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THE IMPLICATIONS OF TECHNICAL CHANGE IN AGRICULTURE

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THE INTERDEPENDENCE OF AGRICULTURE AND FORESTRY

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THIS subject is a very wide one and is limited only by the breadth of the basis selected for study and by the region of the globe involved.

A very considerable proportion of the earth's surface is still covered by forest in spite of man's efforts through the course of time. These efforts have been inspired by two main reasons. Either he has required wood for his various needs, which especially in the era of modern technology has led to extensive logging, or the agriculture and cattle husbandry he practises has necessitated clearing forest and keeping the land open. Although the aim of modern silviculture is to prevent the continuous decline of forest, there are very extensive areas which as a result of loggings remain permanently forestless, and seem to be multiplying. The abandonment of cultivation and grazing has not always enabled forest to reoccupy lost ground. On the contrary, there are very extensive areas where shifting cultivation and extensive grazing have made proper reforestation impossible and have left the land practically waste. However, there is plenty of land at the moment that could be restored by suitable measures so as to yield wood.

If agriculture is more productive for humanity than the forest that it has displaced, nothing but good can be said of it. But the issue is often not so simple. The kind of agriculture may not be intense enough to make anything like full use of the productive resources available, farm management may dissipate its strength, yields may decline and land use may be confined to extensive grazing.

The worst thing, however, is the calamitous effect which the destruction of forests may have on the basic factors upon which the life and prosperity of whole nations depend. The water management of very extensive, naturally forestless regions may be dependent on the survival of the forests of the higher slopes. The forests that retain the precipitation and flow of water keep the run even and help to avoid erosion, major floods, and extreme drought. The disappearance of many an ancient, prosperous civilization is now largely ascribed to the destruction of forests and the resulting disturbance

of water management. The increase in catastrophic sand and dust storms may also be a result of the destruction of forests. The fact that many of the known deserts of the globe go on expanding at the expense of forest or cultivation is a serious warning.

The continuous increase of the world's population and the growing consumption of various foodstuffs and other necessities demand that the greatest attention be devoted to these factors in the future. These problems, generally grouped under the heading soil conservation, are common to agriculture and forestry, and experts in the two branches must be able to agree on the measures required for the ideal solution in each particular case, always bearing in mind the general benefit.

The interests of the two enterprises may appear to conflict. For instance, the reafforestation of open areas may imply a reduction of agriculture or grazing and may run counter to established customs and popular views. Even political considerations may come into play.

The Fourth World Forestry Congress of 1954, in India, devoted special attention to the large Thar Desert on the border between India and Pakistan which is a typical example. This desert is encroaching year by year on the fertile plains of India. Farming has to be given up and production interrupted, although the soil itself is fertile. The immediate cause is a superabundance of cattle. They prevent the formation of ground vegetation that will bind dust, and the net result is the destruction of all tree growth. Experts consider that the advance of the desert could be controlled, and even that much of the ground could be regained, if cattle grazing could be completely stopped for a number of years. Following this, the district could be used for relatively diversified production and could even graze a herd many times the size of the one it supports now. How to stop the present, destructive, yet not very intensive, grazing is a problem not easy of solution.

Similar examples can be listed from several regions of the globe; only the local colouring differs. There are considerable regions where the importance of forest for the maintenance of water supplies, as protection against erosion and wind, or as a favourable factor *vis-à-vis* the climate in general, is greater than its value as a source of wood.

There are also regions of another type, however, especially in the northern coniferous forest zone. Here the threat is excessive moisture in the soil, leading to the formation of marshes. Extensive drainage measures are required. These, again, are often the concern of both

agriculture and forestry, and considerations pertaining to both must be taken into account impartially before a plan is finally accepted.

A feature deserving mention is the practice previously followed in many countries, and still in use in some, of collecting forest litter to help fertilize the fields. This humus-containing material is important for agriculture, especially where the soils under the plough are meagre and retain water poorly. Removal of litter often results in definite and permanent impoverishment of forest soil. Some countries still enforce ancient servitudes on the basis of which farms with no forest whatever are entitled to collect litter from the forests of the neighbourhood. An attempt to stop this harmful practice may meet with considerable opposition.

The real interdependence of agriculture and forestry is most clearly seen, of course, in areas where planned production can be carried out to the satisfaction of both. Such regions are numerous. One most readily recalled is the northern coniferous forest zone, though similar regions exist much farther south and even in the tropics. Of special interest are those where agriculture and forestry progress side by side as integral parts of a single farm business.

In Finland and its western neighbours the rule is that every farm should include an appropriate area of both arable land and forest. The following table shows how in 1950 the total number of farms in Finland was grouped by the agricultural land area and forest area:

Forest area, ha.	*Agricultural land area, ha.*						
	−1·99	2−4·99	5−9·99	10−19·99	20−49·99	50+	*Total*
	Number of farms						
nil	139,801	7,799	2,042	425	108	21	150,196
0·1−4·99	39,853	17,907	6,632	1,404	97	1	65,894
5−19·99	14,483	39,142	33,747	15,235	1,630	7	104,244
20−49·99	5,527	22,741	30,532	20,556	5,776	131	85,263
50−99·99	3,079	8,392	10,923	10,537	5,605	346	38,882
100−199·99	1,007	2,635	3,603	4,735	3,395	470	15,845
200−499·99	136	688	876	1,286	1,340	369	4,695
500+	19	96	79	98	182	162	636
Total	203,905	99,400	88,434	54,276	18,133	1,507	465,655

The reasons for this condition are historical. A century ago agriculture in Finland was still largely based on burning over for crop raising—which meant every farmer had to have forest land. Also, owing to the cold climate, each farm requires plenty of wood both for building purposes and for fuel.

On a farm which includes both ploughland and forest (hereafter termed a combined farm) the connexion between forestry and agriculture is highly complementary. There is a mutual give and take, so to speak.

The buildings required for agriculture in the northern climate need timber which is in fact the common building material for agricultural housing. The drawback of wood is its relatively short life, but modern methods of impregnation, insulation, and ventilation and the use of more durable building materials for critical points help to overcome this disadvantage today. Compared with the heavy building materials, wood has the excellent property of being easily replaced. With the rapid progress of technology the importance of this fact hardly needs emphasis.

The old idea was that the function of the special forest lot included in the farm was simply to supply timber for the household. This idea of a natural economy, however, has been superseded as wood has come to be increasingly in demand as a marketable article and as a raw material for industry. Farms have begun to show a definite tendency to use only their wood of inferior quality for their own requirements. The more valuable part is kept for sale. Before long production for sale will clearly become the main *raison d'être* of the farm forest. A logical result is that farms no longer try to be self-sufficient. If timber can be obtained more profitably from the market than from the farm's own forests it is purchased, and this applies both to building timber and to wood for fuel. The fuel requirements of a small farm may be met by collecting slash from a larger forest enterprise in the neighbourhood or by purchase of coal or oil.

With wood sales providing a considerable income, the farm forest has become a production unit which decisively affects the development of the whole farm economy. The monetary income made available for the farm is partly in the form of the commercial value of the wood itself and partly as wages for the work that has to be done before timber can be marketed.

The concept of stumpage price originated and developed parallel with the need to exploit ever more distant forest resources in order to meet the demand. The greater the distance the raw wood must travel, the higher the price commanded by raw wood in the more accessible areas. Stumpage income has provided a source of capital for the combined farms which was unknown before. Agriculture could hardly keep up with development and with the capital investment involved had the capital not been available in the forest. This is especially the case in regions, like Finland, where the natural

conditions for agriculture, for climatic reasons alone, make it impossible to think in terms of the large-scale surpluses of better situated regions. A topical application of this phenomenon is the mechanization of farming now under way.

Moreover the aspects of work and earnings connected with timber production on farm forests are of no little importance. In certain conditions they may even exceed the income from stumpage. The farmer often prefers to sell his timber prepared as far as possible and transported. The seasons govern the use of man-power on the agricultural jobs of the farm, leaving the combined farm in the winter half-year with more man-power than its crops and livestock can use. How advantageous it is then if the farm's own forest can offer profitable work. Failing this, wage-earning work must be sought farther afield, or perhaps the man-power has to remain unemployed. This applies not only to human labour, but to the traction power of the farm, the horses or tractors.

Compared with a large-scale forestry enterprise, which has to obtain its labour force by paying a full wage in money and defraying all social benefit costs, &c., the farm forest is competitive as it can draw on a man-power pool otherwise unemployed or underemployed on the agricultural side of the combined farm. The agricultural side, which in the winter half-year is in any case responsible for the basic support of the labour force, readily surrenders its help at a low cost, at a dumping price. Many examples show that the farmer interested in silviculture, using his surplus labour wisely, can carry out many jobs and can achieve a highly intensive economy that the large-scale forest owner would hardly consider practicable.

