CADU FORESTRY ACTIVITIES

BY

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Some of the Principal Sources of Information

Eucalyptus for Planting, F.A.O. 1958


Tree Planting Practices for Africa, F.A.O. 1959

Forestry and Planning & Evaluation Section:


1. **THE FORESTRY SITUATION IN CHILALO AWRAJA**

When the preparatory team, who were investigating the possibilities of organizing a Regional Development Project in Chilalo Awraja, surveyed the area in 1966, the forestry situation (can briefly be described) as follows.

The only remaining natural forest, containing large timber trees, was found on the Rift Valley escarpment between Munessa Gabriel in the North and the Lepis stream in the South. This forest covered some 15,000 ha., i.e. 1.5% of the total area of the Awraja. Rapid destruction of the forest was at that time estimated to be reducing its area by some 7% per annum.

Half of the area of this so-called Munessa forest was believed to belong to private land owners and half to the government.

On the mountain slopes East and South East of Asella there was evidence that an even larger forest had been destroyed very recently. Most of an area of some 30,000 ha. was still covered by scattered **branchy trees**, which the timber traders had declined to take, and which made the hills look as if they were covered by real dense forest, when seen from a distance.

Above these rains vestiges of tropical mountain rain-forest, Giant Heather moorlands covered most mountain areas above 3,000 metres. Below, in that part of the Rift Valley which lies within Chilalo Awraja, fairly dense Acacia savanna probably covered some \( \frac{2}{3} \) of the valley floor. Here also it was evident that deforestation progressed very rapidly, as a result of charcoal burning and clearing for agriculture.

The only form of reafforestation that could be observed was the planting of Eucalyptus trees.

Most planting had been done round the Provincial capital, Asella, and two smaller towns, Koffele and Bekoji, but many small farm plantations were also sprouting up all over the area from Ethaya in the North down to Sagure.
All these very conspicuous Eucalyptus plantations, however, hardly covered more than 300 - 400 ha.

From Bekoji all the way down to the Wabe river, and in many other areas, trees were almost non-existent and cow-manure was the only fuel used for cooking.

Despite the wide-spread deforestation of steep slopes, erosion had not yet become nearly so serious a problem as further North in Ethiopia.

This could probably be explained by the fact that many hill sides had only been deforested very recently and still possessed soils rich in humus, with an erosion-resistant crumb-structure.

Furthermore since wide-spread cultivation had only recently begun to spread over the Southern part of the Awraja, most of the openland was here still covered by grass.

Serious gully erosion could be observed on the rift Valley escarpment and along cattle-tracks. Elsewhere only the more insidious sheet-erosion was taking place, undermining the fertility of the soil, but observed only with difficulty.

The worst degree of sheet-erosion was found in the Rift Valley, caused by the combined effects of deforestation, heavy over-grazing and a long dry season. In the high rainfall areas erosion seemed mainly limited to leaching of the plant nutrients from soils on sloping land.

A poor, rapidly disintegrating forest cover would have been less of a misfortune for the Awraja if it had been easy to obtain supplies of timber and firewood from outside.

This was, however, far from being the case. From an estimated original total forest cover of some 60%, only 4% of the country as a whole was still under some kind of dense forest.
There was no remaining forest at all in the half of Ethiopia lying North of Addis Ababa and from the capital one had to travel over 300 kms. South or South West to reach timber-producing natural forests.

Nevertheless, the remaining forest area in the Southern and Western Provinces was still big enough to ensure the supply of sawn timber for the country for many years to come, given that it be properly protected and managed.

However, the processes that had eliminated all the forests from Northern Ethiopia were still at work.

An area of forest roughly estimated at 100,000 ha. seemed to be disintegrating annually and the almost total elimination of all real forest from the country seemed probable within 30 years at the most.

Against this background, the urgent forestry needs within the Project Area seemed to be:

- Protection and rational utilization of the remaining forests.
- Increased reafforestation of erosion-prone slopes and other areas available for planting.
- Improved wood utilization.
2. **FOREST PROTECTION**

Initially our aim was to concentrate on protection of both the state and privately owned sections of the Munessa forest.

It was finally, however, decided that CAWÜ's Forestry Section should assume responsibility for the enforcement of the Ethiopian Forestry legislation in the whole Awraja.

CAWÜ started its forest protection activities early in 1969.

In principle nobody was allowed, from then on, to cut down any forest and transport any timber without first having obtained an exploitation permit from CAWÜ's Forestry Section and unless he had made a written undertaking to reafforest the area after exploitation.

Implementation of this policy mainly involved supervision of the Munessa forest region and the vast savanna areas where charcoal and fire-wood were being produced. Above Asella we considered that the battle had already been lost and that it was too late to save any remaining forest.

The Munessa forest had a dented irregular shape, like bread partly eaten by mice, due to the progressing forest destruction. To simplify the task of supervision we decided to establish straight simple boundaries, demarcated by concrete stones, which would include the bulk of the forest. The people were left free to cut the scattered trees outside the boundary, except on steep erosion-prone slopes. But we declared that the land inside the boundary was forest land, which could only be exploited after the necessary permit had been obtained.

The issue of permits was made difficult by the fact that no detailed maps of the Awraja existed. Furthermore private land, as well as government land, was rarely demarcated by any tangible boundaries. The corners of a holding might be marked by a more or less conspicuous tree, by a stone and sometimes by a paint-mark on a tree. Boundaries between private land and government owned forest were in most cases unmarked.
In some cases we were able to assemble the neighbours and obtain their joint statement about the alignment of a boundary. In other cases we had to rely on more one-sided information.

In all cases we would not issue an exploitation permit before the applicant had produced a certificate from the Woreda Office that stated that he was legal owner of the land in question and had paid the land-taxes. Furthermore a "boundary-men" declaration was required in which the neighbours stated that they were in agreement about the boundaries. Despite this "documentary evidence", experience soon showed that information about ownership and boundaries had to be considered unreliable in numerous cases.

As stated above, a precondition of the issue of an exploitation permit was that the land-owner would sign an undertaking to re-afforest the exploited area. The Forestry Department of the Ministry of Agriculture, when responsible for forest protection in Chilalo Awraja, had, in principle, followed the rule that six seedlings, usually of *Cupressus lusitanica*, should be planted for each exploited timber tree, without giving any specification of how they should be planted. In the cases where the forest owners felt compelled to respect this rule, they normally planted the required number of seedlings very densely on any open space available, for example along tracks and on areas used for loading etc. The result was, in most cases, an insignificantly small reafforestation area in relation to the area exploited. In addition these small and narrow plantations mostly became suppressed, within a short time, by surrounding bushes and remaining trees of no timber value. In these circumstances this way of imposing reafforestation appeared to be completely futile.

For reafforestation to result in productive plantations, we considered that planting would have to be done with regular spacing (2½ x 2½ or 3 x 3 metres in most cases) over the whole of the area exploited, and imposed rules governing the clearing of dominant bushes and trees and about weeding until the seedlings were successfully established.
Such technically satisfactory reafforestation would cost from Eth.$100 to Eth.$300 per ha. which in many cases was as much, if not more, than the owner could expect to obtain from the sale of his marketable trees.

A serious difficulty in connection with obliging the owners to reafforest was that no really reliable planting techniques covering the various site conditions had then been developed. We could with some degree of certainty advise people about what and how to plant in the high rainfall areas; but in respect of the acacia savannas we were without the experience to endorse particular techniques.

Despite all these handicaps we started control of timber transportation of logs, cutting of trees for charcoal and firewood and all large scale transportation of fuel wood. We obtained written undertakings to reafforest, according to the methods prescribed by CADU, and we issued exploitation permits and removal passes.

In the Munessa forest almost all exploitation activities were under our control. Hardly any timber was cut without the necessary documents being prepared and hardly any logs left the forest which were not covered by a removal pass. People who exploited without a permit and people who cleared forest to obtain agricultural land were reported to the police and taken to court.

In the Acacia savannas, the difficulties were greater. The areas were much larger and, as a whole, so flat that lorries could go in and out by numerous tracks leading to either the main Rift-Valley road or to the Awash-Asella road. Ownership rights and boundaries were extremely difficult to identify on the featureless plain. We tried to impose our authority here also, but we soon realized that for each exploiting forest owner who we managed to get under some kind of control, nine others slipped through our net. Without having many more staff and means of transport at our disposal we were just helplessly wasting our time.

Those to whom we gave permits had, as already mentioned, signed
undertakings to reafforest. These undertakings looked fine in our files but we had our misgivings about them. Hardly any of the owners seemed to consider their forest as anything but stored capital to be used when needed, or as an area which sooner or later ought to be converted from wilderness to agricultural land. The idea of protecting and maintaining their forest, or converting it to a plantation forest, was strange to them and had little appeal as they generally lived far from the forest and were professionally engaged in some completely unrelated kind of activity. Most seemed to be pensioned army officers or civil servants—or widows of such people.

Despite the fact that these owners signed undertakings to reafforest in accordance with CADU's directives and thus agreed (on paper) to reinvest a large proportion of their exploitation income in forest plantations, we began to suspect that many of them had no intention of fulfilling their obligations. In fact the undertaking was very often signed by a timber merchant to whom the owner had given power of attorney to prepare and sign all the necessary documents in connection with a timber sale.

Reafforestation would not have been a bad investment for wealthy people who had the means to maintain and look after forest plantations and wait 15–30 years for a return on their capital. There were some very wealthy forest owners and some who possessed a large number of gashas, people whom one would have expected to be interested in the development of their land and who had the necessary resources. But most of the forest areas did not, however, belong to that category of people.

The typical holding was one gasha (which could be anything from 40 ha. to 200 ha.) and belonged to people who, although much better off than the average citizen, did not really possess the capital resources necessary to engage in plantation forestry.

In all cases it appeared that we were unable to generate any interest in investment in plantation forestry. Those who disposed of a substantial surplus always preferred to invest in mechanized
agriculture, an activity which at the time was seen to give a fast and big return.

We studied the possibility of organizing some forestry cooperatives but abandoned the idea as completely impracticable. After having spent much of the department's time and resources on forest protection and having taken numerous people to court for not respecting the rules and regulations we had tried to impose, it became more and more clear that we were failing in our efforts.

If a man cleared forest to obtain agricultural land and we tried to stop him by reporting to the police and the judiciary, we found that these authorities refused to back us up and help enforce the existing forestry legislation.

And it was the same in all other respects. We could get no backing for enforcing reafforestation. We were unable to get people punished for unauthorized exploitation. We were making forest protection on paper without seeing any results in the field.

