings grow too fast if they are overfed and if such tall nursery stock is planted out great losses are likely as they transpire more water than their roots can assimilate in the first growing phase.

It is indispensable to protect the seedlings from wind, sun and frost, which is especially important in open nurseries where there is no side-protection from neighbouring stands.

Straw-mats, branches or twigs of broom that we put over, around and between the beds have shown good results.

Depending upon the growth the transplanting is done when the seedlings are 1 to 2 years old. If the seedlings have suffered from frost in the first year—which unfortunately happens rather often—we should leave them in the seed-bed for another year. We have found that losses are markedly less than in case of transplanting them. Under good conditions the 3 year old transplants reach a height of $1\frac{1}{2}$ foot or more, therefore they should be spaced not less than 4 inches apart. As to the distances between the rows we allow for at least 10-12 inches to permit multiple-row cultivation. These wide rows are very essential. Hardly any species suffers as much from root damage as douglas.

When the transplants are finally lifted with digging forks or mechanical lifters air temperatures should not be below freezing as the fine rootlets are liable to frost damage. As to the cutting of roots we should avoid it if possible, as our comparisons prove that young trees with cut roots grow worse than untreated material.

Planting Sites.

If we examine the forest soil and site quality of existing stands and if we want to determine where it finds good growing conditions we come to the conclusion that apart from extremely light or heavy and wet soil most forest soils or sites are suitable. The actual yield obtainable from any stand is affected, of course, by many factors such as wind, rainfall, temperature, altitude, slope and aspect. But it would be difficult, if not impossible, to say what part each physical factor plays

in making an area productive. Yet our study has given some indications of the combinations of factors that contribute toward productivity.

In its natural range in Western North-America douglas is not used to strong winds. Perhaps you know that in our German language the Pacific is called the "Quiet Ocean" and this name is especially justified as far as Oregon and Washington are concerned. As a result of this hardly any other tree suffers as much from wind or storm.

Most of our exposed stands or single trees show wind damage in their wry, bald or broken tops. And without any doubt such permanent injuries to crowns and foliage reduce the increment of the tree very markedly. This undesirable effect partly explains the lower yield which many European stands produce in comparison to American volume growth. It is a vicious circle that these damages grow larger as the tree grows older and higher. The American yield tables indicate that a 100 year old douglas stand will reach a height of 180 ft. on Site class 1. If you grow douglas in mixed stands you will hardly find any other species that may compete with this growth. So, as a result of this experience we try to avoid the planting of douglas on locations which are exposed to the wind, and from the same experience we prefer cultivations on large areas where in the higher age the trees are less damaged by wind. You might object against douglas stands on extensive areas that there is the risk of the needle-cast (*Phaeocryptopus Gaümannii*—or formerly *Adelopus*. This is true, of course, though this needle-cast mainly occurs in mountainous or coastal regions with wet summers. But this disease seldom kills a stand very suddenly and if for some reason the whole stand has to be cleared off at once the timber may be utilized at any age and will yield good revenue. And, finally, the falling out of one larger area is less detrimental to a forest than losing numerous groups.

Aspect was found to be an important factor in regulating the productivity of douglas. The most rapid growth was observed on slopes facing north, northeast and east, probably because the soil on these exposures is less subject to the drying rays of the summer sun and consequently remains more moist than on other aspects. The south and west aspects were found to be more variable in their effect on site than the sorth to east aspect. The poorest sites were found on south to west aspects, or on level ground.

Slope affects site quality by reason of the fact that, even when other factors remain the same, an increase in the gradient makes possible a more advantageous exposure of the crowns with resultant increase in density of stocking.

Silvicultural Considerations.

An ever important problem has been the question : Should we plant douglas in pure or mixed stands? In its home country the tree,

especially the *viridis*-type appears mostly in even-aged stands, sometimes pure and eventually mixed with other species. In the upper age classes it is seldom mixed with hardwoods. None of our native species is able to mix with it through its whole rotation in equal vitality. The spruce singly mixed into a douglas stand is very often overgrown at an early age. The same holds true for european larch, it only occurs at a later age, perhaps when the trees are 30-35 years old. A mixture of douglas and beech will finally result in a pure douglas stand unless we have to do with excellent beech sites. In a douglas plantation in the Eifel mountains where hardwoods were brought in singly or in groups all hardwoods are completely overgrown or suppressed after 11 years. Only few American species like *Abies grandis* and *Abies nobilis* are able to compete with it in its vigorous growth. But *Abies grandis* has little commercial value and is only eventually cultivated in Europe for its glossy green foliage, and *Abies nobilis* is only suitable for mixing with douglas in our northern mountains at an elevation of around 2,000 ft. If in the first decades of its rotation douglas is overgrown by other species—which likely happens with japanese larch or with beech on lime or loess soil the douglas might be easily infected by needle-cast.