The following figures indicate the income from stumpage and the amount of wages for forest work in Finland in recent years.

	1950	*1951*	*1952*	*1953*	*1954*
	1,000 million marks				
Stumpage income:					
State-owned forests . . .	2·0	4·1	5·0	3·0	..
Company-owned forests . .	2·4	7·5	4·8	3·7	..
Farm forests	14·6	47·3	30·4	23·5	..
Total	19·0	58·9	40·2	30·2	38·4
Wages paid for work in the forest, all forests	13·7	25·9	26·2	20·0	23·0

The man-power in the logging operations of the northern countries comes mainly from the smaller farms. It often depends on whether the farmer is able to live without the money earned by forest work. In good times, when agriculture produces reasonable crops and

incomes, some farmers do not like the hard work in the forests and stay at home. But when the crops fail, or when farmers are in difficulties about their debts, they are very glad to have work in the woods. This makes the question of employment and unemployment in forestry peculiar. There seems at all times to be potential unemployment, not dependent entirely on forestry conditions, but more on the variation in the supply of labour generally. But if logging operations really are going to be suspended and unemployment comes into sight, the men from the farms will have a much less difficult time than those who are without an agricultural living of their own.

For the combined farmer to make competent use of the economic possibilities offered by his forest lot he must have a fairly thorough knowledge of the facts of forestry. If all the marketable timber in the forest is logged and marketed at one time the farmer will have to get along for some time without monetary income, and the jobs available will perhaps be confined to forest reconditioning measures which yield no immediate cash return. The first prerequisite for sound farm management, therefore, is to ensure the continuity of forest production. All developed countries in fact have introduced legislation to this effect long ago.

The mere ensuring of continuity, however, is not enough, particularly if it is based only on fear of the law. True silviculture, the marketing of timber and the preparation and haulage of wood presuppose technical knowledge. In this respect the success of farm forestry, especially when operated as a small enterprise, has been considered dubious; it has been assumed that the difficulties to be overcome are so great that large-scale enterprises, backed by the State for example, or by a commune or a company, have incomparable advantages. However, at least in countries whose population may be said to be forestry-minded, the development has taken a more favourable course than expected. The repeated national forest surveys in the northern countries have shown that the condition of farm forests is definitely improving, even in districts where the size of the management unit is remarkably small.

The continuity of forestry production presupposes above all the maintenance of an adequate growing stock. In this respect combined farms may experience difficulties, and situations may arise involving the imminent risk of excessive sales of growing stock. This may occur when the farm finds itself in financial difficulties as, for example, in the event of crop failure or in connexion with the division of an inheritance. Farmers should have other means of overcoming

difficulties such as these. The importance of suitable credit facilities must be emphasized. Experience shows that the most advanced farm forestry is to be found where the agriculture of the farms is on the firmest basis.

For many combined farms the problem of pasture has developed into a joint problem of agriculture and forestry. Formerly, grazing on forest land was a general practice, so much so that the forest lots of various farms made up a common grazing ground for all. In some areas this is still the practice. But forest pasture represents extensive grazing of a type that does not suit the intensive cattle husbandry of today. Nor does the grazing benefit the forest; cattle cause damage to regeneration areas in particular. In fact, a primary condition of rational forest management is the discontinuation of grazing, especially where the growing of broad-leaved trees is important.

The solution suggested is the formation of special pasture areas. Where suitable areas for this purpose are available on forest land the pasture grounds often have to be cleared, very much as a new field is cleared for the plough. Failing this, the pasture has to come from ploughland.

The different domestic animals vary in the harm they do. Goats are known to be the worst, followed by sheep, cattle, and horses. An example of the measures that have been considered necessary in this connexion can be seen in Yugoslavia where the goat population of the country was completely eliminated by the State a few years ago.

In Finland, work to improve farm forestry has been deliberately carried on for just over fifty years. The present legislation and organizational set-up has operated since 1928. The leading principle has been to make the farmers themselves feel their responsibility and to encourage their initiative. Only on this basis could a group of individualists, such as farmers are, be persuaded to accept the considerable restrictions imposed on their private ownership rights by the Forests Act. Their own initiative has assumed especially the form of joint activities and co-operation; joint bodies place at the individual farmer's disposal competent professional help for silvicultural tasks and timber marketing. Even the smallest parcels of timber can be marketed profitably today.

It is natural that the Government should give its full support to this development by paying the wage bill of the leading organization and by granting subsidies and loans at a low rate of interest for afforestation, drainage, and road construction. But essentially the

farmers defray all the costs. The thesis that silviculture must be paid for by the one who benefits from the yield of the forest is coming to be accepted.

When a forest officer tries to promote farm forestry, he finds sometimes that he has more to do with human beings who think and feel than he has with trees and forests. Only if he is able to make the human beings his allies will he succeed.

When thinking of the future of farm management and the common problems confronting agriculture and forestry, the question of mechanization inevitably comes to mind. If agriculture requires great muscular effort, the forest calls, if possible, for even more. For this reason the increased use of machine power is one of the big problems of today in both enterprises. The solution is not exactly simple, especially on a combined farm where the same man-power is expected to work both in the fields and in the forest. The machines developed for agriculture are not so readily adaptable for use in the forest as is the horse, particularly one which has been bred for this work for centuries.

Compared with its value, timber is heavy and bulky, and for this reason any rationalization of the transport of timber is likely to pay. Replacing the horse by the tractor, therefore, is one of the first measures to be considered. Under many conditions this development has in fact resulted in the disappearance of the horse from the forest. But this has not occurred where winter and snow are available as allies in transport work. At the present stage of knowledge at least, the horse holds its own well in these conditions for the first phase of haulage—collecting the timber from the stump and taking it to the road or the floating channel and so on—so long as the distance is only a few kilometres. A necessary condition is that the proper number of horses be readily available at the farms. Otherwise, the solution could only be total motorization.

However, the amount of horse-work is gradually being reduced, and tractors and motor vehicles are doing more and more transport. This is especially seen in the fact that the distances covered by horses are growing shorter and shorter. At present wheel tractors of ordinary type, fitted with additional equipment, are being developed into serviceable forest tractors for difficult cross-country conditions and even for snow. If this development is successful the horse may soon have outlived its usefulness even in the far northern, snow-rich areas. Then the farmer will look for additional earnings for his tractor in the forest, as he does today for his horse.

Compared with everything that modern agriculture and animal

husbandry requires from the man who practises it—that is to say a diversified knowledge of a most varied range of subjects—forestry does not seem impossible to master. The younger generation especially, which has had the chance of acquainting itself with the problems of forestry at a sufficiently early age, will learn readily and will find in the forest an interest fully comparable with that which the older generation has in the problems of agriculture. On this basis we can see a hopeful future for farm forestry; and where agriculture and forestry are operated side by side, it is clear that they can support one another most effectively.

A highly developed farm forestry is one of the best guarantees for the conservation and progression of a strong, free, farming population with a high standard of living—a sound basis for the whole nation.

THE IMPACT OF TECHNICAL CHANGES ON WOODLAND MANAGEMENT

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THE technical developments which have influenced forest practice during the last fifty years fall into two main groups. First, there are those which run parallel with developments in agriculture—improvement of race by breeding and selection, mechanization, manures, chemical weeding. Second, there is a branch of study which is peculiar to forestry because it attempts to mitigate the economic balefulness of the very long period which is required for growing trees to timber size.

In those developments which are common to the two industries forestry is far behind agriculture. Agriculture has great advantages. It is a much larger industry and engages a vast army of researchers and experimenters; it offers a wide field for mechanical development with glittering prizes for those who invent or manufacture dependable machines; and a technical improvement in cultivation may profit a farmer within a year. An even more important difference is that, on the whole, farmers occupy the best and most easily worked land, while foresters have to be content with the poorer land, steep hill-sides and rocky outcrops, peaty soils and even the small plots which farmers have abandoned because they do not lend themselves

to mechanized cultivation. So the story we have to tell may appear rather insignificant to an audience of agricultural economists, and I shall pass rather lightly over it, drawing attention mainly to those features which are peculiar to forestry.