After 2 years of frustrated efforts, we decided that our limited resources could be used better and we, therefore, arranged early in 1971 to hand back to the Forestry Department of the Ministry of Agriculture the responsibility for enforcing the forest laws in Chilalo Awraja.
3. MUNESSA FOREST INVESTIGATIONS

3.1 Getting Control of the State Forest

The munessa forest covers the escarpment of the Rift Valley between munessa Gabriel to the North and the Lepis stream to the South.

The total area of the part of the forest which lies within Arussi Province, and which concerns us here, is approximately 15,000 ha. The altitude varies between 2,000 metres and 2,600 metres. The average rainfall is estimated to be some 1,100 mms.

On the deep volcanic soils there is a tropical mountain rain forest dominated by Podocarpus gracilior (Zigba) and containing also numerous Lygium africanum (Tikur inchet), Croton macrostachys (bisana), and there are bamboo-thickets (Arundinaria alpina) on humid highlying areas. The forest is intersected by numerous perennial streams that drain into Lake Langano.

According to a report submitted to the Ministry of Agriculture in 1965 by its advisor, Mr. R. Sabati, ownership conditions had somehow got out of control in the area. The forest was recorded as consisting of 149 gashas. Out of these 32 gashas were privately owned without any dispute of the legality of the ownership. Another 63 gashas were also privately owned but in a somewhat less legal way.

In 1949 a decree had in fact been passed which prohibited the allocation of government land, covered by forest, to private individuals. No government land should forthwith be distributed before a certificate, on a special form, had been obtained from the local authority, ascertaining that there was no forest on the land in question.

Irrespective of this decree the balabat had distributed 63 gashas of forest land.
When this was discovered the Munessa Woreda Tax Office was instructed not to accept payment of land taxes from people who had received land in a way which conflicted with the decree of 1949. In this way 24 of the not quite legal land owners were prevented from paying land taxes for their forest land. 39 of the owners, however, succeeded in getting round this impediment by paying the taxes at an office in Addis Ababa where it was accepted without objection.

In 1963 a government committee had decided that the 24 forest owners from whom land taxes had not been accepted should be evicted without compensation, and that those who had succeeded in paying land-tax should be given non-forest land in compensation.

If these two decisions had been carried out, the government controlled forest would have increased from 54 gashas to 117 gashas, or 5,000 - 6,000 ha. according to the size of the gashas. A forest area of this size would be quite sufficient to make possible the development of plantation forestry on an industrial scale.

In the proposal for the establishment of a Regional Development Project it was therefore suggested that CADU should take over responsibility for the Munessa state forest and organize and develop it according to modern forestry methods. The proposal was agreed to by the Ethiopian Government.

As a first step in implementation, the Forestry Department of the Ministry of Agriculture sent a team of surveyors down to the Munessa forest so that it could be demarcated and mapped before being handed over to CADU's Forestry Department. The team found itself faced by a hostile population and returned almost immediately to Addis Ababa without having achieved anything.

After that, the handing over of the forest was pending for nearly two years despite repeated reminders to the Ministry
of agriculture that the government decision should be implemented. Finally early in 1969 instructions were given to the Provincial Agricultural Office in Asella to hand over the Munessa state forest to CADU's Forestry Section.

It appeared, however, that neither the local forestry commissioner, nor the guards stationed in the forest, knew anything about the boundaries, or if they knew they were unwilling to pass on the information. Then started the long and arduous task for us of investigating the ownership situation ourselves and finding out if an operational unit of government forest really could be found and demarcated and brought under control.

This boundary investigation took nearly 2 years to complete. Numerous people, including a forest ranger who had been stationed 5 years in the area, were called in to assist us. Eventually there emerged the disappointing picture that all the forest along the top and the bottom of the escarpment was privately claimed and that only a narrow zone of government forest remained in the middle of the slope.

To get a more precise picture of the situation, it was decided that it would be necessary to have a proper boundary investigation made by CADU's Survey Section on behalf of and in collaboration with the Ministry of Land Reform.

This investigation was organized by the CADU surveyor, Mr. K.I. Akerblom. Besides a representative of the Ministry of Land Reform, he was assisted also by a member of the Forestry Department of the Ministry of Agriculture, representatives from the Woreda Office, the balabat, local elders and land owners. The identification of boundaries was started from the Northern end of the forest. Boundary corners were marked by numbered concrete posts as soon as they had been identified. The representatives of the authorities, landowners and witnesses signed forms supporting the location of the agreed boundaries. Maps were subsequently prepared showing the distribution of the
forest between owners. The question of the legality of ownership was not entered into at this stage. The picture slowly reemerged of the situation we had feared. Almost all land was in private hands. Small pieces of government forest were only left here and there, mainly confined to steep slopes or rocky unattractive sites.

The boundary investigation proved to be a very slow and expensive operation. When about a quarter of the whole forest area had been covered, without locating more than half a dozen government owned forest gashas, it became apparent that there would not be funds available to continue the operation to the Southern end of the forest.

Hearing that it was most likely that we would be able to find a bigger area of government owned land in the very centre of the forest above Degaga,1/ it was therefore decided to switch the survey team to this area for a last effort, before funds became exhausted.

We now discovered the interesting fact that with one or two exceptions in the big forest area, limited to the South by the Rajabo river and to the North by the Matana river, no boundaries had ever been demarcated between private land and government owned forest and neither balabat, nor elders, nor even the forest owners themselves were able to indicate any boundaries. A document stating that boundaries within the forest were non existent was prepared and signed by the local notables.

In this situation the only way of defining the boundary of what would eventual be government owned land appeared to be to identify the inner-most known boundary line, demarcating private holdings known and agreed upon by the neighbours, and then to assume that people who had been given undemarcated land inside this "zero-line" were entitled to dispose of 40 ha. for each gasha allocated to them and for which they paid land-taxes. There was some doubt about the legality of imposing

1/ See map facing page one.
a 40 ha. gasha, rather than a bigger one, on all forest owners with undefined boundaries. We were not able to obtain any definite legal opinion on this problem. In this situation we found it advisable to stick to the 40 ha. gasha which since the end of the Italian occupation has been the official size of a gasha.

Another problem which arose, concerning our "zero-line", was that in several cases it became apparent that land-owners who had earlier received government land had appropriated more land than they were entitled to, so that those next in turn to be granted land by the government were pushed further into the government forest than would otherwise have been the case.

We found it inadvisable to try to correct these old irregularities. We considered it more realistic and practical to forget about the tactics used in the past to get more land, and accept the locally acknowledged boundaries as our "zero-line" well knowing that some land was in this way being lost to the government.

By drawing the "zero-line" on the aerial photo-mosaic of the area and then allocating, on the mosaic, 40 ha. per gasha for each holding lying inside the line, and for which taxes had been paid, we then discovered that it ought to be possible to demarcate the unexpectedly large area of 7,000 ha. of still undistributed government forest.

Having reached this conclusion, we approached the Ministry of Agriculture and the Ministry of Land Reform and asked for an official survey and allocation of the undemarcated private holdings, so that the residual government forest could be given a legally defined boundary. For various reasons it proved impossible for this to be done. This was exceedingly disappointing as no development plans could be drawn up before we disposed of a forest unit of known size with legally acknowledged boundaries.
In this predicament, we decided to make a very rapid move to demarcate what would have become government forest if a government gasha-measuring team had actually been dispatched to allocate 40 ha. per gasha to the owners with undefined boundaries. According to the State Forest Proclamation, para. 7, it could in fact be assumed that it was incumbent on us to demarcate the state forest boundaries, although we obviously had no authority to demarcate private land. What we wanted was to present our neighbours with a fait-accompli, being convinced that they would then have little chance of being able to sue us successfully afterwards being unable to substantiate any claims that we had crossed their boundary or had reduced their property to a smaller area than that for which they had been paying taxes.

After a careful study on the photo-mosaic, and in the field, we started the demarcation operation with a big labour force and completed the clearing of a 10 metres wide line round the state forest within a few weeks.

Although some dissent could be heard, our boundary line was only seriously disputed in two cases. One owner to whom we had correctly allocated a half gasha according to old tax receipts, was surprisingly able to prove that he had paid tax on one whole gasha for the last 7 years, and we had to give in to his legal argument although we had a fairly clear idea about the way in which a half gasha had grown and become one gasha.

More seriously some relatively influential land-owners claimed that their gashas should cover 60 ha. each as their land had been allocated at a time in the past when that was the size of a forest gasha in this area. If this claim had been accepted it could have had serious repercussions outside the area under dispute. Fortunately the owners in question were very keen on getting other government land in replacement for their forest, in another locality, where they wanted to start farming. It suited us very well to get them out of the area as rapidly as
possible, even at some cost, so that the location of the boundary separating their land from the government would become immaterial. A settlement to this effect, was therefore, agreed upon, between the owners concerned and the Forestry Section of CADU whereby the owners accepted as compensation a piece of land that the Ministry of Agriculture disposed of near Shashamanne, plus a relatively modest cash payment for their stock of standing trees.

Most unfortunately the arrangement could not be carried out, because of various difficulties and since then we have been faced with some intractable money and time-consuming problems in this section of the forest which threaten to cause difficulties at other points on the boundary, and for which we have still not found solution, at the time of writing.

When demarcating the boundary between government-owned forest and the private gashas, we had not made any distinction between legal forest ownership and less legal ownership by people who had in an unauthorized way had been given land by the balabat.

Although it had earlier been agreed upon that the latter 'owners' should be evicted with compensation if they had paid land-taxes and without compensation if they had not paid taxes, renewed consideration of the problem made the Ministry of Agriculture decide that it would be impracticable to try to evict people whose land-tax had been accepted and even doubtful if it would possible to evict owners who had been prevented from paying taxes by the tax office.

The demarcated boundary delimited an area of unclaimed government forest covering some 7,000 ha. But from the point of view of establishing a practical unit of sufficient size for industrial forestry development, the boundaries were, however, not quite satisfactory. Ideally, the whole remaining forest area covering the Eastern escarpment of the Rift Valley from the Matana river down to the Rajabo river ought to have been included in the development unit. This would have meant fairly
straight boundaries following the upper and the lower limit of the escarpment, easy to traverse with four-wheel-drive vehicles and encompassing all erosion-prone slopes. The actual situation was, however, that the demarcated state forest on both the lower and upper sides was bordered by a single row of privately-owned forest gashas. The lower and the upper limits of these two strips followed as a whole the transition between the sloping escarpment and the cultivated or grazed plateaux below and above the forest. The state forest would obviously get much more natural and practical boundaries if ways could be found to incorporate the two bordering strips of private forest.

An even more unfavourable boundary alignment was found in the area above Degaga. Here a big 'peninsula' of private forest protruded far into the government forest.