And yet, in spite of all these difficulties it is mostly grown in mixture with other species. It is quite obvious that already the high price of seed or transplants of the species and the difficulty in meeting the demand suggest such a procedure. In Germany norway spruce ranks first amongst all species which are mixed with it, the proportion of douglas to spruce may be 1 :1, 1 :2 or 1 :3. The young trees are planted alternately in the rows as well as from row to row. In earlier times the different species were planted each one separately in a row but this practice is no longer used as in the final stage the remaining douglas stand had holes in the canopy and thin spots due to wide spacing, both conditions contributing alike to subnormal stand volume. Another common practice, if only few plants are at hand, is that they are mixed in in little groups, but the proper spots for these groups have to be carefully selected as one always has to consider that these groups might survive when the rest is mature and will be felled.

Two important species which very often appear in mixture with douglas in its home country are *Thuja gigantea* and *Tsuga heterophylla.* According to our experiences they might play such an important part in European silviculture for the future that I shall cover them in separate paragraphs later on.

And as to the question of mixed or pure stands I want to underline at this stage that quite a few of the objections which we have against pure spruce stands do not hold true for douglas. In its root energy douglas ranks between spruce and silver fir. It has a very dense root system which fills all spaces in the soil whilst for spruce large parts of the soil around the main roots are absolutely free of finer rootlets.

Therefore a pure douglas stand is much less exposed to windthrow than a spruce stand might be on the same soil. Though the proportion of carbon : nitrogen in douglas litter is less favourable than in spruce or pine needles it easily decomposes and there seems to be no disadvantageous effect on the soil, especially in the United States where pure douglas stands have covered certain sites for centuries no deterioration of the soil has been noticed.

I have already mentioned how susceptible the seedlings are to frost damage. The same applies when nursery stock finally is planted out in the cultivation. Two year old seedlings are especially endangered as they have not yet overcome the shock of transplanting like 3 year old transplants. The damage usually runs high if the transplants are extraordinarily tall or if the cultivation is carried out on extensive clear-cut areas in higher elevations. If such plantations were actually damaged by late frost in a mountainous location we have often observed the following symptoms : after the top-part of the little plant had died new shoots developed around the lower stem and kept on growing till late in the year and if weather conditions were unfavourable a late frost finally killed the whole plant.

So, it is quite important that douglas plantations are established under some sort of a shelter if at all possible. Several methods have proved to be quite efficient in this regard : Where available we take advantage of existing coppice, birch thickets or even broom brush which are thinned in a very drastic way so that only a light shelter will be left. If we have to afforest blank areas without any cover we like to plant white alder in the first phase in a wide, loose spacing to serve as such a shelter and we have even used the fast growing poplar for this purpose in cases where site and soil were suitable for the poplars. It is important, however, that none of this shelter be left too long as all these species then tend to suppress the douglas and to diminish the increment. There is also greater danger of needle-cast infection as high relative humidity under the shelter favours the conditions for the development of this disease. In a douglas plantation near Bonn which was partly established under a light shelter of birch which is about 12 feet high and has a spacing of 9 ft. square there is evidence that only some of the plants under the shelter turned brown while all the rest of the plantation on the bare ground was heavily damaged by an early frost which occurred on September 21, 1951.

Finally the light shelter seems to restrain the development of weeds thus saving money and favouring the growth of the douglas. I might add to this point that on very extensive areas where we establish douglas plantations under the shelter of existing species it has become a good practice not only to create this shelter but to leave some strips of the thicket, coppice or brush untouched. These wind-shelter belts which we leave in the shape of frames surrounding 1 to 3 acres of plantation have proved very helpful.

Plant Spacing.

The spacing in douglas plantations, whether in pure or mixed stands, varies from 3-7 ft. square. As pruning has to be done in almost any case no matter which spacing had been chosen we may neglect the detailed consideration of pruning in this regard.

Pure plantations in a narrow spacing yields early thinnings and remarkable revenue from selling the green branches provided, of course, that there is the proper market. In the U.S.A. where chances to sell the small poles and the branches are limited douglas plantations are usually established at a wide spacing which means that only 500 to 700 plants are planted per acre. As the price of plants is comparatively high the question of the proper spacing deserves careful consideration. For instance if we have to choose between a spacing of 3 ft. square or 5 ft. square we must realize that the wider spacing will be about £35 cheaper per acre than the narrow one. The final decision depends greatly upon the local conditions, especially on the soil. An experience for which we have no complete explanation yet has taught us that densely planted douglas on soil with a high proportion of silt particles suffers more from windfall and snow-break than plantations on coarse soil. So, as a rough rule, we might say that the best spacing for douglas is 5 ft. square on coarse gravelly soils, 6 ft. square on sand and sandy loam and 7 ft. square on silt and clay loam.