The most distinctive feature of forestry as an industry is its long period of production. It takes 50, 100, or even 200 years to produce a mature tree, and early expenditure on cultivation grows by compound interest to vast sums at the end of the rotation. In order to keep the ultimate cost within bounds it is necessary to grow trees as fast as is possible without seriously impairing the quality of the resulting timber; but although this must be obvious to an economist, it is only within recent years that intensive research has been applied to securing economies in this respect. Although a parallel might be traced in attempts to hasten the maturing of wine, this type of work is almost peculiar to forestry and I shall deal with it at greater length.

Breeding and Provenance Studies

Most of the trees we grow are mixed lines of natural species. There are many means, however, by which the quality of our planting stock can be improved. Cultivation of trees may by itself result in the selection of the better types because the worst are removed in the process of thinning. It is usual to plant some 4,000 trees a hectare, but during the course of a rotation the number is usually reduced to between 200 and 400 by thinning every two to ten years. Each time a forester makes a thinning he removes those trees which are ill-shaped or heavily branched as well as those which have been unable to keep up with the rest and are becoming suppressed; so, if thinning is conducted with appropriate discernment, the final crop will be composed of trees which are fast-growing and have good form. Where the following crop is raised by natural regeneration, or where seed is collected from these final crop trees, a similar process of selection may be again applied to the second and subsequent rotations.

Some foresters are seeking to accelerate this procedure by isolating the best trees in a middle-aged crop, i.e. by a very heavy thinning. Isolated trees frequently bear heavy crops of seed and these mother trees can be used for seed collection for a number of years.

A more refined development of this method is the creation of tree-seed orchards, based on the pioneer work of Bertil Lindquist in Sweden and C. Syrach Larson in Denmark. A seed orchard may be composed of widely spaced trees, belonging to the same clone, as

they have been reproduced by grafting or budding from a single *élite* tree. It should be situated at a sufficient distance from sources of foreign pollen to ensure self-pollination; and the trees are induced to seed early by strangulation and other means. It is hoped that by this means both Sweden and Denmark may shortly obtain sufficient improved seed of their main species for their countries' needs.

Much experimental work of this nature has been started in the United States and, at the tree-breeding station at Placerville, many pine hybrids have been obtained, some of which have promising features. Hybridization is particularly easy with poplars and willows because these trees are normally reproduced from cuttings. Once a desirable hybrid has been raised it can be increased indefinitely as a clone, with the result that an enormous number of clones is now available for cultivation.

For most of our seed stocks, however, we are still dependent on commercial sources and, as any particular forest may bear a full crop only once in five or ten years, we cannot be as particular as we should like to be about the origins. Provenance tests have shown the regions from which seed should be obtained for use under certain climatic conditions. For instance Britain obtains most of its Douglas fir from near the mouth of the Fraser River and its Sitka spruce from the Queen Charlotte Islands. But we expect to secure a gradually increasing proportion from home sources and, following Lindquist's example, *élite* stands are being preserved as a source from which seed can be collected.

Mechanization

An immense amount of manual work is still required in forestry and, for the reasons which I have stated, this will continue to be so for a long time. Nevertheless, mechanization is helping us in many ways.

In modern forest nurseries most of the operations are now mechanized. Difficulty has been found, however, in designing a suitable machine for lining out seedlings at our usual spacing of about 5 cm.

Mechanization has brought certain difficult soils within the range of cultivation. Soils which are podsolized, or composed of deep peat, are now ploughed with very heavy tackle, often to a depth of 60 cm. Where heavy drainage is desirable, the soil is left in furrow and ridge and the trees are usually planted on the ridge sides.

Planting machines have been developed, particularly in America, but they are only usable on fairly easy ground, as are motor-mowers

which cut the weeds between the planted trees. Powered saws are now used on an increasing scale for felling trees.

The most widespread use of heavy machinery is in the bulldozing of forest roads and in the extraction of timber. Although the horse is still the cheapest machine for extracting small poles, larger timber requires tractors, often of the heaviest type.

Extraction of timber is a matter of immense importance in forest management. Where conditions favour rapid growth the weight of product that has to be extracted each year from a forest may amount to 15 tons a hectare; and, though it is less in slower-growing regions, the development and maintenance of extraction routes engages a large part of a forester's attention. Tushing on snow to rivers which can be flushed is still the cheapest method but, apart from this, road building is replacing all other methods such as specially constructed railways and rope-ways. In regions such as western America, where very large quantities of timber are removed in a short time, heavily metalled, tarmac-surfaced roads are worth building. But such roads are very expensive and most of us have to be content with bulldozed tracks which may be suitable only for four-wheel-drive lorries.

Manures

The wood of trees contains only a very small amount of mineral compounds and, since under forest conditions the leaves are returned to the soil, manuring is seldom required. On peat and some very infertile soils, however, young planted-out trees respond to doses of nitrogen and phosphates, and complete fertilizers are frequently used in forest nurseries. The liming of the soil in older woods is now being practised in some countries.

Poisons and Chemical Sprays

Appropriate paraffin sprays are now being used in nurseries to control weeds in coniferous seed-beds and, to a less extent, in coniferous lined-out beds. Hormone weed-killers have also been used for the control of weeds among natural regeneration and in very young plantations, but this treatment is, as yet, experimental. Poisons are employed for killing undesirable trees in natural forests.

Spacing of Trees and Thinning Techniques

I now come to a type of technical development which is peculiar to forestry because it is concerned with the very long interval which elapses between the planting of a tree and its maturity. When computing the cost of growing trees we have to take into account the

compound interest which mounts up on all expenditure involved in cultivation, and in the final account compound interest amounts to a far larger sum than all other costs put together. Intermediate receipts are obtained from thinnings and these receipts offset to some extent the growing load of compound interest.

If the trees in a forest stand are crowded, the crowns of the individual trees are small, so each tree grows in thickness very slowly. If, on the other hand, the trees are farther apart, the crowns can be bigger, and each tree can grow in diameter more rapidly. The variation in the rate of growth can be very pronounced, and it has been shown that, with Norway spruce on sites equivalent to the second quality class of the British Yield Tables, trees grow to an average diameter at breast height of 40 cm. in 110 years, 80 years, or 55 years, according as the thinning is light, moderate, or heavy. So heavy thinning, by reducing the length of the forest rotation, allows an important saving in compound interest. It also increases the money yield from thinnings and reduces the debt under which the plantation labours. Nevertheless, the total volume in the final crop will be considerably less.

Making allowance for all these variations it is possible to compute the relative costs of growing a final crop tree with various cultural methods. Allowing a representative price for the land, a representative cost for each cultural operation, and representative prices for thinnings, we can work out the price per unit volume for the final crop which would be required to earn any given rate of compound interest on the fluctuating amount of capital invested in the plantation. Applying this kind of calculation to the Norway spruce which I have just referred to, and working at 4 per cent. compound interest, it is found that the cost per cubic metre (under bark) of growing a tree of 40 cm. diameter at breast height is £24, £6·2, or £3·5, according as the thinning is light, moderate, or heavy. These differences are so important that thinning practice is clearly a matter of great significance in forestry.

It is generally believed that, within the range which foresters would regard as reasonable, the degree of thinning does not materially affect either the height growth of the dominant trees, or the volume increment of a stand. Individual plots grow erratically and the evidence is conflicting, but we are now reasonably certain that, on the average, the rate of volume growth is independent of the grade of thinning. This is sometimes known as Møller's principle; and, as I shall show later, it has an important significance in forest theory.

Certain advantages arise from growing trees in close formation.

The first is that the lower branches are killed off while they are still small, which reduces the knottiness of the timber. Heavy thinning, which gives the individual trees more room, allows the branches to grow larger and to persist longer; and, to overcome this disadvantage, it is often necessary to prune the trees artificially. Artificial pruning is more effective than natural pruning and ensures that all the wood which is put on a tree outside the central knotty core will be entirely free of knots. It is rather expensive, but this matters less with short rotations than with long rotations.

The second advantage of light thinning is that, since the trees grow in diameter more slowly, they have narrower annual rings, and narrow annual rings are preferred by many users of wood, especially for joinery. The strength of wood is not causally related with ring width, but the wood made while a tree is young is rather weak and we do not like too large a proportion of a tree's cross-section to be composed of this youthful wood.

The considerations which I have briefly outlined in the foregoing paragraphs introduce the technical problem of how much space we should allow for each growing tree or, in other words, the kind of thinning régime which we should follow. The problem has received little attention in the past, and a wide field for research is open to us, research which is likely to pay higher dividends than in any other field of investigation. The question is primarily economic but it involves inquiry into the response of trees to spacing distance and the quality of wood grown in various ways. The importance of the subject is so evident that it is worth while to recall the history of forest thinning so as to see why it has been neglected in the past.