To get the upper and lower strips of private forest land and even more important the whole 'peninsula' included in the state forest was important not only from the point of view of obtaining simple boundaries which could easily be supervised. This inclusion was even more imperative for economic reasons. Of the 7,000 ha. of demarcated government forest, only 4,000 ha. were suitable for production forestry, the remaining 3,000 ha. being located on excessively steep hillsides. If the surrounding private forest areas were incorporated in the government forest the productive area would be increased to 5,000 ha.

Calculations showed that such an enlargement of the production unit would improve the profitability of an eventual forestry development scheme in a decisive way, mainly because it would need much the same infrastructure to exploit and develop 5,000 ha. as 4,000 ha. As it seemed very unlikely that funds could be found to buy out land-owners concerned the alternative solution appeared to be to offer them government land else-where in compensation provided suitable such land could be found.

Despite initial official information to the contrary, the
Forestry Section succeeded in discovering that there still remained over one hundred undistributed government gashas in the region lying between the forest and Lake Langano. If some of this area could be disposed of by CADU it seemed therefore that it would be possible to solve most or all of the boundary problems either by voluntary or enforced exchange of land.

Many of the owners, who we wanted to evict from the forest, fortunately expressed, when sounded by us, the opinion that they were not opposed to such an exchange. To begin with the idea was also welcomed by most of the authorities concerned. However, when it came to the realisation of the scheme, resistance in various quarters seemed to build up, delaying the official identification and demarcation of the government-owned vacant areas. Some of the land was even distributed to other deserving citizens while the discussions were going on, reducing the area which might finally become available.

After considerable delays, the necessary orders were however issued by the Ministry of Land Reform. At the time of writing this report, work is in progress to delimit and demarcate the remaining government land. The operation is being carried out by CADU's forestry staff with collaboration from representatives of the Ministry of Land Reform.

When completed the areas are going to be handed over initially to CADU. The Project should therefore soon be in a position to execute a whole series of land-exchanges.

Some problems have, nonetheless, not yet been solved. The most serious is the question of whether or not the owners who get agricultural land in exchange for their forest-covered land would be given compensation for their trees. Strictly legally we could maintain that they were not entitled to be paid, at least not in full, for the value of their timber. If they were going to exploit the forest themselves, they would, under the Private Forests Conservation Proclamation, be obliged to spend all or most of the revenue on reafforestation,
for the replanting to be technically satisfactory, and in accordance with the reforestation methods advocated by CADU. The owners might however argue that they would be able to follow the common practice of planting 6 seedlings for each timber tree exploited, thus spending next to nothing on reafforestation, and achieving nothing worthy of that name; or that they might be able, in defiance of the forest law, to clear the area and cultivate it, as so many other people are doing. For these reasons many owners are likely to insist that they are not going to accept any exchange of land unless they also are paid for their trees. CADU can hardly willingly agree to this but bad precedents when dealing with some forest owners in the Dagaga area may make it very difficult to avoid some kind of cash compensation.

The most important part of the Munessa forest investigations was obviously to locate the boundaries of the state forest and find out which kind of forest unit we could dispose of for further development. While waiting for the result of this basic land investigation, several other activities were however also in progress. These were: introduction trials to find suitable timber-producing plantation trees for the area, development of nursery and planting techniques, stock-survey of the timber resources, survey of the water resources and a study of the relationship between soil, elevation and natural vegetation within the forest area.

3.2 Gambo Forest and the Taungya Reafforestation Method

As mentioned, CADU did not receive official authorization to manage the Munessa State forest before early in 1969, although it was assumed in the original plan of operation that development of the Munessa forest would be one of our principal activities.

Expecting sooner or later to be able to organize big scale reafforestation in the State forest, we were very eager to start some nursery and planting trials as soon as possible somewhere in the vicinity in order to gain the necessary experience and to train our staff in plantation work.
We were fortunate enough to be offered such a trial and training ground in the forest belonging to Gambo Catholique Mission.

Gambo Mission owned 10 gashas of forest land at the Southern end of the Munessa forest along the Lepis stream. The forest had a few years before been badly over-exploited by a timber-merchant with whom the missionaries had made a deal, which for them had been very unsatisfactory. To obtain an exploitation permit it had been necessary to deposit a considerable sum, as guarantee for reafforestation, with the Ministry of Agriculture. No reafforestation had taken place when CAJU made an agreement with the mission in October 1967 which enabled the Project to start some planting activities in Gambo forest. According to the agreement, CAJU's Forestry Section was given a free rein to clear and use land for reafforestation trials within the forest belonging to the Mission.

If any trees had to be felled to clear the reafforestation areas, CAJU was authorized to sell the logs and use the income to meet the cost of planting. If the income were to exceed this cost, the surplus was to be paid to the Mission. It was clearly stated that all the plantations established under the agreement would become the property of the forest owner and that CAJU's activities would in no way restrict the owner's legal right to the forest.

On the basis of this agreement a forestry station was established at Gambo early in 1968. Two kinds of activities were organized. A nursery was started to prepare seedlings for introduction and planting trials and, up in the forest, six farmers were settled with the purpose of determining if it would be practical and economical to use the Taungya reafforestation method in the Munessa forest. The Taungya method consists of letting farmers clear the forest, allowing them, as compensation for their efforts, to cultivate the cleared area for about four years before reafforestation. After the tree seedlings have been planted, the farmers might even be able to grow agricultural
crops between the young trees for an additional couple of years, before they will finally have to move on to another uncleared section of the forest. In practice, the method is organized in such a way that the farmers, after the initial running-in period is passed, quit a piece of established plantation, every year at one end of their farming area, and clear an area, of equal size, of forest at the other end.

A precondition for the effective use of Taungya is that there is shortage of agricultural land and that good crops can be obtained on the ashes of the cleared forest. If this is the case, numerous landless farmers might be attracted by the possibility of farming in the forest for a number of years. Where applied, the method enables the forest owner to reafforest at very low cost since it eliminates much of the expense of clearing and weeding.

If the operation is run on a large scale the method can also be made socially attractive for the farmers involved. They can be settled in well-organized villages, equipped with clinics and eventually schools, and made accessible by all-weather forest roads. They would have opportunity to obtain additional income by doing forestry work during the periods of the year when farming is not demanding all their time. When Taungya operation finally comes to an end, having converted all the natural forest to plantations, work in forestry and related wood-industries should have expanded so much that all redundant Taungya farmers can be absorbed in other work. All these considerations were in our minds when we started a Taungya reafforestation experiment with six farmers at Gambo.

The nursery at Gambo operated from 1968 until 1971. Soil and climatic conditions were exceptionally favourable and several hundred thousand seedlings of a wide range of species were produced there for introduction trials and other reafforestation both in Gambo forest and in the state forest further north. Details about nursery and reafforestation investigations are given elsewhere in this report.
As soon as we obtained authority to move into the state forest our main nursery and reafforestation activities were, however, shifted up to Degaga and Koke where our main forest camp was also established. This transfer of our centre of activities took place during the second half of 1969.

Gambo forest, however, continued to play an important role in our forestry investigations. There, we had our oldest trial plots in the Munessa forest area with the most interesting reafforestation species. These plots would need to be protected, maintained, measured and observed in the future.

The Taungya experiment continued. The results of this investigation were, however, disappointing. The farmers, we had been able to engage proved not to be of the ideal kind for forest clearing. Hard-working people with an aptitude for this kind of work existed: they were very efficiently destroying other forest areas all around, but they would not come to us. Our farmers could not make a living out of their farming in the forest and we had to assist them for too long, with a monthly subsidy, for the operation to be economically justifiable.

The main obstacle to a successful introduction of Taungya farming was, however, that the Ethiopian farmers' practice of cultivating the land with plough and oxen rather than with a hoe as in other countries where Taungya is practiced. This makes the clearing more lengthy and difficult and makes the farmers more reluctant to abandon the area again after a few years. Lengthening the farming period, on the other hand, cannot be considered, as this would expose the sloping forest soils to erosion and seriously reduce their fertility.

An additional disadvantage of plough farming is that it cannot be practiced after planting of the tree crop. Farmers who normally use hoe-cultivation continue to grow cereals between the trees for the first 2 years after planting, thus making weeding by the forestry service unnecessary.
In 1971 we came to the conclusion that the system could not be made workable under Munessa forest conditions for the time being and we discontinued the experiment. We were, however, aware that a situation might arise where land-hungry farmers, with no other alternative, could be brought in who would follow the farming practices that are necessary to make Taungya successful.

At the close of the Taungya experiment, the area cleared by the six farmers had to be reafforested. Some funds for this purpose were obtained by getting most of the previously-mentioned reafforestation deposit released by the Ministry of Agriculture. By selling some timber from the forest in accordance with our agreement with the Mission, we obtained additional resources and it became possible during 1971 and 1972 not only to reafforest the 24 ha. cultivated by the farmers but also to clear and plant a further 50 ha., all with Cupressus lusitanica. The 1971 plantation was very successful, but the larger plantation of 1972 has suffered badly from the prolonged drought in early 1973.

CADU had to discontinue its reafforestation effort, at the end of 1972, although a greater part of the forest still needed to be replanted, since exploitation of the forest had reached the stage at which no more funds could be obtained from the sale of timber.

The Mission is now willing to maintain the already established plantations and to continue planting on a very modest scale, but it does not unfortunately seem to dispose of sufficient resources to manage the whole of its large forest in a proper way.

CADU is retaining a foreman in the area who, besides looking after the introduction trials established in 1968, provides advice and some supervision to the labourers allocated by the Mission to forestry work.
3.3 Degaga Nursery and Koke Plantations

Early in 1969 we received, as already mentioned, authorization to move into the Munessa State forest. The value of this authorization was questionable, as no boundaries could be shown to us and much evidence (of a doubtful nature) seemed to indicate that there might only be few patches of undistributed government land high up on the slopes.

Fortunately one gasha of government-owned land, not covered by forest and not far from the main forest area, was found near Dagaga. This area offered a possible site for a nursery and an administration centre, and also considerable space for introduction trials. It was, however, essential to get planting trials started as early as possible within the forest itself.

An open area of grass land, named Koke, offered the perfect location. Unfortunately, according to local opinion, it was privately owned. We tried to make a deal with the claimants permitting us to use the area for reafforestation trials, but failed. Then the Arussi Provincial Agricultural Office, expressed the opinion that, concerning Koke there could be no doubt that the whole area belonged to the government.

Although we were slightly doubtful about the basis for this statement, we welcomed it because it gave us an argument, or at least an excuse, to occupy part of Koke and to start reafforestation trials during the rains 1969.

If we were later to be proved wrong, compensation for the owners could be arranged.