Type of Plant and Time of Planting.

In the U.S.A. a great number of the present douglas plantations are established with 2 year-old seedlings. As each transplanting causes certain losses and as especially douglas is a very delicate species in this regard we should benefit more from the American experience, at least on such soils where there is no danger of intensive weed growth. As a matter of fact, we in Germany had to use this method extensively in the years after the war when older nursery-stock was not available, and as far as we can say now we have had good results. It is essential, however, that these seedlings are sturdy and healthy, and I might even recommend that their roots are treated with a root-cutter when still in the seed bed to stimulate the development of fibrous roots which will pay by a higher survival than those with only large tap and long lateral roots. The worst material should always be rejected and the existing heavy demand should never lead to using also plants of dubious quality. We must never forget that our experimental lots of douglas which we established in 1910 showed the marked differences in growth which were evident in the nursery and in the young plants still 25 years later.

For douglas the time between lifting and planting must be as short as possible. I want to underline that this rule is about the most important one for a successful cultivation of this tree. A longer transport might already be fatal. In 1930 a comprehensive campaign for planting

the species in different regions of Germany proved that losses run parallel to the distance of transport.

In the most critical phase from early March to the time when the buds start to swell the plants should not be touched at all. If they have to be transported the lifting should only be done shortly before delivery. Some German experts claim that douglas even suffers if kept in heeling-in beds after delivery and therefore recommend immediate planting when the young trees arrive. Ernest Pein, the president of our commercial nurserymen, has developed a special packing procedure known as "Shipping in soil cover" which ensures proper treatment of young trees from the moment they are lifted until they are planted.

The best time for planting and transplanting seems to be Spring. No other species requires such a careful control of this short period as this tree. It is about the time—as I already mentioned—when the winter buds start to swell, a process which usually occurs around the middle of April, sometimes as late as in May. As a rule we might say: douglas planting is always the last phase of the planting campaign. Plantations which were established when the buds had not yet budged usually suffered greater losses than those which for some reason were planted when the buds had almost opened. It seems that with the swelling of the buds the roots develop the ability to draw water from the soil. As a matter of fact the green douglas usually flushes 10-14 days later than the grey or blue type; that means that losses in case of a too early planting of nursery stock from mixed seed will mainly affect the green type and thus lead to a negative selection.

I have mentioned this example as quite an amount of the douglas seed which we receive from the U.S. is mixed seed, and unfortunately it is impossible to tell the difference by the seed.

Douglas cultivations which were established in autumn did not do too well. There were in many cases heavy losses or complete failures. And, we think, the reason for this is that the summer growth was not entirely finished yet when the young trees were lifted and transplanted. Therefore plantations in late summer or early autumn should be limited to cases where quickest transport and immediate planting are possible.

The most common way for the planting itself is the hole-planting, especially if we have to do with 3-year-old plants. The soil has to be dug on a surface of about 16 inches square and it is just as essential to prepare the hole deep enough. Mattock and spade are the proper tools. Loose soil around the root system will favour the growth of the young plants, especially on heavier soils. The intensive cultivation will also ensure that weeds do not come up in the first period; this is quite an advantage as hardly any other tree suffers as much from stripping of the bark, which might easily happen when we weed the cultivations. Later on, of course, when the plants are more sturdy it has to be done from time to time.

Sometimes the weevil attacks douglas plantations, but serious damage can be avoided by spraying. Hylarsol, a German spray, has proved to be most efficient. In districts with roe or red deer the whole cultivation must be fenced in and where douglas is planted singly or in groups the young trees have to be protected singly by hoses of meshwire.

Thinning and Pruning.

The first thinning should be carried out rather early. All dead and suppressed trees are taken out.

Differently from a first thinning in a pine stand we do not so much extract the smaller trees as with douglas they are the best future crop trees.

The early extraction of crooked, bulky and "noddy" trees is especially important to favour the surrounding specimens which are thin, straight and clear. This first thinning, in fact, is decisive for the whole further development of the stand. As to the cost of these thinnings all expenditures have been repaid by revenue from selling the green branches for which there is the greatest dmand all over Germany. We have had an average net income of about £45 per acre from those sales.