European forestry has been dominated by the techniques adopted in the State forests of Germany. Through a century and a half these forests have been continuously improved by skilful and conservative management and by taking out less timber each year than was added by normal increment. Up to a point this restraint in felling is wholly praiseworthy; but if it is continued beyond the time when the forests are economically stocked, it results either in under-thinning or in lengthening the rotation. Both these phenomena can be observed in German forests which become very heavily stocked indeed. However, they are splendid to look at and foresters in most parts of the world have adopted them as a model that they should attempt to imitate. Few foresters have paid serious attention to the economics of their industry, and the economic significance of these methods was seldom questioned. The forests earned a large annual income, but their

capital value was so high that the income represented a low rate of interest.

Those who are starting forestry from bare ground are naturally anxious to grow their timber more quickly, and they can do so by thinning their woods more heavily. As early as 1811 Reventlow in Denmark advocated heavy thinning and, although this practice has not been scientifically followed until recent years, the Danes thin more heavily than foresters in other parts of Europe. As expressed by the yield tables which Møller has published for Denmark, thinning during early years is light and frequent, which kills off the lower branches; but later thinnings are extremely heavy. The resulting trees have broader annual rings in the outer layers than in the centre, which reverses the order which is generally found in trees.

In 1939 I. J. Craib, who directed forest research in the Union of South Africa, published thinning schedules for exotic pines (mainly *P. patula* and *P. radiata*) which were based on a mathematical analysis of the periodic measurements in permanent sample plots. As these plots were still young and had been studied for a comparatively short time, the calculated schedules were open to criticism. And as he advocated extremely heavy thinning especially while the trees were young, accompanied by artificial pruning to remove the lower branches, and long intervals between the thinnings, his methods were too revolutionary to be taken seriously by foresters in other countries. But his prescriptions were adopted by the Forest Service in South Africa, and forest officers were instructed to follow them after being trained in a method of numerical thinning which was new.

When I visited some of these forests in 1947 I expected to find them filled with rough, overgrown trees. I was astonished to find the best-looking plantations I had ever seen. The trees were so vigorous that canopy closed within a few years of a heavy thinning. They were even and straight, and as they had all been pruned to 22 feet they were cleaner than in any comparable forests I knew. On first quality sites the rotation was fixed at thirty years, at which age the trees were expected to reach a breast-height diameter of 45 cm. and, although few of the plantations were more than twenty years old, large sawmills had been built which were producing building timber and box shooks from thinnings. What had appeared to most of us an outrageous gamble had come off!

Craib's methods have been followed with pines and cypresses (chiefly *C. lusitanica*) in Kenya and in other parts of East and Central Africa, and more recently in parts of Australia, and they have made

forestry so profitable that important syndicates have invested large sums in planting. But they have had little influence in Europe.

Britain, like South Africa, has always been short of timber. And owing to the heavy fellings, particularly of conifers, which became necessary during two world wars, we have to start again, almost from scratch, in building up forests. In order to meet the possibility of imports being again cut off it is necessary to grow timber quickly, so heavy thinning is favoured and the British Yield Tables have recently been revised to allow of a thinning grade which is considerably heavier than is customary in Germany, though it is still lighter than Danish practice.

These new yield tables are framed in such a manner that it is possible to trace the rate of growth of the dominant trees from the first thinning to the end of the rotation. This provides a picture of the pattern of the annual rings at breast height in the final crop trees and we can form an opinion as to whether this pattern is a desirable one. In nearly every case the annual rings are rather broad near the centre, but become narrow or very narrow in later years. This is not a desirable feature in trees because boards with broad rings in the centre and narrow rings at the edge are particularly liable to warp. Recent work has shown that we might with advantage thin more heavily still, especially during later years, and that we might thereby produce our timber much more cheaply.

Calculated Thinning Grades

It takes many decades to test the effect of a new thinning grade by the traditional method of measuring the growth in permanent sample plots, and a great deal of time will be saved if we can calculate, even approximately, the manner in which trees are likely to respond to a new method of thinning. Gehrhardt in Germany and Craib in South Africa have used mathematical methods for this purpose, and Møller's principle greatly simplifies the procedure. From existing yield tables we know the annual increment per hectare which a particular species on a site of specified productive quality is likely to put on at any age; and the annual ring put on by all the trees on a hectare in a year equals the increment in that year. So, if the dimensions of the average tree at the beginning of a year are known, we can calculate the average width of the annual ring which will be made during the year. Conversely, we can calculate the number of trees per hectare which should be left at each thinning age in order to produce final crop trees with a desired pattern of annual ring

thicknesses. We can also calculate the volume of wood which will be removed at each thinning.

Any particular stand may not give the required result. The growth of trees is affected by environmental conditions—by wind, frost, disease, and many other factors. All we can hope to predict is the response which will be shown as the average of a large number of stands. But it is on such averages that our forest policy is based.

If, by these means, we can construct new yield tables which will depict the manner in which plantations will, on the average, respond to untried methods of thinning, we can also determine the relative costs of growing trees of various sizes and with various annual ring patterns. The calculations are long and tedious, and little use has yet been made of them. But, particularly in those countries, such as Britain, which are building up new forests, this technique may be a valuable tool in the preparation of a forest policy.

T. STREYFFERT, *Royal School of Forestry, Stockholm, Sweden*

Technical developments are the most important agency in helping to increase production with a diminishing expenditure of the means of production. In this way we ultimately raise our standard of living. Technical developments go on in every field of economic activity. They seem to proceed more rapidly in industry, but their application is also wide in agriculture and forestry. In these, however, the benefit of technical developments, be it in the way of increasing production per man-hour, or reducing cost, is somewhat lessened by the incidence of diminishing returns.

This arises from the fact that in agriculture and forestry it is more difficult to increase the size of individual working units than it is in industry. For a country as a whole—and to a certain extent for the world as a whole—the total area of land for agriculture and for forestry is physically limited. This does not generally apply to the factors of production in industry. The limiting effect of the size of working units is less prominent with some types of technical development than with others.

Technical development leads to the adoption of new methods. One set of such new methods is characterized by mechanization. In this case the size of the working unit may have a rather limiting effect upon the possibility of reducing cost. In other cases, the change of method may not imply any mechanization, and the size of the working unit may not have any limiting effect, as for instance in the application of different methods of thinning. The same applies to the

application of manure, to the use of seed and plants obtained by tree breeding, &c.

We all know how in industry mechanization tends to produce bigger working units. The same principle applies to agriculture although to a lesser extent because it is more difficult. As a consequence we have, in the industrialized countries and elsewhere, the problem of the uneconomic small farm, which in some cases is too small even to give full employment to the owner.

In forestry the problem of uneconomic small units is not yet serious, in general. However, with increasing mechanization this problem is beginning to make itself felt in the northern countries of Europe, especially where there is an increasing shortage of labour. This has been an important reason for mechanization in Sweden as in the other nordic countries. The big forest owners in Sweden—i.e. the lumber and pulp companies—have, in co-operation with the State forests, taken the initiative in research work in this field on a large scale.

Mechanization will itself have a certain bearing upon the method of management employed in forestry, as it favours concentration of work. Consequently, there is a tendency, in State and company forests, towards clear cutting on rather big areas, followed by planting or sowing. This method, of course, is not so well suited to the small forest owner, who is dependent upon a continuous income from his forest.

There are some other aspects of technical developments in forestry. First, it is obvious that such developments increase the demand for trained administrative and managerial personnel. They also raise the demand for trained forest labour, especially in the case of mechanization. However, trained personnel cannot be employed on small forest units. Thus the State and other big forest owners have taken the lead in employing trained personnel, and consequently also in applying technical developments.

The training of specialized forest labour leads to the employment of permanent labour in the woods. This tends to weaken the integration of forestry and agriculture which has its foundation, at least in the northern countries, in the fact that demand for labour in agriculture and in forestry respectively is concentrated in different seasons of the year. Thus, most of the felling and hauling in the northern countries, even in State and company forests, has usually been done in winter by the farming population.

On the other hand, the big forest owner cannot employ more permanent forest labour than he can keep busy the vear round. This

favours the lengthening of the logging season, which is made possible by substituting truck hauling for sled haulings. This in turn has also weakened the integration of agriculture and forestry. Moreover, it makes the big forest owner more inclined to finance forestry measures done in the summer season in order to keep the men busy the year round.

The demand for trained forest labour is less easily met by the small forest owner, who is usually a farmer also. Courses may be given to him on the use of modern tools and other equipment in felling and transport; but this cannot be quite the same, although it will help him in his own forest.