There was no physical interference when we moved rapidly into the southern half of the area with a large work force, but later it was found that, in fact, at least part of Koke was privately owned. The owners showed us old paint-marks on some conspicuous trees that they claimed constituted the corners of the one gasha for which they had paid taxes for many years.
The claimed gasha covered over 200 ha. It seemed doubtful that so big a gasha could have been allocated to them by any legal procedure and there was no evidence to show the authenticity of the paint marks as boundary markers. So although it seemed clear that we had occupied a privately owned area the extent of our transgression was arguable and likewise our concomittant obligation to pay compensation.

Those who claimed ownership were obviously very offended and not without reason. To mollify them we offered employment to some of the family group.

Due to the complicated boundary problems the dispute could not be settled rapidly. At the time of writing the matter is still pending but a solution is now in sight, giving the owners land in compensation from the area of government land which should become available near Lake Langano.

It should be mentioned that due to the uncertainty about boundaries we later occupied elsewhere other private areas unintentionally, bringing us into similar conflicts with offended land-owners. We also came across people claiming up to 360 ha. for their gashas.

Degaga nursery was started too late in 1969 to be able to supply seedlings before the 1970 rains. Fortunately we had prepared a large number of seedlings of many species in Gambo nursery under the assumption that land would at last be made available to us in the Munessa state forest during 1969.

We were therefore able to start a whole series of trials at Koke during the rains 1969, including introduction trials with numerous eucalypts and conifers and spacing trials for the important species Pinus patula and Cupressus lusitanica. The outcome of these and other trials are discussed in the following section.

To get a nursery started at Degaga it was necessary to lay a 3,500 metres long pipe-line from the Mokonissa stream. The
nursery site is not ideal. It is exposed to frost and wind, and some still-unidentified soil deficiency is causing difficulties. Nevertheless it has gradually been possible to build up a nursery there with an annual capacity of 300,000 potted seedlings.

3.4 Stock-Taking of the Timber Resources

Originally we intended to postpone stock-taking of the resources of standing timber until we know the boundaries of the state forest. As, however, the boundary identification made only very slow progress, we decided not to delay the stock taking any further but to proceed with a survey of the timber resources in the whole undivided forest area expecting that it would be possible later, when boundaries had become known, to evaluate the amount of the total stock belonging to both the government and to private owners.

Our survey involved sample measuring of the timber available on 1% of the area. 10-metre wide strips from the bottom to the top of the escarpment, were surveyed at 1 km. intervals. The quality of logs was estimated in accordance with normal exploitation practice. The stock-survey was completed early in 1970. Of the 15,000 ha. total forest area, only 7,345 ha. of well stocked forest were actually surveyed as we excluded the highlying thickets which only contained very little timber of commercial value. Economically inaccessible trees on steep slopes were also excluded.

The result of the survey can briefly be summarized as follows:- The total stock was 3,200,000 m³ of stem-wood of which 55% was made up of Zigba (*Podocarpus gracillior*), 11% by other marketable trees and 34% by trees which have no market value at present. Out of this impressive volume, only 303,700 m³ or 10% consisted of marketable saw logs, an indication of the enormous wastage which takes place when Ethiopian forests are exploited.

In 1971 when about 7,000 ha. of government-owned land had been identified, it was possible to estimate the stock of marketable timber in the state forest at 150,000 m³ out of which 80% was Zigba. This was done by referring to the original strip-survey plus measuring in addition some strips between the old survey lines and counting the trees on a high-lying area, which had not been included in the first stock-taking.
3.5 Water Resources

Large scale forestry development would demand a considerable water supply for nursery activities, domestic use by staff and labourers, and industrial development. Numerous perennial streams crossed the forest before flowing into Lake Langano. Five of them flow through the state forest. They are, from North to South: the Matana, the Hongi, the Mokonissa, the Guna and the Rajabo.

The water Development Section was therefore asked to make a survey of available water in the area. The survey was started in 1970 and consisted of making regular measurements of the water flow in all the perennial streams. No drilling was carried out as the terrain made it unlikely that there would be a deep-lying water table. Members of the section also visited the proposed centre of activities in the middle of the state forest and advised alternative methods of supplying the proposed nursery, sawmill and camp with water.

When the study was concluded, during the dry season 1971/72, it had become clear that although the streams carried plenty of water during part of the year, a very modest water flow could prevail for several months in the dry season.

It would be possible to draw enough water from the streams to supply large scale nursery activities, the domestic requirements of staff, a big labour camp and a sawmill, but the water would be insufficient to cover the needs of some of the more water-demanding types of wood-industries.

The survey did not, however, include any investigation of possible dam-sites where water from the plentiful flow during the rainy season might be stored. It is fairly certain that within the forest area no suitable sites can be found; but on the clay plains above, it is far from impossible that economical water-storage could be organized.
3.6 Road Investigations

Any development of the state forest would require the construction of an access road connecting the forest with one of the main roads leading to Addis Ababa.

Studies of possible road alignments were carried out both by the forestry staff and by members of CADU's Infrastructure Department. Possible alignments were found for an access road leading to the main Rift Valley road and for another road connecting the forest with the new Aleltu-Kersa road. Estimates showed that the road Westwards would be much cheaper to construct than the road towards Kersa and also offer better conditions for transport towards the main market at Addis Ababa.

It would not, however, be very expensive to connect Kersa with the forest by a track possible by 4-wheel drive vehicles. It was suggested that such a track should be opened with a bulldozer and then gradually improved to become an all-weather road for light transport making the forest easily accessible from Asella.

It was assumed that the access road from outside would lead to a kind of forest headquarters, where sawmill, nursery and staff houses would be located. This centre would then be connected with all parts of the production forest by a system of internal roads. No detailed survey was made for the alignment of such an internal road network but it was found that a place located about 3 kms. west of Sarru, would make a suitable centre where access road and internal roads could without difficulty be brought together. Furthermore this site offered the right type of terrain and soil for the planned activities.

3.7 Ecological Investigations

A detailed study of the relationship between soil, elevation and natural vegetation in some typical sections of the Munessa forest, was carried out in 1969 as a Minor Research Task sponsored by SIDA and the Swedish College of Forestry.
The two researchers were Bjorn and Lill Lundgren. They spent nearly three months on field-work collecting data in the forest. The result was a report: 'The Munessa forest, a plant ecological study', and a later published appendix on the results of the soil-analyses. This study provides valuable basic information for later reafforestation planning.

3.8 Administration of the Munessa Operations; Continuation of Activities; Budget and Timber Exploitation

Identification and demarcation of the state forest, stock-survey of the timber resources, investigation of nursery and planting techniques, survey of water resources, survey of possible alignment of access and internal roads, and an ecological study, provide the basic data on which development of the forest can be planned and a feasibility study made.

A precondition for the eventual start of an important forestry scheme would also be that a sufficient force of trained manpower had been prepared, especially as we could not expect people experienced in nursery and plantation work to be recruited from elsewhere.

During the prolonged preparatory stage we therefore considered it essential to run nursery and plantation activities above a purely experimental scale.

When preparing the plan of operation for the 1970-75 period we had suggested that as much as 2,000 ha. should be reafforested before the end of that period. If a large enough area for this purpose could not be found at Munessa, it was proposed that some of the activities should be transferred to the government-owned forest near Shashamanne. In this way plantation forestry would be demonstrated on an impressive scale. There would be ample opportunity to train staff in plantation management and labourers in plantation work. Furthermore the timber supply supply would later become sufficient to support a large scale modern wood industry. This pilot plantation scheme was initially agreed upon at discussions on the highest level.
When the long-term budget for 1970-75 was decided upon the plan was totally cut out, without consultation with the Forestry Department. It was apparently considered that it had now become clear that no government-owned forest could be found at Munessa and that it was not necessary to reserve any more funds for work in this area beyond what was needed to finalize the initial investigation. The contingency plan to transfer some activities to the Shashamanne area was apparently disregarded.

Since it would have jeopardized the long term aims of the Section to stop nursery and plantation activities, and to discharge staff and labourers engaged and being trained in these activities, the Department (or Section, as it became when the Project was reorganized in 1970), tried to fulfill its original plans by obtaining the necessary operational funds from the sale of timber. For various reasons this did not work out very well.

In the original proposal for operations at Munessa, we had suggested that the forestry camp, being so remote from the Project Headquarters at Asella, should be provided with some housing facilities and a small office, staffed by a clerk-accountant. This proposal was not accepted since the operation at Munessa was only considered a preliminary investigation which did not justify investment in housing and other facilities.

As the 'investigation' developed to large scale timber exploitation, reafforestation on a considerable scale and ownership and boundary investigations of a magnitude nobody had foreseen, with periodically more than 400 labourers on the monthly payroll, our administration, established in some miserable sheds without office staff and office equipment, was felt to be completely inadequate. Establishment of a radio link with Asella improved the situation a little but for more than half of the time the radio did not function due to lack of spare parts or other mishaps.

It soon proved impossible to market enough timber to maintain
the original planting target. The Annual planting had therefore to be cut down to a maximum of 150 ha. Even to cut and sell logs in sufficient quantities to maintain activities at this level was a very tricky business, getting us involved with some of the less reliable people in the timber trade, and it was not made easier by our lack of administrative facilities in the area. One must also admit, that we suffered a considerable loss to a fraudulent trader because of deficiencies in our control system.

To run our budget on timber sales was, economically a very unsatisfactory solution. If we had had other budgetary sources we would still have had to fell and sell some logs from the clearing of plantation areas, but we could have concentrated our activities on thinly stocked areas. In the event we had instead to boost timber sales and to clear bigger areas than we could reafforest.

Since there were no proper extraction facilities and no local wood industry located in the forest, logs had to be sold at much lower prices than could be expected once our development plans were put into effect. In this way several hundred thousand dollars of potential income were lost. Furthermore the wastage was excessive since the buyers were only prepared to spend money on hauling good quality logs, of the main species, the long way over bad tracks and then up to Addis Ababa.

Taking everything into consideration we think however that it was worth the sacrifice to maintain nursery and planting activities on full field scale and in this way prepare the staff for rapid expansion to large scale reafforestation once our development plans had been approved.

Up to the time of writing this report approximately 25,000 m$^3$ of timber logs have been marketed and 385 ha have been covered by timber plantations within the state forest.
Early in 1971 it was at long last ascertained that a sufficiently big area of state forest existed in Munessa Woreda to make it feasible to start a combined reafforestation-wood industry scheme.

7,000 ha. of government-owned land had been identified and demarcated. Of these, 4,000 ha. covered gently rolling hills and had deep, fertile soils offering excellent conditions for plantation forestry, whereas 3,000 ha. were located on inaccessible steeper slopes intersected by deep gullies. The government-owned forest contained approximately 150,000 m$^3$ of exploitable timber.