I have already mentioned that douglas has to be pruned, even in pure stands which are established in a narrow spacing. The procedure is best done in two phases : firstly to a height of 15-18 ft. and secondly —after some years—at least to a height of 30 ft. Roughly 100 trees per acre should be selected. W have developed special light ladders for this purpose the highest rung of which is a rope. The cost runs up to about £3 per half acre and also these expenses are mostly covered from the sale of the green branches.

Douglas tolerates pruning in the green, so there is no risk in cutting off the lower branches which have already developed shade-needles.

The later thinnings should be repeated rather often and moderately with the main aim to allow for a full development of the crowns. If we keep the stands too dense there is always the danger of competition between the crowns and also between the roots and we have always found that stands which were badly thinned or not at all suffered severely from windthrow.

If we properly apply this procedure we come rather early to the final position of the stand, maybe at the age of about 50-60 years. At that time we shall have 120-180 stems per acre, which are all pruned and which have been for long treated as future crop trees. There are no objections to leaving these stands for 4 or more decades. The American yield-tables prove that on favourable sites douglas might gain an increment of 80 cu.m. per acre between the age 80 and 100.

In South-Western Germany where many of you have seen the thrifty

growth of silver fir and spruce conditions are somewhat different. There from the age of 70 years on douglas is overgrown by these two native species, so that we have to try what other exotic species we may successfully mix with it.

Seed Origin.

All our experiments and experiences with douglas have proved the great importance of seed origin. A classical experiment had been carried out in Forest District Kaiserslautern in the Palatinate where in 1910 experimental plots were established with 10 different provenances. Only one out of these 10 provenances, the one from Snoqualmie, has shown good results while most of the rest were a complete failure from the economic point of view.

In 1954 the OEEC in Paris has tried to find a way to make sure that the American Forest Service provides bonded seed to cover the demand of the European nations, but also this combined effort did not have much success, so that we from our German side sent an expert to Oregon and Washington in 1955. This forester has selected 31 seed-production stands in the douglas region of these two States and we have arranged with the American forestry authorities and seed dealers that we shall preferably get our seed from these stands.

The Wood.

The wood of douglas varies widely in colour, grain, texture, strength and working qualities depending on the age of the tree and the locations in which it is grown. In Western Oregon timber from rapid-growing, immature trees is wide-ringed with a wide band of dense summer wood, of more or less uneven texture and reddish orange in colour, a characteristic that has caused timbermen to call the wood red fir. Older stands are classed as yellow fir forests. Since the rate of growth diminishes with age the trees in old forests are likely to contain a relatively large proportion of yellow wood. Both kinds of wood may be in the same tree, the coarse-grained centre being reddish and the fine-grained outer portions of the stem yellowish. The yellow-fir is considered more desirable because of its colour, fine grain and easy-working qualities.

Douglas wood has a specific gravity of 0.45, is very strong, stiff, high on shock-resistance and durable. These properties, together with availability in exceptionally large sizes and high quality make it an excellent structural material. Its greatest use is in the form of dimension timber, ship and bridge timbers, piling, railroad sleepers, cross arms and pit-props. Because of the large size of logs and amount of clear volume it is an outstanding veneer-wood and large quantities are manufactured as plywood. Other important uses include sashes, doors, flooring, Venetian blinds, general millwork, cooperage and silo and tank staves.

A considerable volume is used for sulphate pulp. In the last war

¼ of the aircraft material that was produced on the West Coast of the United States was of this species. Other important products for war use included pontoon timber and ship decking.

There has always been a special demand frim factories which produce accumulators where it is used for insulation walls.

In the past few years the bark has been utilized for the production of wax. All these technological abilities have made douglas timber No. 1 of the World.

Of course, not every European timberman is convinced of this fact yet. I still remember when some years ago one of my customers, a very smart saw-miller, refused to buy one douglas log which was right in the middle of a large spruce lot, which he had bought at an auction. We had a very long debate in which I found out he could not even pronounce the name of the tree and somehow he felt cheated. It took all my skill to persuade him to take this log as it could not be hauled out by another buyer. Some time later this saw-miller showed up again with the brightest smile. He wanted to thank me that he had got the tree. He had personally used the boards for the manufacture of some very stylish furiture for his home, which were extraordinarily attractive and solid.

So, not only we foresters, but also the timbermen have to learn a few more lessons before we really know enough about douglas, its silviculture and its utilization.

I am very much afraid that my limited time does not allow for further remarks on this species therefore I had better proceed to some other tree species which are native to the West Coast of the U.S. and which also show great promise for our European silviculture.

Tsuga heterophylla.