Technical achievements, with their increased demand for technical knowledge, lead to specialization. There is a tendency in Finland and Sweden (and probably in other countries as well) to use specialists who take over certain tasks from the forester in charge of a district. There will be specialists in road building, house building, draining, in mapping and stock-taking, and so on.

So far it has been argued that technical development—and more especially increased mechanization—will require an increase of the size of the working units in order to yield the economic results aimed at by these technical developments. There is, however, an important way to reduce the limitation of the small forest units. This is by co-operation. Everybody in this assembly knows, and appreciates—and even admires—the achievements realized in agriculture by the agencies of co-operation. Could not the same be achieved in forestry? As a matter of fact, a certain amount of co-operation is already practised among small forest owners in several countries. Without this co-operation, the small forest units would be in a difficult position.

First I want to mention co-operation in the use of trained personnel. This is usually initiated by public bodies, as such personnel is often employed by them to advise small forest owners, to awaken their interest in forestry, &c. This applies mainly to silviculture, which it is in the public interest to promote. In some cases, as in Finland, the forest owners in a certain district may employ a trained forester themselves. There is, however, another form of co-operation, which aims at rationalization of felling and transport. In Sweden this kind of co-operation has been initiated by the small forest owners themselves, by the agency of the Forest Owners Associations. These associations were originally intended to facilitate the marketing of the forest products from the small forest units. They have gradually entered other fields of activities in forestry. A considerable interest is

shown by the small forest owners in new tools and machinery for logging, for the preparing of the ground for sowing or planting, &c. These forest associations will furnish tools, and they will lease heavier equipment such as road-making tractors, to the small forest owners. They will even supply gangs of trained labour in some cases. In all, it seems that co-operation can do a lot in forestry. On the other hand, co-operation in forestry, as in agriculture, cannot overcome all the limitations of small working units. Furthermore, in the last instance, not all small forest owners are interested in co-operation.

However, big forest owners do not always have their forest holdings in working units of suitable form. For instance, in Sweden the company forests are made up, for the greater part, of farm forests bought from their former owners. This means that the forest holdings may comprise a great many working units, often of an unsuitable shape—that is, too long and narrow. This condition did not matter so much in the past, but with mechanization and the intensification of silviculture it limits the advantages of technical achievements. The inconveniences are apt to grow. Many consider this to be the greatest obstacle to rational management of forestry in Sweden, particularly as it increases the limitations of the small independent forest holdings. Attempts are being made to overcome this by the exchange of forest land between owners, but this is difficult. Also companies are not allowed to buy forest land (except from other companies) and in this way to adapt their working units to technical developments.

While mechanization mainly attracts the forest owner by an immediate return through reduced cost, other aspects of technical development, mainly affecting silviculture, are primarily of interest in so far as they increase production, although they should also reduce the cost of long-term investments.

Although long-term investments in forestry are promoted by technical developments resulting from forest research, it is nevertheless true that the return on these investments is by itself generally too low and too far in the future to arouse great interest in forest owners —especially in northern countries with their slow timber growth. Thus, such investments are largely dependent upon the way the forests are integrated with other activities carried on by the owners. For example, the State forests are connected with the public interest in safeguarding future supplies of wood and hence of employment for the nation as a whole; and forests belonging to the forest industries are developed so as to guarantee the future supply of raw material for these industries. In the case of the farmers' forests the prime necessity seems to be the safeguarding of a source of ready

money for various purposes, not least for investment in agriculture, and to add to the generally scant income from agriculture. Forest policies will vary accordingly. But when all this is said, we cannot fail to realize that technical development—be it in logging or in silviculture—is a necessary means of keeping forestry in line with other industries and thus of safeguarding the future supply of an essential raw material.

A. Huni, *Swiss Farmers' Federation, Brugg, Switzerland*

I fully agree that there are vast territories where forests serve primarily for the securing of water supplies and for the protection for soil and nearby settlements, rather than for the gaining of timber. There are many examples of protective forests in Switzerland. Some of you may remember the little mountain village of Andermatt which we visited some six years ago. If the forests above Andermatt and Hospenthal were cleared, the settlements would be exposed to all kinds of danger from the mountains—avalanches, stone hails, or water damage—which might easily be the end of one or even both of these villages. It would be impossible to resettle this mountain valley (1,450 metres above sea-level) and to make such excellent use of it as is made at present. There are thousands and thousands of similar cases in the Alps and, no doubt, in other mountainous territories as well.

In Switzerland we have other names for protective forests—the German words, *Schutzwald* or *Bannwald*, that is to say, *Reserve*. In Schiller's play *Wilhelm Tell*—the setting of which lies some seven centuries back—the hero explains to his small son the meaning of *Schutzwald*, and it was actually true that in those times the protective forests used to be preserved against commercial exploitation; for between the fifth and the fourteenth centuries, many forests in Switzerland had been uprooted to make arable land and pastures to grow more food for an increasing population. But the conflict between forestry on one hand and cattle breeding and arable farming on the other has ceased now for several generations.

Nor is it a question of coexistence, and I am glad that Professor Thomas has chosen a different title for today's discussion from that given to the recent issue of the *International Journal of Agrarian Affairs* for I do not think we should have reached agreement over the meaning of the term coexistence. Coexistence can only refer to a transition period which would soon have either to revert to opposition, or to develop into wholesome co-operation.

In Switzerland today the farmer, partly as a result of experience and

partly by training, is a friend of the forest. The relationship between agriculture and forestry is a happy one. In order to illustrate their interdependence, Professor Osara spoke of the conditions and preconditions in the northern pinewood zone, with special reference to Finland. There is nothing I could add to this except perhaps to say that we should understand that the conditions in the northern forests do not necessarily occur in other countries. From the figures he gave we may assume that most of the agricultural enterprises in Finland have wooded areas of anything from 5 to 50 ha., covering more than half their land, probably, whereas 60,000 farmers have even more than 50 ha. In Switzerland, in comparison, the wooded area per farm very seldom, i.e. in thirty-six cases only, exceeds 50 ha.

The climatic conditions of Finland and Scandinavia are not easily found elsewhere—nor are those vast areas of woodland. In Switzerland, for instance, mountain farms high up in the Alps have, as a rule, no private woods adjoining; the woods are either communal property or owned by local co-operative societies. In the central plain, between the Alps and the Jura, where agricultural conditions are favourable, almost every farm has some wood belonging to it. A farm with woodland sells much better than one without. Soil formation there—tableland with ranges of hills between about 200 and 500 metres altitude—often makes the existence of a forest imperative for protection against erosion.

But none of this explains fully the Swiss farmer's eagerness for obtaining some woodland of his own, however small an area. Many reasons have been given by Professor Osara as well as by other authors in various articles in the *International Journal of Agrarian Affairs*. I need not go into details here, but I would mention that the reasons vary greatly in importance in the various countries. In Switzerland, for example, where according to the altitude above sea-level the growing season lasts for between six and nine months only, the woodland offers gainful occupation of labour and traction power in the winter time. Even in the Alps where most of the forests are the common property of communes or of co-operatives the mountain peasants value very highly the additional income they earn for work done in the forests. Nor is there any real competition between agriculture and forestry in regard to labour, for if these opportunities for work in the forests in winter did not exist, fewer family members would remain on these holdings. This would be a great disadvantage in the short growing season when many hands are needed in agriculture. Even if the forests in the Alps call for work in summer, which they very seldom do, it by no means involves real

competition between agriculture and forestry because in these areas a smallholder can easily let some of his land. Or, if his children are grown up, he may hand over the farm to one of his sons much sooner than he otherwise would, and go on living on the farm and helping his son.

In regions of intensified agriculture which cover a little over one-quarter of the country, the second reason for the farmer's keen desire to possess wooded property lies in the fact that he regards it as a safe economic reserve. Not without justification is the wood called a farmer's savings box. The Swiss farmer who has only 15 or 20 per cent. of his land as wood does not depend in normal years on the income from the sale of timber. Unlike the farmers in the Black Forest to whom Professor von Dietze referred, he does not fell as many old trees each year as the young ones would justify, but builds up a reserve for future needs, such as for enlarging his buildings or for the higher education of a child or to meet the expense of illness or of an accident; or he might be planning further mechanization and could invest in additional machinery without drawing too heavily on his bank balance.

A further reason for having woods is firewood, although this should not necessitate his owning a forest. Even where the forest is owned in common, the peasant gets all the timber he needs for a very small fee.