Our silvicultural research had reached a stage where several fast-growing timber species could be recommended for reafforestation in the forest area.

A proposal for a forest development scheme was therefore advanced in August 1971. It was briefly proposed:

a) to increase the area of production forest from 4,000 ha. to 5,000 ha. by a land exchange operation that would, at the same time, give the state forest boundaries which wood be more practical.

b) to open up the forest area by constructing an access road and a system of internal forest roads.

c) to establish a sawmill in the centre of the forest and to build offices, staff quarters and labour houses there.

d) to exploit and utilize the existing timber resources over a period of 10 years.

e) to convert the whole production forest area (5,000 ha.) from natural forest to plantation forest within the same period.

f) to develop the remaining 3,000 ha. located on steep hills as a nature and game reserve.
The rapid exploitation and conversion from natural to plantation forest was justified by the possibility of reafforesting with fast-growing timber trees, expected to yield as much timber, from thinnings, after the end of the 10 year period, as could be obtained annually during that period from exploitation of the natural forest.

The trees proposed for reafforestation were *Eucalyptus regnans*, 40%, *Cupressus lusitanica*, 30%, and *Pinus patula*, 30%.

The rapid conversion to plantation forest and the use of a species till now untried in Africa, *Eucalyptus regnans* were subjects of much controversy. However, the proposal, as a whole, was found very interesting and the Planning and Evaluation Section was asked to collaborate with CADU’s forestry staff in preparing a pre-feasibility study for the exploitation of the Munessa forest. Since the use of the controversial timber tree, *Eucalyptus regnans*, was fundamental to the whole proposal it was arranged that three staff members, one from Planning and Evaluation Section and two from the Forestry Section, should go on a study tour and investigate what was known about the utilization of *Eucalyptus* timber in Malawi, Kenya and Uganda.

Sawing of *Eucalyptus saligna* timber was done on a considerable scale in Malawi and valuable information was obtained there both about the silvicultural treatment of *Eucalyptus* plantations and the methods used for sawing and seasoning.

The species which mainly interested us, *Eucalyptus regnans*, had, however, been planted only in small trial plots in the countries visited. Utilization research with this species was rudimentary and limited to manufacture of some samples of plywood by the wood technologist in Nairobi. It had proved excellent for this purpose.

Maybe the most important outcome of the expedition, was that we were able, after having visited an older trial plot of *Eucalyptus regnans* on Mount Kinangop in Kenya, to arrange
with the Kenya Forestry Department that they would cut some typical trees in the plantation, saw the logs into construction size timber and send to us a sample of about 1 m$^3$ of the produced boards for further investigation of the timber properties. Since the conditions on Kinangop do not differ too much from the sites on which we would be able to grow *Eucalyptus regnans* at Munessa, it is expected that this investigation, which has not yet been completed, will give us fairly reliable information, about the timber quality we can expect to obtain in our own plantations.

*Eucalyptus regnans* is naturally mainly found in its home country, Australia, where it is considered an excellent timber tree. Growth conditions in the natural forests are, however, so different from those found in an artificial plantation in East Africa, that one cannot be at all sure of obtaining a comparable timber quality. Therefore the investigation of Kenya-grown timber is going to be much more relevant than information obtained about the quality of the Australian timber.

Since there was still some doubt about the possibility of increasing the area of production forest from 4,000 ha. to 5,000 ha. by evicting some private forest owners, the pre-feasibility study was made under two alternative assumptions:

a) for an area of 4,000 ha. and

b) for 5,000 ha. Furthermore calculations were made separately for a scheme limited to exploitation of the natural forest accompanied by reafforestation, the logs being sold to existing wood-industries, and also a rather more comprehensive scheme involving exploitation, sawmilling and reafforestation. This provided 4 different project alternatives.

The study showed that it would be far more profitable to operate with 5,000 ha. than with the smaller area. But it was debatable whether it would be more advantageous to sell logs to existing wood industries or to establish a sawmill and market the processed timber.
After the pre-feasibility study had been circulated to the concerned parties, a meeting to discuss the report and decide on the next stage in planning was arranged at the Minister of Agriculture's office on October 24th 1972.

Besides the Minister and the Minister of State for Agriculture, members of the Forestry Department, the State Forest Agency, a representative from the Forest Industries Division of E.C.A. and a big deputation from CADU were present. The study was favourably received although misgivings were heard concerning the use of *Eucalyptus regnans* and the short conversion period. Despite these doubts it was decided that CADU should go ahead with the plans as suggested in the study and prepare a final feasibility study for the development of the Munessa forest. Concurrently investigations concerning *Eucalyptus regnans* should be intensified and if they should lead to adverse conclusions the plans would have to be modified. At the meeting, the E.C.A. representative presented a preliminary study of timber consumption in Ethiopia. The study showed that the consumption was about 50% higher than assumed previously. This information gave a strong argument for going ahead with CADU's proposal. There seemed now to be no doubt that there would be a market for the timber produced from the proposed sawmill, and its output during the initial period would be so modest in relation to total consumption that no disruption could be expected of the already existing timber trade, as some had feared. On the other hand the study also showed that the Ethiopian wood-industry had a considerable excess capacity in sawmilling equipment, so that the addition of a new sawmill and more equipment would have its disadvantages.

At the time of writing this report, the feasibility study is under preparation.

The recommendation will be to exploit and develop for timber production 5,000 ha. and to establish a nature and game reserve in the contiguous, inaccessible part of the forest.
It is also recommended that the conversion to plantation forestry should take place over a 10 years period and that logs and other wood products should be sold during the initial period without entering into the processing of timber.

If the feasibility study is approved and the necessary investment funds are obtained a detailed development plan for the forest will have to be worked out.

This would include:

a) Mapping of the forest, preferably with contours.
b) A soil survey
c) A more detailed stock-survey
d) Planning of internal roads and tracks
e) Sub-division of the forest area into administrative compartments
f) Planning of exploitation
g) Planning of reafforestation and management of plantations
h) Planning of protection, foremost fire protection
i) Further research activities
j) Management of the nature and game-reserve
k) Last but not least, planning of the necessary infrastructure: access road, housing, water supply, nursery installations etc.

A few recommendations will here be made about some important points.

Fire protection of the forest will be of prime importance. Several approaches can be combined to reduce the fire-risk. When planning the layout of plantations, it must be arranged that big blocks of uninterrupted coniferous plantations are avoided. An alternate pattern, when moving uphill, as fires do, of soft wood plantations and broad belts with eucalypts, will greatly reduce the risk of top-fires getting completely out of control. Between soft wood and Eucalyptus plantations narrow lines should be cleared for all organic material, so that if the dry season is prolonged, it becomes possible to control ground fires.
Along the natural protective zones constituted by moist valleys, the natural forest cover should be maintained.

Along the outer boundaries, especially below the forest, it is advisable on exposed places to 'early burn' a one hundred metres wide fire line. This can be done by clearing two narrow fire lines 100 metre apart and then burning the vegetation in between on a day when there is little wind from a safe direction. This must be done before the dry season is too advanced.

A dense system of tracks making every corner of the forest accessible to four-wheel drive vehicles is essential for rapidly reaching and suppressing a reported fire before it spreads to uncontrollable dimensions.

Just as important is a guarding and early reporting system with telephone lines from a watch-tower to the place from where fire-fighting can be organized, and where the appropriate equipment will have to be ready. Also for successfully fighting a big fire plenty of labourers must be available. In most years there is only danger of fire during a very short period of the year. It is advisable to organize work in such a way that very many labourers will be available during that short fire season. Most of the fire hazard comes from people trespassing into the forest collecting honey and hunting game. These age-old occupations will have to be curtailed, despite all the local opposition such a measure will cause.

Eucalyptus regnans has been proposed as the most important reafforestation species covering 40% of the planted area. Research should be continued to select the most promising variety from the many provenances which are reported to exist in Victoria and in Tasmania. Selection should take into consideration frost resistance, growth rate, stem and crown form and eventually timber quality.

Planting distance experiments ought to be laid out. It might also be valuable to study the effects and the economy of
pruning *Eucalyptus regnans*.

Monoculture is always a risk, especially with a species which is new in the country, such as *Eucalyptus regnans*. Diversification of the Eucalyptus plantations would be advisable and could probably be achieved by planting some of the other good timber eucalypts which have shown promise in our trials such as *Eucalyptus fastigata*, *Eucalyptus nitens* and *Eucalyptus delegatensis*. The last species, which is reputed for its good timber quality in its home-land, has the big advantage over *Eucalyptus regnans* that it is extremely frost-hardy.

On the coniferous side continuous research is indicated for the fast-growing *P. radiata* to find out if it will be possible to grow this species without having trouble with *Dothystroma pini*, the pest which plagues it in East Africa.

Concerning protection of the nature and game reserve, collaboration with the Wild Life Conservation Department ought to be established. It ought also to be studied if parts of Mount Kubsa and Kaka, which seem to be government owned, could be included so as to provide protection for the Mountain Nyala whose habitat on Kaka is being destroyed by annual burning. The mountain Nyala comes down into the Munessa forest very frequently. The layout of paths and tracks for tourists might be worth considering.
4. INTRODUCTION OF NEW TAKES

4.1 Comment on Introduction Trials

When CADU started its activities the only species used for reforestation within the Project area was Eucalyptus globulus. Cupressus lusitanica had been planted a little here and there but on an insignificant scale. Pinus radiata could be observed in a few gardens.

CADU's Forestry Section has made numerous introduction trials to find suitable reforestation species for various site conditions, including trials on hardy species resistant to drought and frost, fast-growing species and species with interesting wood properties. Trials have not only been made at the Project Centre and in the Munessa forest but also in most parts of the whole Project area.

A brief description of the results for the tried species follows, in alphabetic order. Additional information about expected wood properties is provided for the more interesting species, and important characteristics are listed at the end in short graded tables for some of the more valuable species.

Some wrong recording of trial plots is likely to have taken place, but we believe that the records are about 90% reliable. In some cases records have been lost, so that no information can be drawn from the field trial.

All trials are recorded on registration cards.

4.2 List and Brief Description of Introduced Species

Acacias

1. Acacia cyanophylla

A bushy not very fast-growing firewood producing tree. Drought - but not frost-resistant. Not hardy enough, though, for the drier places in the Rift Valley. Not very demanding as to soil quality but grows poorly on leached soil with no phosphorus. Seeds obtained from Tigre Province, identification not quite sure. The species is at
present being studied as a possible fodder crop for cattle and sheep and could be grown on marginal agricultural land. It needs direct sowing of hot-water treated seeds or planting of potted seedlings.

2. **Acacia dealbata**
   No records left.