First of all, there is western hemlock (*Tsuga heterophylla*). From the standpoint of volume it is the number three species in Oregon after the yellow pine (*Pinus ponderosa*). Commercially it is rapidly gaining importance as new and wider use is made of the wood. Over the period from 1925-1941 hemlock has shown a greater increase in volume of sawlogs produced in Oregon than any of the other major species.

In mature forest-grown trees the boles are clear with little taper, usually 3 to 4 ft. in diameter breast height and 150 to 175 ft. in height. Trees up to 8 ft. in diameter and 200 ft. in height are sometimes found. In its favourite habitat, the coastal fog-belt region, western hemlock is one of the most rapid growing conifers; here it forms dense stands of unusually high yield. Hemlock is a prolific seeder and frequently re-stocks cut- and burned-out areas on which the former stands were predominantly douglas. The native range of this tree reaches from Alaska down to Northern California and in a more or less wide strip from the Pacific Coast up to the Western slopes of the Cascade Mountains.

In Canada it is found at elevations of 6,000 ft. The best stands grow in the moist Coast Region around 3,000 ft. above sea level in Oregon, Washington, British Columbia and Alaska. It is accustomed to moderate temperatures with little fluctuation throughout the year. Different provenances were found which differ in their resistance to frost.

Hemlock is very tolerant to shade, much more than any other tree species of the Pacific region. On the other hand it regenerates easily on bare soil without shelter, growing up in pure stands. It grows best with high precipitation varying from 64 to 80 inches.

Soil requirements are not too distinct provided there is enough rainfall or air-moisture. Higher volume yields are obtained from wet and cold sites in middle elevations. On site I and II the tree will reach a height of about 120 ft. and a breast-high diameter of 20 inches at the age of 100 years. The tree forms extensive even-aged pure stands but also appears in ideal mixture with douglas, *Thuja plicata* and some other conifers.

The thin bark makes the tree suffer from sun-burn, therefore sudden exposure has to be avoided. The same holds true for its susceptibility to wind-throw which is caused by its shallow root system, and due to these factors ground fires are usually fatal. Two insects are rather detrimental : the hemlock looper (*Therina somniaria*) and the bud-borer (*Peronia variana*), but both these are still unknown in Germany.

Young plantations are browsed by game and pole stands may be peeled if they are not protected.

Older trees are often infected by a fungus (*Echinodentium tinctorium*). Some of our young cultivations have suffered from snow-pressure and near Weinheim a 20-year-old stand of *Tsuga* was completely destroyed by snow-and ice-break in 1936.

Now, you might object that all these facts do not recommend any further cultivation of *Tsuga* in Europe. But in truth all these disadvantages together are less than those from which our native species suffer. For spruce, for instance, I could list a much greater number of dangerous agents, pests and diseases and yet we have not given up growing it.

But let us try to find out now what are the advantages which *Tsuga* offers.

It regenerates easily. Its great tolerance to shade makes it an ideal tree for underplanting stands of other species. If grown under an older stand it will surround the other trees so densely that these trees will develop straight clear boles. Experiments in Germany, Denmark and Holland prove that it grows exceptionally well even on poor heather soil near the sea-shore.

Tsuga wood is somewhat less valuable than that of douglas. It is

moderately strong, light in specific weight (0.38) and has good working qualities. It is generally straight- and even-grained, light in colour—from a yellowish to a purplish tinge. The long fibres of the wood and its freedom from resin make it an excellent pulpwood—the principal use of this species to date in Oregon. The wood machines well and considerable quantities are sawn as siding, ceiling, flooring and casket stock. In construction work it is used for all but the larger sized timbers. In the last war select grades of timber of this species have been found satisfactory for aircraft material. Box-factories claim that the wood does not hold the nails too well, but at the same time they praise the fact that the timber is absolutely odourless and so, it is mainly used for food boxes.

The timber does not split too well. The American pulp mills therefore split their pulpwood by screwing a cartridge into the log thus blasting it to smaller pieces. The bark of *Tsuga* contains 15 per cent. tanning acid so that this by-product even might be used for tanning purposes.

The paper manufactured from hemlock is a bit thicker than spruce paper. It has a very high content of Alpha-cellulose which makes it quite suitable for the production of artificial silk. In fact great quantities of*Tsuga* sulphite go from the U.S.A. to the silk-weaving mills in Japan each year. Newsprint is a bit reddish in colour, that is why it is only used by provincial newspapers.

Unfortunately we do not know much yet about the right seed origin. We hardly have any of our own stands that could make us self-supporting in our seed supply. And seed production in a *Tsuga* stand starts rather late, usually not before the age of 60. So we are still depending upon the seed deliveries from the United States. We seem to have found out that provenances from Southern Alaska and British-Columbia show greater frost resistance than other strains. In Norway, for instance, they were not damaged by heavy frost.