In connexion with a farmer's producing timber from his forest for his own use, Professor Osara told us of the disadvantage of using timber for building because it is not a lasting material. He said too that in Finland they now take only second qualities for their own requirements. To the first point I would say that we in Switzerland give our timber better marks! In the Alps you can see hundreds and hundreds of wooden houses which were built three or four hundred years ago and which are still very sound; they may not be modern but they even stand rebuilding, and whenever one of these houses becomes vacant it is often bought by a townsman for the family's summer holiday. To the second point I would reply that our peasants —and probably those of many other countries—prefer to select the very best qualities for their own purposes. It may well be different where the sale of timber constitutes a substantial part of a farmer's income.

In conclusion let me say that there can be no standardized rule that would fit all countries alike for the ideal relationship between agriculture and forestry. Different circumstances of property and manpower, different conditions of soil and climate demand different ways

and means. But one thing is clear: the forest which first provided us with most of the arable land is a very important factor in the life of mankind. It is the willing protector of our soil, of our homes, of the basis of our very existence. Let us, in our turn, thank the forest by helping it to serve us.

J. J. MacGregor, *Imperial Forestry Institute, University of Oxford, England*

Agriculture and forestry have much in common: they compete with each other for the factors of production on farms, on estates, and in the nation as a whole; they may coexist and they may be interdependent. It is not surprising, therefore, that their relationship should be thought worthy of further analysis to provide criteria for judging economic policies of individual countries. The judgements, however, will have to allow for the special physical and historical influences which have moulded the two industries to the present relationship. The degree of integration may be inferred from the forestry and agricultural policies of some countries although in the United Kingdom this is difficult because the tendency is to formulate policies as if the industries were in watertight compartments.

From what has been written and said on the subject certain broad and general conditions can be recognized: (1) at some time or another competition has been of such intensity as to cause friction or ill-feeling between the two industries; (2) the relative importance of the two industries and their comparative advantage can vary greatly from country to country and thus directly affect their relationship; (3) in addition to being productive, forestry has certain protective influences and functions—and their destruction can give rise to certain social costs; (4) forestry may be managed in self-contained units, usually on a large scale; or it may be managed as a complementary enterprise with agriculture—often on a small or farm scale; (5) forestry may have what can be described as a capital reserve or 'savings box' function which may be helpful to the agricultural as well as to the other enterprises within an individual's estate.

It is on the last two aspects that I would like to make my comments. Dr. Osara has confined most of his remarks to the combined farm economy, but I feel that the large-scale forestry development and its relationship with agriculture in the national economy should be an even more urgent subject for study by the economist. Here we are entering more into the realms of public policy—and it is important to give first thought to the basic principles which should govern national policy decisions. At the farm level it would be easy

to fall in with the basic principles of general policy. It was Joe Duncan who averred that one of the main functions of the economist should be to influence the decisions of the politicians and the statesmen, in the belief that ideas do tell in the end—even on politicians!

To some extent the planning of the integration at farm or estate level is made easier because this will take place within a unit of known size and because the essential management problems stand out. It is difficult to plan beyond the individual unit and get the co-operation of several units—as not all farmers will feel that they require co-operation. Elements of public policy such as State control over private woodlands may help to smooth over difficulties and prevent obvious malpractices. These situations help to stress the fact that definite limits are set to the management problems of individual units. It is not always so clear what is best in the national interest when thinking, for example, in terms of how much forestry or how much agriculture should be encouraged or expanded.

Many of the people who live in development areas have yet to be convinced that forestry and agriculture are interdependent. The impact of forestry in an area where forestry is being promoted for the first time may involve considerable dislocation on many farms, and the alteration of farm boundaries. To some extent the blow may be softened where the expansion is accompanied by opportunities for work in agriculture. Almost any change, whether or not it comes under the banner of economic progress, involves hardship to some people, and the expansion of forestry is no exception. It may be, as one of my students at Oxford told me before I left, that the inclosure riots of 1549 have found an echo in the twentieth century in the protest meeting and the public inquiry. There is a field of activity for the rural economist in all this, and it seems clear, if the public inquiry is to be developed as a constructive instrument of policy, that it will function best if backed by solid evidence, including irrefutable economic evidence.

While it is obvious that there is interdependence and integration between agriculture and forestry, it is not always so clear how much there is. Should we rest content with the degree of integration so far achieved? Where are the standards of economic achievement—either in forestry or farming—which would help to decide the best combination for forestry and agriculture? If agricultural ministers, as in the United Kingdom, have the final decision about whether a given farm or estate should be handed over to an expanding forestry programme, how do they decide? Should we be content with the hunch—based, of course, on the experience of the busy administrator—and should

forestry, for example, always be confined to the poorest agricultural land? Should we not have more confidence in the techniques of the economists? In the past when there was some doubt about a new proposal it was fashionable to urge pilot schemes or surveys. Would I be very unfashionable if I were to suggest that the views and evidence of economists were to be tried out in a series of pilot schemes?

How to compare values of land for farming, grazing, forestry, and watershed protection where, as Mr. Wooten of the U.S.D.A. has written, costs and returns are spread over different periods of time and shared by different groups of the population, is a major problem in deciding alternative uses of land. The discount rate is, indeed, an important element in making the comparisons.

There has been some study of the interdependence and integration at the farm level. Studies at Harvard by Barraclough and Gould, and the reference to investigations in the Black Forest by Herr von Dietze, spring to mind. Perhaps Dr. Sen's reference in the *International Journal of Agrarian Affairs* to the new forest policy in India indicates the kind of approach which I have in mind. He argues that the correct solution of the land problem is to evolve a system of balanced and complementary land use 'under which each type of land is allocated to that form for which it is best suited'. I presume that such a policy will recognize the 'multiple use' concept of the planners, but I do not know how far this particular policy has been built up from detailed economic evidence and argument. In other countries, attitudes to what is essentially a land problem have tended in the past to be tinged with emotionalism rather than with realism.

Much of the interdependence or coexistence and provision of sustained benefits in the northern countries appear to be within the framework of the single farm, whereas in the United Kingdom we find it operating within the framework of a single estate made up of several farms. The estate owner usually retains the woodland in his own occupation and provides from it the repair and other materials of the tenant farmers. This kind of landlord and tenant relationship appears to go back a very long way in English history and we have the Anglo-Saxon terms: plough bote, house bote, fire bote and hedge bote signifying and setting limits to the tenant's rights to certain forms of timber. Special taxation concessions or discriminations have made the contribution of the woodlands to the estate economy very much greater than the area involved would suggest. In discussions on the social policy of sparsely populated areas—which tend to lose what little population they have because of lack

of amenities—the United Kingdom experience at any rate indicates that the expansion and integration of forestry with agriculture, which has been going on on a relatively large scale since 1919, will have something to offer. The associated development of roads and housing will help to give stability to the communities affected and very directly influence their welfare. The French experience is that the hamlets which have remained active in semi-mountainous areas have been helped by forestry which has provided funds for the provision of roads, water, and electricity. Thus it finances modern social equipment and is obviously an effective factor in the consolidation of the rural population.

In discussions on technical change in forestry such as that put forward by Mr. Hiley, I feel that it is convenient to distinguish between what are essentially improved techniques, such as mechanization on the one hand, and 'rationalization' on the other hand, which can broadly be taken to cover such aspects as organization and training.

There are many parts of the world where agriculture and forestry are, in effect, part of the same enterprise, as in Scandinavia; not only do the trees supply much of the timber needs of the farms but they also provide cash incomes. The forestry part of the enterprise can take over a savings type of function and provide the capital for urgent needs, whether to maintain agriculture in an up-to-date condition, as Dr. Osara mentioned, or to provide the dowry of a desirable or, even more so, of a less attractive daughter, or the education of a son. This saving or storing of capital is likely to be of special value where a currency is liable to fluctuate widely in value. Nor should it be forgotten that timber prices sometimes move in a different direction from those of agriculture; and forestry sales can, if necessary, be held over. We have seen this year the effect of drought on agricultural crops and incomes, but where farm forestry is practised we can expect sales of timber to have a compensatory effect.

Dr. Osara has drawn attention to the dangerous effects which destruction of forestry can have on water, soil, and other basic factors upon which the life and prosperity of a nation depend. In view of the growing world population and the limited resources of good land the urgency of recognizing these common problems in agriculture and forestry is all the greater. These things have frequently been said in the past and I cannot help feeling that as the effect of these destructions tend to be gradual, the individuals who go to make up public opinion react in much the same way as the villagers in the fable reacted to the cry of 'Wolf, Wolf'. Public opinion in these matters is extremely difficult to arouse. One reason is that forestry is often

in areas of sparse populations and local opinion, therefore, has relatively little weight. Furthermore, the agriculturist may feel that some aspects of forestry expansion are unwarranted and harmful to agriculture.