3. **Acacia decurrens**
   A fast-growing fairly hardy firewood-producing species. Suitable for sites above 2,200 metres elevation and up to 2,700 metres. Direct sowing of hot-water treated seeds. It has nice yellow flowers.

4. **Acacia farnesiana**
   Unpromising in Rift Valley and at Dodota.

5. **Acacia longifolia**
   Tried near Asella. Destroyed by rabbit browsing.

6. **Acacia podalyriaefolia**
   A beautiful flowering Acacia with silvery leaves. Nice amenity tree, thrives well at Asella.

7. **Acacia pycnantha**
   Fast growing at 2,080 metres at Dodota. 6 metres in 2 years, but spindly stems. A possible fire-wood species.

8. **Acacia retinoides**
   A beautiful flowering Acacia. Thrives well at Asella. Only for amenity.

Other Broad-leaved Species

9. **Acrocarpus fraxinifolius**
   Shingle tree. Showed good initial growth at Gambo but
after 3 years trees began to die. Locality probably too high above sea-level. Species likely to grow well at Jimma. A big timber tree, which can also be used for shading coffee.

10. **Ailanthus excelsa**

Tried at 1,660 metres at Dhera. Grew slowly in nursery. Locality too high above sea-level. Might be interesting in lower Awash Valley for irrigated land or sites with ground-water. Leaves can be used as cattle-fodder, (after conditioning of the cattle to the peculiar smell). Soft non durable timber, useful for boxes. A very nice shade tree. Seeds do not keep their viability for much more than two months.

11. **Albizia lebbek**

Tried at Dhera 1,660. Slow-growing and unpromising.

12. **Alnus acuminata**

No germination of seeds.

13. **Alnus jorulensis**

This Central American tree was raised successfully in Asella nursery. The climate seemed unsuitable, however, growth was very slow.

14. **Azadirachta indica**

Germinated at Dhera in Rift Valley but seedlings were destroyed by goats. Probably an interesting species for lower Awash Valley. A nice fast-growing shade tree. Timber can be used for furniture. Seeds lose their viability within a month of maturing, so import and sowing of seeds must be well-coordinated.

15. **Calodendron capense, Cape chestnut tree**

An ornamental tree with nice pink flowers. Will grow at Asella.
16. **Canevalia ensiformis**

This hardy bush was introduced as a possible species for erosion control. Seeds germinated but did not develop much farther. Climate at Asella seemed too cold.

17. **Cassia siamea**

This interesting pole and fire-wood species was sown at Dhera. Seeds would only germinate in the heat under plastic cover. Seedlings did not develop. Possibly a very interesting species for the lower Awash Valley.

18. **Casuarina luehmannii**

Seeds were introduced from New South Wales. Seedlings were raised in Dhera nursery, but were lost by some mishap. A few specimens are growing at Project Centre. Worth trying again in Rift Valley.

19. **Casuarina montana**

This pole and fire-wood species thrives well at Dodota. Seeds were obtained from Bogor, Java. 20 months after planting trees had reached 2.5 m. Probably best suited for elevations between 2,000 and 2,200 metres.

20. **Casuarina stricta**

Seeds were obtained from New South Wales. Germinated in Dhera nursery but seedlings lost accidentally. Worth trying again in Rift Valley as a pole and fire-wood species.

21. **Cedrela odorata**

Tried as a possible species for green fire-breaks. Seedlings raised successfully in Degaga nursery but failed in plantation due to frost.

22. **Ceratonia siliqua**

Tried at Dhera. Proved not quite hardy enough and too slow growing to be of interest.
23. **Dalbergia sissoo**

An interesting pole and fuel species. Seeds would not germinate at Dhera. We then got a few seedlings raised in the warmer climate at Wonji. One specimen does still survive at Dhera but does not seem hardy enough for most Rift Valley conditions. Worth trying under irrigation in lower Awash Valley.

24. **Hakea saligna**

A small Australian tree related to the eucalypts. Introduced successfully as a hedge plant at Asella. Not frost-hardy.

25. **Frosopis juliflora**

An exceedingly drought-resistant small tree of Central American origin. It is a good producer of poles and firewood and furthermore it yields pods which are valuable as cattle fodder in dry country. It regenerates naturally in low rainfall area without any need for fencing since goats do not eat the seedlings. At Dhera at 1,660 m. it survives well and flowers and produces seeds. It is however too slow-growing to be of interest at such a high altitude. A potentially very interesting species for the lower Awash.

Seeds require hot-water treatment. Big seedlings cannot be transplanted so must be planted as potted seedlings.

26. **Frunus serotina, salicifolia**

No germination was obtained.

27. **Pterolobium stellatum**


28. **Tephrosia candida**

A bush introduced from India. It was hoped it could be
used for covering eroded slopes and at the same time be a source of cattle fodder. Flots at Asella, Kulumsa and Dhera all showed too poor growth to make the species interesting.

The Eucalyptus

29. *Eucalyptus alba*

There seems to be some disagreement about the nomenclature of this group. For most of the sub-species, Forestry Research in Australia now uses the name *Eucalyptus* decaisniana, and we have followed this practice (see below).

30. *Eucalyptus astringens*

This species, highly valued in Australia because of the high tannin content of its bark, was a failure in the Rift Valley.

31. *Eucalyptus bicostata*

Closely related to *Eucalyptus globulus*, this species was introduced because of its higher frost-resistance. There is reason to believe that under humid highland conditions its growth rate exceeds that of *Eucalyptus globulus*. It is on the other hand not quite as drought-resistant as Bahr-zaaf. It appears to be relatively tolerant of grass-competition and deficiency of Phosphorus. The wood resembles that of *Eucalyptus globulus*. A promising species for Asella and higher.

32. *Eucalyptus botryoides*

A fairly hardy species which has grown well both at Asella and in the Munessa forest, where it has resisted frost better than *Eucalyptus saligna*, although it is not reputed to be frost hardy. It has a good stem form and produces a strong, hard and durable wood. It would produce much better fence posts than *Eucalyptus globulus* and be worth planting for this purpose.
33. **Eucalyptus caesia**

A flowering eucalyptus. Failed at Asella.

34. **Eucalyptus camaldulensis**

In Australia this is the most widely distributed eucalyptus, occurring over most of the dryer part of the continent. It has therefore, developed numerous provenances with distinct characteristics.

In Ethiopia the species is known under the name Kai Bahr-zaaf to distinguish it from Nech Bahr-zaaf, *Eucalyptus globulus*.

CADU's Forestry Section has made introduction trials with 8 different provenances.

At Asassa at 2,300 metres which is probably the height limit at which *Eucalyptus camaldulensis* will show an acceptable growth rate, one strain has proved absolutely superior. It comes from the Lake Albacutiya area in Victoria. Growth was 50% better than for other provenances and losses caused by drought were much fewer. Height after 32 months, 6 metres. At Dodota vigorous growth, 4 metres after 20 months, and a good stem form has been obtained with a provenance from Mount Newman in Western Australia.

The top scorer down at Dhera, in the Rift Valley, 1,660 m., is the same provenance from Mt. Newman. After 20 months height is 2 metres. It has suffered no losses in the extreme drought in 1973, which has been decimating most other provenances. The only other provenance which appears to be hardy enough for this area comes from Alice Springs in Central Australia. It looks less vigorous, though, than the above-mentioned provenance although rate of growth seems almost the same - 4.5 metres in nearly 5 years.

It cannot be stressed too much that it is of extreme importance that the right provenance of *Eucalyptus camaldulensis* is carefully chosen for each distinct
plantation area. *Eucalyptus camaldulensis* is not only a drought-resistant eucalyptus, it is also one of the more frost-resistant, considerably more hardy than *Eucalyptus globulus*.

The wood is strong and durable. It makes good fence posts and fire-wood. In Israel it is used for sawn timber, but sawing and seasoning is difficult, requiring special care.

35. *E. campanulata*

Unpromising at Asella.

36. *E. cloeziana*

This elsewhere excellent pole-species seems to find the climate too cold at Asella. Would probably be valuable at Jimma and other lower not too dry areas.

37. *E. crebra*

At Asassa the trial was destroyed by browsing animals. At Dodota growth was too slow to make the species interesting.

38. *E. dalrympleana*

was introduced mainly because of its considerable frost-hardiness. It shows a promising fast growth on sufficiently humid sites from Asella upwards. At Asella 13 m. has been reached in just under 5 years. It does not seem to tolerate grass-competition well. There is also some indication that it needs micro-nutrients not required by some of the other eucalypts. This at least could explain big differences in growth between otherwise comparable sites. An investigation has just been started at Woole, adding different micro-nutrients.

The species has everywhere shown a bushy growth during the first year after planting, after which it has developed a fairly good stem form. As an exception the few specimens
growing at Dhigelu show a perfectly straight stem. We do not know whether this variation in stem form is caused by differences in elevation or by possible differences in the micro-nutrient status of the soils.

Planting of *E. dalrympleana* seems indicated mainly where the frost-risk makes it difficult to grow other species, and it will only succeed on fairly good deep soils in areas with moderate to high rainfall. The wood is light and moderately strong and durable.

Although the timber is not easy to season, *E. dalrympleana* can be considered one of the more promising eucalypts for production of saw timber in Chilalo Awraja, which could supply wood for construction, packing cases and furniture.

39. *E. deanei*

This is one of the more promising of the introduced eucalypts. It shows very vigorous growth at Asella and a straight stem form. It seems to require deep fertile soils and a fairly high rainfall. It is moderately frost-resistant, probably comparable to *E. globulus*. It is intolerant of grass-competition, and susceptible to damage by rodents.

It is a very promising species for production of transmission poles. The wood is moderately heavy but it is tough and fairly durable. It can be sawn and seasoned without too much difficulty, producing timber suitable for agricultural implements, boxes and furniture.

40. *E. decaisniana* (sometimes recorded as *E. alba*)

Many introduction trials have been made with different provenances of this species. Unfortunately many of the trials have not been properly recorded and have therefore been of little value.

The species has proved too frost-tender for the Asassa area.
At Dhera browsing cattle destroyed the trial, so that it cannot be ascertained if any of the provenances would have been hardy enough for that area. At Dodota a provenance, probably from Flores in Indonesia, shows a very healthy appearance but its growth rate does not at all match that of *E. camaldalensis*.

At the Project Centre several well-recorded plots established in 1972 at 2,260 metres have shown vigorous initial growth and a good resistance to the 1973 drought although they had been planted partly on unploughed grassland and partly on badly eroded stiff clay soil. It is still too early to draw any definitive conclusions but at the time of writing the most promising provenances are those from Timor especially those from Dili Port, whereas the variety from Flores in Indonesia seems much less vigorous and hardy.