On dryer sites (interior continent and mountainous locations) we should try out seeds originating from the Rocky Mountains and Idaho, but where the rainfall is less than 30″ all experiments will be in vain. It would be a false conclusion if we would earnestly try to grow two-storied mixed forests of douglas and hemlock like the ones we find in the U.S. This will be out of reach for our shorter rotations.

But by all means should we use hemlock as a serving species and not only in douglas stands, but also in mixture with spruce, pine, oak, beech, birch and larch. Especially with pine and oak we have two fine sample-stands in Oldenburg where 20-30 year-old stands of scots pine and oak were underplanted with 3 year-old hemlock in 1932.

About 450 hemlock were planted per acre. Now, only 25 years later, the hemlock makes up about 20-30 per cent. of the total volume of these stands, in other words: the volume of these stands has been

increased by ¼ to ⅓ by bringing in hemlock. I must mention that in both sites there is a rather high groundwater level—4 to 5 ft. below the surface.

Some German foresters recommend hemlock for filling openings in spruce pole-stands which were damaged by snow-break. This method may lead to higher financial yield of the final crop as the *Tsuga* may be sold as valuable pulp-wood. The procedure should be limited, however, to spruce-stands the ages of which do not exceed half the length of their rotations.

As a rule *Tsuga* prefers northern aspects and not too basic soil. It germinates better in humus soil than on mineral soil which is important for selecting the proper seed-bed. I may finally mention that if *Tsuga* is sown or planted somewhere it should be *Tsuga heterophylla* and not *Tsuga canadensis,* its sister from Eastern America which remains a much smaller tree and has less commercial value. The latter's usefulness is almost limited to pulp-wood.

Thuja plicata.

I shall come now to the third species of the American conifers which deserves the attention of European foresters. It is *Thuja plicata,* red-cedar or giant arborvitae. Red-cedar is a forest tree, attaining a height of 200 feet and a diameter of 15 feet, with a trunk tapering from the base and often strongly buttressed.

The tree is native along the north-western coast of North-America from Alaska to Humbolt County, California, and eastward in British Columbia, Northern Washington and Idaho to Montana. In elevation it goes from sea-level to 4,500 ft. in the Cascades and even up to 6,000 ft. in the Rocky Mountains. Along the coast as well as in the interior continent it prefers fresh sites. It is one of the most tolerant trees to shade but grows also well in full light.

The coastal type grows best in the fogbelt along the Pacific where it profits from the comparatively high air-moisture and good stands are mostly found on shady aspects or wet gorges. The yearly precipitation in its range varies from 20 to 120 inches.

Its requirements in regard to soil are rather vague but sufficient soil moisture is important. In the interior of British-Columbia it even grows on swamps and in the flood area of the rivers.

The first red-cedar was brought to Europe in 1796. From an inventory which was carried out in Germany in 1951 we know that red cedar grows in at least 49 locations all over Western Germany. It did not suffer from our coldest winters and did not die during our hottest summers. We know nothing about the seed origin of these stands. Moreover it is seldom thrown by the wind as the root system stretches out far around the tree.

The first growth of the tree is a very slow one, so slow that it is surpassed by all other European species but this tree has patience, it knows it will be the final winner.

The dense crowns of the stand prevent any undergrowth. All you find on the ground are the tiny shoots which it casts and renews every year.

The tree has few enemies. Even the game does not browse on it.

In an article of R. L. Robinson "World Forestry Congress 1926" I found the statement that in Ireland red-cedar is heavily infested by a fungus *"Keithia thujina."* We have not noticed this fungus on the continent yet. According to another report from Denmark *"Thuja* has suffered from a fungus *Didymascella thujina."*

The giant *Thujas* in the virgin forests of the United States are always infested by red-rot, caused by *Fomes annosus, Trametes pini, Polyporus Schweinitzii,* etc.

In many respects the silvicultural behaviour of *Thuja* is similar to that of hemlock. Both species are extremely tolerant of shade and yet grow in full light. Their requirements as to the soil are rather vague, but they thoroughly open up the soil, especially in the upper layers. Examinations of the litter of douglas, spruce, hemlock and red-cedar showed that the litter under a red-cedar stand decomposes rapidly and has the highest proportion of bases. In a 66-year-old sample stand of *Thuja* in Harzburg I measured an average thickness of the needle-litter of only $\frac{1}{2}$ inch and a volume of 33,600 board feet per acre. Both species seem to be very suitable substitutes for our silver fir where summers are too cold and winters too warm, where the complex phenomenon of silver fir dying is acute and where repeated infestation by *"Dreyfusia Nüsslini"* makes silver fir management dubious. Sometimes, silver fir fails in our country due to numerous droughts within a short period. Also in such cases hemlock and red-cedar are of some promise as they are used to less summer rain.