LENNART HJELM, *College of Agriculture, Uppsala, Sweden*

Some of the factors in combined agriculture and forestry farming distinguish those enterprises from purely agricultural ones.

In the first place, as we have heard from Dr. Osara, a combination of agriculture and forestry leads to a levelling of work distribution. The first demands most work in the summer and the latter in the winter, but the importance of this must not be over-estimated. Within the regions where forestry exists along with agriculture, dairy farming is predominant, an enterprise which is relatively labour-demanding during winter. Because of this it may be difficult to devote sufficient time and interest to the cattle if there is much forest on the farm. These conditions are prominent in north Sweden where the women often have to manage the cattle while the men are working in forestry. It is possible that this has been a contributary cause of the inefficient management in Norland cattle-farming compared with that in south Sweden. This concerns both feeding and breeding. A certain area of forest land may be more important for small farmers who can work in the forest the whole year when they are under-employed in agriculture.

Combined agriculture and forestry is very advantageous in reducing risk. In Sweden for the last fifty years the price variation in forestry has amounted to 30 or 40 per cent. of the average, and is, thus, relatively important. For agriculture the variation is less, at about 20 per cent., but there are great technical risks which hardly exist in forestry. Under Swedish conditions the yield variation in agriculture for the last fifteen years has amounted to 15 per cent. The correlation between yield and price has not been so great and the income variation in agriculture is therefore essentially greater than in forestry. There has also been a low correlation between the price-variations for agriculture and forestry, which, on the combined agriculture and forestry farms, has to some extent removed the price risk. More important, however, is the fact that the inferior harvests can be compensated for by an intensified lumbering of the forest, which gives greater safety to the farmers. This also improves the possibilites of working with a relatively risk-sensitive production plan in agriculture. One need not be anxious to press liquidity too hard. According to Dr. Osara these possibilities can lead to a risk of

excessive sale of growing stock. Many factors are in favour of combining agriculture and forestry. From social and economic points of view, however, the advantages of doing this are debatable. In Sweden it has led to a demand for the addition of forest land to some farms.

There is also some competition for land between agriculture and forestry. In this context, the fertility of the land is the principal determining factor. Very roughly, for Swedish conditions, forestry is generally superior to agriculture where the agricultural yield does not exceed 1,500 crop units a hectare.

TAO TUNG-TAI, *People's Republic of China*

A country should have a suitable proportion of its land covered with forests which must be well distributed in order to prevent floods, droughts, windstorms, and shifting sands from menacing agricultural production and people's livelihood.

In 1949 the aggregate area of forests comprised only about 5 per cent. of the area of China. This is evidently quite inadequate. Owing to the lack of forests, farm lands in many places in North China have been so damaged that the yields of crops are very uncertain. In the Yellow River Valley, soil erosion is especially serious and flooding is frequent. When the Republic was founded, the people were led by the Government to embark on the tremendous work of planting shelterbelts.

Harnessing the Yellow River. This is the biggest river in North China. With a length of more than 4,800 kilometres, it runs through seven provinces covering an area of more than 740,000 square kilometres. This is a very important cotton- and grain-producing area and abounds in industrial and hydraulic resources. But the river is well known as China's sorrow. Among the rivers of the world, its water carries the highest percentage of mud. Some 34 kilogrammes of sediment per cubic metre of water is recorded at Shenhsien, Honan Province. From there 380 million tons of sand and silt, amounting to some 920 million cubic metres, are brought down every year. Such a huge amount coming from the loess regions in the upper and middle reaches of the river, as a direct result of serious soil erosion in these regions, not only causes floods in the lower reaches but is also a constant menace to the local agriculture. In such circumstances, we have not only to check the soil erosion of the region so as to stop the evil at its source, but also fully to utilize the river for irrigation, navigation, and electricity generation to promote agriculture, industry, and transportation. In short, we want to control the river completely and change fundamentally the economic

physiognomy of the region in order to raise the standards of living of the people.

For such purposes, the Yellow River Area Planning Committee was set up in 1954 and its plan was adopted by the National People's Congress in July this year. The basic principle of the plan is to store water and check soil erosion section by section, from plateaux to gullies and from the tributaries to the main stream, so that the water will be used for agriculture, industry, and transport. Large-scale soil conservation work will be undertaken in Kansu, Shensi, and Shansi Provinces, where serious soil erosion takes place. The work in the first period (1953–67) includes the planting of 1,400,000 ha. of 'conservation forests' and the protecting of deforested areas up to 2,440,000 ha. for the purpose of natural reafforestation. The essential measures to be taken are as follows: (*a*) on bare slopes and hillsides, over-all reafforestation with mixed species of trees, or a mixture of trees and shrubs, by close seeding and planting; (*b*) on slopes used for farming and grazing and along edges of gullies, planting belts of trees 30 metres in width along the contours from 200 to 300 metres apart, to prevent run-off and erosion; (*c*) on bottoms of gullies with low gradients, over-all reafforestation or planting in patches; in bottoms of gullies with steep grades, forest planting combined with stone and earth structures, to stop the downward cutting of the gullies; (*d*) along river banks, planting belts of trees; in case of serious caving of the bank, building dykes before planting trees, or erecting wattle work with willow cuttings which later develop into trees; and on wide beaches, planting belts several metres in width and with an angle of from 30 to 45 degrees to the stream course at intervals of between 10 and 30 metres in order to slow down the flow, and fix the river bed; (*e*) on barren areas around reservoirs, over-all planting or planting in belts; (*f*) in order to promote the regrowth of vegetative cover, organizing the peasants to enclose slopes and sand dunes for the protection of grasses and trees that may grow naturally on these mountainous areas.

Since 1949, the peasants of the Yellow River region have planted more than 150,000 ha. of trees and have revegetated enclosed areas of more than one million hectares. In part of that region, remarkable results of soil and water conservation have been achieved. For instance, the Tienchiachuang Agricultural Producers' Co-operative at Tienshui, Kansu, which possesses two hundred hectares of hilly land, has, since 1952, conducted some necessary engineering works on the farms and has reafforested forty-six hectares of waste slopes equivalent to 23 per cent. of the total hilly area. The resultant black locust

wood-lot already has its canopy closed and begins to play an important role in soil and water conservation and prevention of flood. This serves to prove that the measures so adopted are sound and effective.

In the western part of the north-east, where the climate is arid and windy and the soils are mostly sandy and alkaline, farm lands are subjected to various natural disasters owing to the lack of protection by forests, and the harvest is not stable. In order to change such conditions dramatically, the People's Government in 1951 decided to plant 1,700,000 ha. of shelterbelts to protect an area 1,100 kilometres from north to south and 300 kilometres from east to west, enveloping forty hsiens in four provinces. According to the natural and socio-economic conditions of the various localities, and to meet the need of the national economy, different types of forest such as crop-protecting forest, sand-fixing forest, soil- and water-conserving forest, dyke- and bank-protecting forest, pasture-protecting forest, &c., are to be established in this region.

From 1951 to 1954 more than 240,000 ha. of shelterbelts were planted from which beneficial effects have already been derived in some localities.

In the eastern part of Honan Province including seventeen hsiens, such as ChengChow, Shangchiu, &c., some 280,000 ha. of sandy and alkaline soil have been formed owing to repeated floods and the changes in the course of the Yellow River. In this flat sandy area, wind is violent and there is no forest to check the movement of the fine particles of sand which encroach upon farms and villages. Eventually, much farm land has to be abandoned. For many years the peasants there have suffered very much. For the purpose of ensuring more stable harvests the Government began in 1950 to plant sand-fixing forest in this area. Having gained support from the peasants, 22,000 ha. of barren land have been planted. According to investigation in 1954, 3- or 4-year-old trees on the sandy land have attained an average height of about 4 metres and the highest ones are more than 7 metres tall. These trees have begun wind prevention and sand fixation. Thus wide areas of sandy wastes have become arable. For example, the Tsaikang Village at Lanfenghsien has increased its farming area from 13 to more than 50 ha. According to reports, the increase in the area of arable land in the eastern part of Honan Province for the past half-year, due to the protective influence of the young trees, amounted to 10,000 ha. And the yield per unit area has been greatly enhanced under the protection of shelterbelts. Take Tuchengshiang in the suburbs of Kaifeng as an example. In 1949

people found it impossible to grow wheat there. But beginning in 1951, wheat has been sown there and since then the crop area and the yield per unit area have both increased.