Only further observation and eventually renewed trials with provenances from New Guinea and Northern Territory can tell if *E. decaisniana* will be of value for certain site conditions in Chilalo Awraja.

41. *E. deglupta*

Unfortunately it seems to be too cold in Chilalo Awraja for this valuable timber species. It might be suitable for the low lying humid areas near Mezan Tefferi.

42. *E. delegatensis*

Trials with this interesting timber tree have been delayed by failure to produce seedlings in our nurseries. This failure is still not well understood. Seeds have been cold-stratified, after having been moistened first, sowing, shading and watering has been done according to methods found appropriate for other species; but despite this systematic care, germination and survival of the young seedlings has remained disappointingly low. In 1971 and 1972 we succeeded, however, in producing enough seedlings to establish some trials. There can, however, be no
doubt that sooner or later it will be possible to discover the weak point in our nursery technique and get nursery production of this species organized in a satisfactory way.

This delay of trials is most annoying because *E. delegatensis* is one of the most promising timber trees which could be grown here.

The small plots established in 1971 and 1972 at the Project Centre and at Kersa, 2,700 m., show very vigorous growth despite relatively poor soil and grass-competition. After 20 months, the height in the Aseila plot is 3.0 m.

The plots have not suffered losses due to the drought in early 1973.

*E. delegatensis* is reputedly very frost-hardy, so there is little risk that it would suffer from the cold within Chilalo Awraja, except in particularly exposed depressions. When we consider that *E. delegatensis* in addition is one of the very best producers of saw timber in its home land, it seems that we might have in this species one of the most promising, fast-growing timber trees for the higher parts of Chilalo Awraja. It is therefore strongly advisable that research with *E. delegatensis* is continued, despite the difficulties in developing a satisfactory nursery technique. Trials should be established to compare provenances from Tasmania, Victoria and New South Wales.

It should be mentioned that *E. delegatensis* does not coppice, a fact that makes the species less suitable for planting by farmers but this is of little significance when it is planted for production of saw logs.

The timber is light and easy to work, suitable for construction, joinery and furniture.
43. **E. dunnii**

Trials at Asella and in the Munessa forest, both at 2,270 m., show that this is a frost-resistant species of fairly vigorous growth. It seems however very sensitive to grass-competition. After almost 4 years, dominating trees at Koke measure 8.5 m. Stem form fairly good but it is coarse-branched. Is not expected to produce an interesting quality of timber.

44. **E. exserta**

Has shown too slow growth at Dodota and Dhera.

45. **E. fastigata**

One of the potentially valuable timber-producing eucalypts. Trials have so far been limited to the Project Centre and Bekoji, 2,700 metres, although this now appears to be one of the potential reforestation species that deserve consideration for the Munessa forest. Growth at Asella has been fairly vigorous except on a swampy area, 4.4 m. in 2 years. At Bekoji it appears that the species is very sensitive to grass-competition and lack of P in the soil. On eroded grass-land the seedlings have grown very slowly, but they look healthy and have proved fairly frost-resistant.

In its home land this is considered one of the best timber eucalypts. The wood is light, easy to work, suitable for construction timber, joinery, furniture etc. Tangential and radial shrinkage are almost identical so the timber is little prone to warping.

Research with **E. fastigata** in the Munessa forest is strongly recommended. It is worth noting that seeds require cold-stratification.

46. **E. ficifolia**

A beautiful red-flowered eucalyptus which grows well, as an
amenity tree, at Asella.

47. **E. forrestiana**
A flowering eucalyptus which failed at Asella.

48. **E. Glaucescens**
A flowering eucalyptus which failed at Asella.

49. **E. globulus**
This is the Nech Bahr-zaaf, the common eucalyptus grown all over the Ethiopian high-lands. It has not been planted, in comparative trials, by CAU's Forestry Section. This is an unfortunate omission. In the future *E. globulus* ought to be included in all replicated trials testing the eucalypts that have shown most promise in our initial introduction investigations.

*E. globulus* is a fast growing species with a fairly good stem form. It thrives only above 2,000 metres and is seen as high as 3,300 m. It tolerates grass-competition and exhausted soils surprisingly well, is quite drought-resistant and will also withstand what night-frost it gets exposed to in Chilalo Awraja in a normal year, except in certain depressions and on high-lying plains. The timber is heavy and strong but not very durable. It has been very much underrated as e-saw-timber in Ethiopia due to ignorance of the special precautions which are necessary to get good results from sawing and seasoning of the wood. When properly treated, the timber is excellent for agricultural implements, lorry-bodies, furniture, especially school furniture, and parquet flooring.

When pressure impregnated it is also suitable for heavy construction, such as bridges. *E. globulus* is already being used for the production of chip-board in Addis Ababa. It also serves as transmission poles in Ethiopia, for lack of anything better. The often slightly twisted and not
quite straight stem makes it far from ideal for this purpose.

Fence posts of Nech Bahr-zaaf do not last long unless impregnated.

50. *E. grandis*

Shows excellent growth and a fine stem form at Gambo, 2,160 metres. At 5 years, 17 metres height and 15 cms. diameter. At 2,300 metres at Asella, the climate seems too cold for this species which probably reaches its best development below 2,200 m. It would most likely grow very well at Jimma. It is a promising species for transmission poles. The timber is similar to that of *E. deanei* but a little lighter and easier to work. It needs careful sawing and seasoning. Possible uses are agricultural implements, furniture and boxes.

51. *E. gunnii*

This tree, reputed for its resistance to frost, has only been introduced in 1972. Initial results are encouraging at Meraru, 2,880 metres, and especially so at Kersa, 2,525 m., where growth has been vigorous and it has withstood the early 1973 drought very well. In Australia *E. gunnii* is considered a good timber tree. There its sweet sap is said to make good cider.

52. *E. johnstoni*

Was also first introduced in 1972. It has shown good initial vigour and hardiness against drought at Degaga, 2,040 m., Asella 2,260 m., Kersa 2,525 m. and Meraru 2,800 m. Like *E. gunnii*, it is considered a very frost-resistant species. In Australia it grows to a big tree with a clean straight pole. The timber is very hard and durable.

53. *E. laevoepinea*

Unpromising at Asella.
54. **E. largiflorens**

   It has been unpromising in 5 trial plots located at different elevations.

55. **E. macrocarpa**

   A small eucalyptus known for its magnificent flowers.
   It will grow at Asella, but has not been flowering yet.

56. **E. maideni**

   This species closely resembles **E. globulus**.

   At the Project Centre it has shown remarkable growth in a trial which dates from 1971. Dominating trees had reached a height of 7 metres, 24 months after planting.

   Although it is premature to arrive at definite conclusions about the growth rate and the adaptability of this species, we believe that we have here found a eucalyptus which grows faster than Bahr-zaaf, is more frost-hardy and also normally develops a much straighter stem, if one can judge from observations in other East African countries. Its only disadvantage compared with **Eucalyptus globulus** is that it is likely to be a little less drought-resistant.

   **E. maideni** is an excellent species for transmission poles. In all other respects the wood has the same utilization as that of **E. globulus**.

   **E. maideni** belongs to the group of eucalypts which are good honey producers. Introduction trials ought to be made with this interesting species on a variety of sites from 2,000 metres up to 3,000 m. and more.

57. **E. microcorys**

   Only one plot has been established at the Project Centre, on badly eroded grassland which was not ploughed before planting. The stand looks healthy but growth has been slow,
5.5 metres in a little less than 5 years. Despite the adverse site conditions one can probably conclude that this species is too slow-growing here to be of value. Otherwise it is an interesting species producing excellent durable fence posts, and sawable timber.

58. E. nesophila
Has been tried at Dhera and Asassa but failed.

59. E. nitens
This appears to be one of the most promising of the introductions. At the Project Centre, plots from 1969 show dominating heights of 13.5 m. at the age of 4 years. Plantations established on unploughed grassland in 1972 have shown vigorous initial growth and good survival in the early 1973 drought.

E. nitens grows very high up in the mountains of Southern Australia and it can be assumed to be fairly frost resistant.

The stem form is excellent and it is also a good self-pruner, having only thin, horizontally-growing branches.

The wood is light, moderately strong but not durable.

The colour is almost white. It is fairly easy to saw and season. Possible uses are construction timber, joinery, furniture and boxes.

E. nitens does not make good fence posts and, because of its poor durability, it is probably not well suited for the building of local houses. As sawn timber the durability is less important and impregnation is always a possibility.

More introduction trials are strongly recommended with this promising timber species, especially in the Munessa forest.
60. *E. obliqua*

This is one of the important timber trees of Australia. In our trials it has only shown a moderate growth rate. The best plot at Degaga, 2,040 metres, has dominating heights of 5.5 metres at the age of almost 3 years. It has shown moderate frost-resistance at Asella and Bekoji. The species is probably too slow-growing to deserve establishment of further trial plots. It will be sufficient to continue observation of the Degaga plot and investigate which quality of timber it will produce.

61. *E. oreades*

This potentially interesting timber tree is being introduced in 1973. This is one of the few species which do not coppice. The seeds need cold-stratification. Worth trying both at medium and high elevations, as it is probably frost-hardy, since it grows at high altitudes in South Eastern Australia.

62. *E. paniculata*

This species produces a heavy, strong durable timber. It makes excellent fence posts. It unfortunately grew too slowly at Asella to be worth planting and proved not hardy enough to survive the hardships of Asassa (frost) and Dhera (drought).

63. *E. pillularis*

Has reached 6 metres in a little less than 3 years at Koke in the Munessa forest, 2,270 m. Too slow growing and not frost-resistant enough to be worth planting within the Project area, despite the quality of its timber.
64. **E. punctata**

This potential producer of strong, heavy, durable timber and excellent fence posts has not proved hardy enough for Asassa and Dhera where it was tried.

65. **E. regnans**

One of the best timber trees of Australia and the tallest known broadleaved tree in the world. Heights of up to 114 metres have been recorded, but mostly the trees do not exceed 90 metres. **E. regnans** has shown great promise in our introduction trials. At the Project Centre 2,300 m., one almost 6 years old plot has dominating trees with heights of 19.5 m. and an average of 22 cms. diameter.

At Gambo a 5 year-old particularly fine specimen measures 21 metres in height and 25 cms. in diameter. In the arboretum trial at Koke almost 4-year-old trees are 14.5 metres tall with 10 cms. b.h.d. (breast-height diameter). **E. regnans** has proved only moderately frost-resistant. On the other hand it has shown great tolerance to grass-competition and to soils poor in Phosphorus. On a badly leached grass covered slope at Bekoji, 2,700 m., less than 3-year-old trees are 5 - 6 metres tall.