The growth and development of red cedar depends greatly upon its position in the stand. The dominant trees usually taper extremely, whilst co-dominant *Thujas* as a rule develop more cylindrical boles. Moderate high-thinning will therefore be the proper treatment and will also diminish the danger of snow-break which sometimes occurs in spite of its spindle-crown.

When stands of pine, spruce or other species are to be underplanted by red-cedar these stands should be heavily thinned. Up to $\frac{1}{3}$ of the trees may be removed so that no further fellings become necessary for quite a time.

Wherever possible and where the necessary seed is available hemlock and red cedar should be mixed. Also in their home country they form a unit. They complement each other in many ways. Their natural range

is about the same and where this natural mixture at present appears in Western America it is not so much a result of tremendous forest fires or natural catastrophes but a true climax-type. As a matter of fact some European foresters do not like the red cedar for aesthetical reasons. They call them the "cemetery trees of Skutari." I like to remind these people that *Thuja* played an important part in our prehistoric forests all over Europe, and that it is extinct since the glacial periods only, which latter is the main reason for the fact that our forests of to-day consist of so few tree species.

As to the technological properties of *Thuja* they are numerous and excellent. To the old Indians in their virgin forests it was the most important tree. They used it for building their canoes, totem-poles and potlatch-houses. The interior bark was used for weaving ropes, nets and blankets, and in case of emergency it even served as food. Also the first white settlers exclusively used *Thuja* for their buildings, at least until such time as they had sawmills. We know that without sawmills they made split-boards of 9 ft. long, 16 inches wide and $\frac{1}{2}$ inch thick. Even now-a-days 90% of the shingle roofs are made from red cedar wood, for there is no better species for this purpose. Another outstanding property of this wood is its durability. Without impregnation it stays sound and healthy in the soil as well as in the open. Fence posts and telephone poles rot much less than even impregnated poles made from other species.

So, we have the queer fact that the dead wood is more resistant to rot and decay than the living tree. Swedish scientists claim that this rot resistance is due to a very efficient poison in the cells of the wood which even in weak solution works as a fungicide.

The wood of western red cedar is not only very light in weight but also extremely tough. The U.S. sailing yacht which took part in the Olympic Games in 1936 was built from *Thuja* wood which is a well-liked material for racing boats. The wood hardly shrinks nor does it swell, if exposed to rain and moisture. It is therefore the ideal raw material for window frames, frames of greenhouses, and venetian blinds. The strong scent has the effect of a moth repellent which means that lockers or drawers made from it are protected against moths.

Some of the American red cedar wood is used for pencil-slat stock. In Germany it filled this purpose only during the war, when the customary imports were not available. In my forest district I have reached the highest prices in selling the wood for fabrication of ladders and wagon shafts. Who ever worked with a light red cedar ladder will never like another one.

Sitka Spruce.

The fourth species of American conifers on which I want to comment is sitka spruce (*Picea sitchensis*). Sitka spruce in Oregon is limited to the narrow fog-belt of the coastal section and for a short distance

inland along the lower Columbia River Valley. Because of its 5 billion board feet of merchantable saw-timber, its thrifty growth characteristics giving high yields on relatively short rotations, and its excellent timber qualities and specialized uses, this species is considered one of the more valuable in the state.

Sitka spruce likes fresh summers and mild winters or oceanic climate in other words. It goes up to elevations of 800 ft. and wherever it grows air-moisture must be high. In exceptional cases, for instance on the northern slope of Mt. Rainier in the State of Washington it grows even at an elevation of 5,400 ft. The tree is tolerant to shade, though not to the same extent as hemlock and red cedar. It recovers even after a long time of suppression.

The seedlings can stand a very high degree of shade if there is enough moisture in the soil. In its later years the tree requires full light for rapid growth. It is used to a precipitation which varies from 75 inches to 150 inches and this rainfall is fairly evenly distributed through the year except during two dry summer months.

If soil- and air-moisture are high enough it grows also with 25 inches of rainfall, but it does not like soils with stagnant water.

The less moisture there is in the soil the more distinct are the requirements for minerals. It regenerates easily on limey soils which on the other hand does not favour the regeneration of hemlock as the latter prefers rather acid humus for its germination.

Sitka spruce mostly occurs in mixture with red cedar, *Abies grandis, Tsuga mertensiana,* lodgepole pine (*P. murrayana*) and *Sequoia* in the South. Pure stands seldom exceed the size of 2 acres.