In regions other than those I have mentioned, shelterbelt planting work has also been under way on various scales, and other important measures in connexion with the forest planting work have also been taken. Firstly, the competition among agriculture, forestry, and animal husbandry in land utilization, which has presented a difficult problem for a long time, can now be solved gradually by means of area planning. Briefly, the method is to classify the land according to its suitability for agriculture, forestry or animal husbandry and to utilize it properly for different purposes. Thus in 1953, the Yang-chingti Village in Shansi Province, under the guidance of the local government, drew up a fifteen-year plan for developing agriculture, forestry, animal husbandry, and irrigation. The expected income *per caput* in 1967 in terms of food prices will be six times that of 1953, of which 79 per cent. will be derived from forestry. Since 1950, this village has planted trees, enclosed the denuded hills, built reservoirs, terraces and dams, and has already obtained some promising results. In the past, after every heavy rain, the water flowed away within from 3 to 5 hours in the form of surface run-off. Nowadays, it takes the rain water, which runs in clear streamlets, about 25 days to drain away. Secondly, these large-scale forest planting and soil-conservation works are being listed as major tasks to be undertaken by the Government in order the better to define the aim, to concentrate the resources, to increase the accuracy of the silvicultural plan, and finally, to demonstrate to the public how the work should be done. Thirdly, in order to overcome the shortage of labour and funds in these gigantic undertakings, forestry enterprises, as in agriculture, are developed with government aid and along co-operative and collective lines. In the wake of agricultural co-operation, mutual-aid teams of forestry, forestry producers' co-operatives, combined co-operatives of agricultural and forestry producers, or co-operatives of farming, forestry, and animal husbandry have been established. Up to the end of May this year, more than 182,000 silvicultural co-operatives of various types have been set up in seventeen provinces.

According to the First Five-Year Plan of the National Economic Reconstruction, a total of 6,011,000 ha. of forest will be planted, which include 1,562,000 ha. of protection forests. The realization of such a plan will make many mountainous regions less susceptible to soil erosion, more farm lands less liable to suffer from droughts, floods, and winds, and will turn more sandy wastes into fertile soil.

E. Kalkkinen, *Forestry Division, F.A.O., Geneva, Switzerland*

Forestry and agriculture are often well established as separate activities particularly in Europe and North America, so that quite a lot of work is done in both of them without much connexion, although their basic inter-dependence is quite clear. However, there are some regions of the world, such as the Near East and many parts of Asia, which are very sparsely forested and where today practically every measure to promote or develop forestry has to use agricultural land. The land which in those regions could be freely used for afforestation is so poor that nothing grows on it. Therefore, we in the F.A.O. Forestry Division, in promoting at least some kind of expansion in forestry in these places, try to achieve something I would call tree-planting policy. It means that we try to persuade the farmers and agricultural officials, in connexion with new agricultural extension schemes, to plant small wood-lots, wind breaks, and other protective tree belts, and show them that by doing even this rather small-scale work, agriculture can get certain benefits. Farmers in those countries who suffer from a permanent shortage of fuel can thus get at least some more; and they can also obtain saw-logs for the local craftsmen in those regions where timber transported from far-away sources is usually so costly as to be beyond the means of the small, poor farmers.

This activity of ours is already beginning to show interesting and useful results, and in order to get them as quickly as possible we particularly encourage the planting of very rapidly growing species, such as poplars and eucalyptus. I would like to stress that in this work, where agriculture and forestry are so important, efficient and profitable work in our field is largely dependent upon the support and understanding of agriculturists.

Eino Saari, *Department of Forest Economics, University of Helsinki, Finland*

Mr. Osara has mentioned some figures showing the stumpage incomes of our farm forests. They were very different in different years. The highest was almost fifty billion Finnish marks. Most of this amount is profit which is very important to the farmer because it provides most of his investment capital for farming. In this way the farmer can keep his finances in balance, even if he continually makes a loss in his agriculture; and that has happened in Finland for a long time for a large proportion of our farmers. In this situation it is absolutely necessary for the farmer to have his own forest, because

otherwise he cannot run his farm. This is an important factor in our landownership policy. When new farms are formed in Finland nowadays, it is a rule that each farmer should receive a wood lot sufficient, not only for his own consumption, but also to enable him to sell some timber. To give full effect to this principle would entail the division amongst farmers of all forest land in Finland which now belongs to the State and to industrial companies, thereby giving to the farmers a monopoly of forest ownership.

A farmer who makes an annual profit from his forest can sell the products of his agriculture for less than the cost of production, because the loss is paid by the forest. However, Finnish economic policy also requires that the prices of agricultural products should be high enough to cover their costs and leave reasonable profits. This is a problem we are discussing in Finland at the moment. But, if this latter requirement is fulfilled the forest is no longer necessary to the farmer. Apparently, then, these two requirements are incompatible.

Although there is lively discussion going on in Finland just now, this particular problem—the effect of farm forests on the prices of agricultural products—has not been touched upon in the present discussion.

C. EVELPIDI, *Agricultural University, Athens, Greece*

The question of the relationship between agriculture and forestry cannot be approached in the same way in the countries of central and northern Europe as in those of the Mediterranean area. In addition to the demographic pressure there are technical and economic questions peculiar to these areas. For this reason the First International Congress of Forestry in Rome decided that the historical, demographic, and economic, as well as pedological conditions, usually make grazing necessary in the forests of the Mediterranean areas, where there is a close relationship between forests and livestock. In the countries of northern and central Europe there is a clear distinction between areas which are suitable only for forestry and areas which could be either afforested or farmed. In any case some balance must be found in the Mediterranean countries between forests, agriculture, and livestock which will give a satisfactory income and at the same time allow the safeguarding of the forest capital, the animal capital, and above all the land capital subject to erosion.

In the category of the Mediterranean countries we must include Greece, where the forest areas cover 15 per cent. of the whole area of the country. But the true forest zone is in the mountains; woodland

vegetation in the plains is mainly of the bushy type. The few forest zones in the plains serve to protect the fields and to shelter the animals during the summer heat. For this reason, from a production of 4 million cubic metres only 220,000 can be used for timber. The forests occupy half as much land as is used for cultivation, but they yield only 2 per cent. of our national income as against the 35 or 40 per cent. contributed by agriculture.

As a rule there is no competition between agriculture and forestry, because (1) the actual forests are in the mountains where cultivation is usually impossible, (2) it is permitted to clear areas covered by forests and use them mainly for horticulture when this is to the benefit of the national economy, and (3) in exceptional cases cultivation of forest areas is permitted after burning the bushes, as for example in Epirus (Law 2501 of 1953).

Often, however, there is a clash between forestry and livestock because there is a lack of rich pastures and meadows in the country where, nevertheless, 76 per cent. of the animal feeds come from the pastures, 13 per cent. from grain, 6 per cent. from straw, and 5 per cent. from hay. It must be noted that the large animals do not usually damage the forests, while the sheep which graze the growth down to the ground, and the goats which eat the new shoots of the trees and the tops of young trees, cause serious damage. For this reason the grazing of goats in forests has been forbidden sectionally (Law 192 of 1946). Some people advised replacing the flocks of sheep and goats by cows, and especially by Swiss cows which are used to grazing on steep and rocky soil. This, however, is impossible on the dry soil of the Mediterranean countries.

Nevertheless, the forest constitutes capital which must be as productive as possible. So, with the exception of cases when it is necessary to protect the land from erosion, it is right to demand the highest possible yield. Grazing in the forest increases income. It must therefore be permitted when it does not damage the forest capital. When we are concerned with fir, deciduous oak, and chestnut, however, all of which are of great value, the grazing of goats must be prohibited and the grazing of sheep permitted only in the summer. In the case of larch (*Pinus laricio*), the damage caused by goats is smaller and therefore the joint exploitation of forestry and livestock is possible. In forests of the acorn tree (*Quercus balani*) the grazing of pigs is indicated because they feed on the acorns. Also, all kinds of grazing must be permitted in bushy forests in the zone of flat-leaved evergreens, where the production of wood mass is smaller and of inferior quality. Thus, the forbidding of grazing in general or of certain

kinds of animals during certain periods, in order to protect forest growth after the wood has been cut, is sufficient to preserve afforestation, while it only slightly impairs animal feeding.

The average income of tree-planted areas (fruit-bearing trees, olives, and vines) in Greece is about 11,070 drs. per hectare; arable areas, 4,650 drs.; pasture lands, 1,380 drs.; and forest areas, 740 drs.; without the right of grazing. These figures explain the tendency of our farmers to use the forests for grazing or to clear them up for cultivation or horticultural exploitation, whenever this is possible.