It is rather resistant to wind throw; the great storm catastrophe on the Olympic Peninsula in 1921 which destroyed extensive sitka-spruce stands was caused by a hurricane. The tree has no dangerous enemies. Quite different from norway spruce it is hardly ever attacked by *Nematus abietum.*

Some old stands were damaged by *Dendroctonus micans* in Holland in 1935. On too dry soils it is liable to suffer from *Agaricus melleus.*

Due to its sharp-pointed needles it is less browsed by the game than other conifers.

Some of our young sitka-spruce plantations suffered from frost during the tough winter 1928/29. Especially the predominant plants which were not covered by snow were killed. But according to all evidence this misfortune seems to have been the result of bad provenance.

The Forest Research Institute in Bergen/Norway has established sample plots with 49 different seed provenances of sitka-spruce. Their main result was the fact that all origins south of the 52nd parallel of latitude were not suitable for Norway as they suffered too much from frost.

I am quite sure that the cause of most of our failures with sitka-spruce was that we chose the wrong climate site. Where the special requirements of this tree were met and where we worked with proper seed origins we have had outstanding results. The yield was about 60 per cent. above the yield of norway spruce on Site class I.

About 20 years ago the British Forestry Commission published its findings on the silvicultural treatment of sitka-spruce. Some of these results confirmed our own experiences.

For instance; larger seeds have a higher germination than small ones, and 1 year-old seedlings are easily damaged when weeded. On the other hand the little plants do not like crusted soil, a fact why heavy rain might damage the seed beds. 6 mm. have been found to be the best depth for sowing, a heavier cover of soil affects the germination very markedly. A cover of straw mats is desirable as a protection against intensive sun light in the summer time, it may even be left in the winter to prevent frost damage. The ideal spacing for transplanting is about 2 by 10 inches.

The properties of the wood make it particularly desirable for special uses. Because of high strength in relation to weight, and even, straight grain, it has been extensively used for aircraft material. The wooden parts of the famous plane "Spirit of St. Louis" in which Lindbergh crossed the Atlantic were of sitka-spruce. Nearly all of the spruce stands of the Pacific fog belt were searched for trees suitable for aircraft during the two wars.

The wood is well suited for pulping and most of the thinnings of smaller dimensions are used for this purpose. Other important uses include boxes and crates, planing-mill products, musical sounding boards and boat timber.

The specific weight of the wood is 0.41. The fibre is about $3\frac{1}{2}$ mm. long. The pulp has a greyish colour, therefore it is not first-class pulp.

The British Forestry Commission published a provisional yield-table for sitka-spruce in 1952.

According to its figures sitka-spruce reaches 10 per cent. and more in volume than even douglas on equal sites.

I have tried to sum up some of the findings which we experienced in our work with conifers from the American West Coast. I assume that, like me, you will have the impression that we European foresters must learn a great deal more before we can really say we are experts in this field. We have to admit that many results are still contradictory. This is mainly due to the fact that in very many cases we know nothing about the seed-origin of our stands or trees.

The information gained from various sample plots have been very helpful, of course, and we have also learned a great deal from American literature. Numerous European foresters were able in the last decades

to have a personal glimpse at the natural stands of these conifers in their home country.

But all this is not enough. We should carry out more and more *provenance experiments,* as has been described by different authors like Fisher, Yates and Edwards. Seed collections should be made from selected stands and these stands must be very fully described. Full records of collection, seed testing and grading are needed. In the nursery stage, plants must be raised in well-designed experiments and methods of selecting and rejecting plants have to be developed. In the forest stage, the shape and size of the plot must be suitable for comparison of crops and not only individuals. Various methods of spacing, planting, beating-up and thinning need to be determined.

At the same time we should not neglect our contracts with foresters and seed dealers in the U.S., though time is working for us in so far as our seed demand from them is going to be more specified. As clever businessmen they will realise in the course of time that they must improve their standards and produce bonded seed if they want to keep their market. Some of them have already adopted proper methods in that regard.

Finally there is hope that for the future some of our seed demands may also be met from graft-plantations which might produce desirable seed of these exotic species. As you all know the field of forest-genetics is a rather new one, but all progress accomplished so far, is really encouraging.

We must be aware that very many of our findings will not hold true permanently, but are only of temporary importance. Changes on the market or new ways of utilization might overthrow them very suddenly.

But we foresters should never capitulate to this problematic uncertainty to which we are so used in our profession. We should rather tackle the task from the optimistic side in the spirit of a famous German forester, Dr. Carl Schenck, who once said : "It is the charm of forestry that we know nothing about it."