The species responds well, however, to clean-weeding and use of fertilizer. A plot at Asella, established on ploughed land, and boosted by a dose of 50 grams NPK fertilizer to each seedling at the time of planting, and furthermore kept meticulously clean-weed during the first 6 months, 12 months after planting had reached a height of 3.5 m. for the dominating trees and was suffering no losses during the early 1973 drought.

There can, therefore, be little doubt that **E. regnans** is well adapted to the prevailing conditions of soil and climate in Chilalo Awraja at altitudes between 2,000 and 2,700 m. provided that the site is not seriously frost-exposed.
E. regnans produces in its home-land a light, reasonably strong and tough timber. Sawing and seasoning require special precautions, as in the case of most of the timber producing eucalypts, but by using the appropriate methods it is possible to obtain a first class timber. Ease of working of the seasoned timber makes it very popular for joinery, furniture and flooring. Furthermore, it is used for all parts of house construction, for boxes and crates, for plywood and matches.

The Australian wood comes almost entirely from old trees in the natural forests of E. regnans. Plantation-grown trees in Ethiopia exploited at ages varying from 9 to 20 years cannot be expected to produce the same timber quality. We can only hope that the timber will be somewhat of the same type and of good enough quality to be used as construction timber, replacing the dwindling supply of Zigba (Podocarpus) wood from the natural forests.

A first small investigation seems to indicate that more than that can be achieved. Small boards obtained from a 4-year-old E. regnans grown at Asella were of good quality and could be made into a small table. There is every reason to believe that older trees could provide a better quality wood than this extremely young timber tree.

Eucalyptus regnans logs cut in a small trial plot on the Kenya highland have proved to make excellent ply-wood.

Collaboration has recently been established between CADU and the wood technologist in Nairobi to investigate the quality of sawn timber made from Kenya-grown E. regnans.

The numerous plots established by CADU's Forestry Section have all been established with non-selected seeds harvested in Tasmania.
The growth rate has been excellent, but lack of frost-resistance has been a problem. Furthermore, the stem form has not been ideal. Some stems have been perfectly straight but a far from insignificant proportion have been marred by bends on the stem. Branching has in general been light, often with thin horizontally oriented branches. The species appears to be a good self-pruner.

Now that *E. regnans* has emerged as a potentially very important tree for reafforestation in Ethiopia, the question arises of whether we have imported the best possible strain, and whether it would be possible to get hold of significantly better types.

To elucidate this question, we have asked the advice of the Australian Forest Research Institute in Canberra. According to their forest geneticist, Dr. K.G. Eldridge, it seems that less wide-spread geographic variations can be expected in *E. regnans* than in several other eucalypts. Studies begun in 1958 show, nevertheless, significant variation between stands from different localities in growth rate, stem straightness, branching and frost-resistance. It is, therefore, strongly indicated that research should be started to select the best provenance, or provenances, for timber production under Chilalo Awraja conditions. It appears that the best growth rates, straightness of stem and most satisfactory type of branching in Australia, have been obtained with provenances from sheltered valleys in Victoria. Considerable frost-resistance has been observed on offspring from trees from high-lying inland areas in the same state. It seems, therefore, likely that we would be able to find somewhere in Victoria, the strain best suited for Ethiopia, a provenance which ideally would combine good growth, straight stem and frostresistance.

Seeds have been supplied in 1972 by the Forest Research Institute of 9 selected provenances from both Tasmania and Victoria, to enable us to start the necessary comparative trials. At the present moment seedlings of these varieties are under preparation in Dagaga nursery, so that
replicated trial plots can be established in the Munessa forest during the 1973 rains. It is very important that this research is followed up systematically, if necessary by renewed imports of seeds if some of the provenances should fail in the nursery. Future observations should not only cover growth rate, stem and crown form and frost-resistance, but it is essential that comparative studies should also be made of the timber quality obtained from different provenances.

*E. regnans* does not coppice after exploitation. This is of no significance when the tree is grown for production of logs but it makes the species unsuitable for small farm plots. The seeds require cold-stratification to give good germination. More extraordinarily the young seedlings must, under Ethiopian conditions, be inoculated with mycorrhiza taken from the roots of some healthy *E. regnans* trees. Otherwise they will remain yellowish and eventually die.

One more observation should be made about this important tree. It seems not to shade the ground nearly as heavily as most of the other eucalypts which have shown good growth here, so that grass and other undergrowth does not get totally suppressed as in the case of, for example, Bahr-Zaaf and *E. grandis*. There is, therefore, little reason to fear sheet-crosion under stands of *E. regnans*.

66. *E. resinifera*

This is one of the good timber producers and has shown quite promising growth here. At the plot at Dagaga, 2,040 m., the dominating trees, have reached a height of 6 m. in less than 3 years. The stem form is excellent.

Plantations established at Asella in 1972 on unploughed grassland are withstanding the drought in early 1973 quite well. However, it is probably not a very frost-resistant species and to get a good growth rate, it is rather demanding on soil and rainfall.
The good quality of its timber might still make it economically interesting to plant it on suitable localities. The wood combines heaviness, strength and durability with ease of working. This makes it attractive for many purposes where strong, durable wood is needed. It also makes good fence posts and transmission poles.

67. *E. robusta*

This species has only been tried at Koke, at 2,270 m. It has proved sufficiently frost hardy for the locality and appears healthy, but growth has been too slow, 4.5 metres in almost 3 years. Since it does not produce any valuable wood quality, *E. robusta* can be considered of no interest for this area.

68. *E. saligna*

This is the most widely planted eucalyptus in South Africa, Rhodesia, Zambia, Malawi, Tanzania, Kenya and Uganda. In South Africa and Malawi it is used for sawn timber on a considerable scale. In all these countries, it is the principal transmission pole species. In Uganda it has furthermore been considered for production of charcoal on an industrial scale.

Since this species is so important in other African countries, we thought at the beginning of our investigation that it might also be the ideal eucalyptus for the Ethiopian highlands. Trials with 7 different provenances were, therefore, initiated at the Project Centre in 1967. The introduction plots were planted at an elevation of 2,300 metres. All plots have shown excellent growth and a straight stem form. There has been a considerable variation in the type of branching, some being much more coarse-branched than others. Of the 7 provenances originating from localities in Queensland and New South Wales, one has gradually emerged as clearly superior, having a
considerably faster growth rate than the others combined with a good crown structure. It comes from Wang Wauk State forest, compartment 28, north of Buladelah in New South Wales. Height after almost 5 years is 11.5 m. and b.h.d. 14 cms.

The trials were established at the top of a slope with very little danger of frost. Other introductions have, unfortunately shown that *E. saligna* is a little too frost tender to be planted safely in many areas of Chilalo Awraja.

Another disadvantage is that it is extremely sensitive to grass-competition and that to grow satisfactorily, it demands a deep fairly rich soil without serious phosphorus deficiency.

It still seems one of the most promising species for areas between 2,100 m. and 2,300 metres with not too low rainfall and relatively deep, fertile soils. It can also be grown higher up, on slopes, where the cold air runs off so that there is no danger of frost-damage. In higher elevation it would, however, be more advisable to plant the closely related but more frost-hardy *E. deanei*.

The wood of *E. saligna* is moderately heavy, hard, strong and fairly durable. It can be sawn and seasoned without too much difficulty. The timber would be excellent for agricultural implements, furniture, general construction and boxes. It is excellent for transmission poles and probably more durable as an untreated fence post than *E. globulus*, although impregnation would be advisable here also. For building of local chica houses, it is probably better than *E. globulus* because the stems do not twist as much when they dry.

The young seedlings are susceptible to damage by browsing cattle and this makes it difficult to raise this species without proper fencing.
E. saligna x E. robusta, "Shoa-saligna"

We got seeds of this hybrid from Shoa and Wonji sugar estates. The identification as a hybrid of E. saligna with E. robusta should only be considered as tentative.

Growth at the Project Center has been vigorous. A plot from 1967 measures after almost 6 years 11.9 m. in height and 15.3 cms. in b.h.d.

Typical of "Shoa saligna", there is considerable variation between the individual trees.

Vigour, straightness, branching and type of bark, all vary as can be expected in a hybrid. There is probably scope for considerable improvement of "Shoa saligna" by selection and breeding.

Stem form is generally good and branching not coarser than that of E. saligna. The species seems to have a tendency to a flowing of gum from cracks in the stem. This would probably make it unsuitable for the production of sawn timber.

As frost and drought hardiness go, it seems comparable to E. saligna. Like this species, it is very sensitive to grass-competition and phosphorous deficiency.

We have only established neighbouring plots of E. saligna and Shoa saligna at Gonde at 2,210 m. elevation. The E. saligna originated from Windsor in New South Wales. After almost 3 years the true E. saligna measured 5.3 metres in height and "Shoa saligna" 5.0 metres. This shows only a slight superiority of the pure species.

"Shoa saligna" flowers and carries fertile seeds after only 3 years; much earlier than true E. saligna. This would be an advantage in extension work. The tree could rapidly become widespread by farmers collecting seeds locally and raising their own seedlings.
If the Eucalyptus weevil should invade the country (see page 89) and make rapid diversification away from *E. globulus* necessary, it would be very useful to dispose of a resistant variety which could become rapidly disseminated.

**E. saligna x E. grandis**

This is a hybrid which has occurred naturally in South Africa. From there it has been introduced to Malawi and other East African countries. The Forestry Research Station in Malawi has supplied us with seeds collected in a stand of superb quality belonging to the Imperial Tobacco Co. at Limbe.

Plantations of this origin have in 1972 been established at the Project Centre and at Dagaga. The plantation at Dagaga in particular is showing vigorous initial growth.

This hybrid is known for its rapid growth, its straight stem and fine crown-structure. It is used for the production of sawn timber and plywood in Malawi. If it will adapt as well as *E. saligna* and be as hardy at medium elevation localities here in Chilalo Awraja cannot be decided yet.

**E. tereticornis**

This reputedly very hardy species has been tried at Dhera and Dodota.

At Dhera, it has proved less drought-resistant than the best provenances of *E. camaldulensis*. At Dodota at 2,080 metres, it grows quite well, 2½ metres in 20 months, but it falls far behind a provenance of *E. camaldulensis* from Western Australia, which reached 4 metres within the same time. As this last species also shows a much better stem form, it is in all respects very superior to *E. tereticornis* which, therefore, cannot be recommended for further planting.
72. *E. viminalis*

*E. viminalis* combines fast growth under favourable conditions, with relatively good resistance to drought and frost.

Stem form has varied enormously for the same provenance when planted at the Project Center and at Dhigelu. In this last place stems have become perfectly straight whereas the stem form is very poor at the Project Centre. Exactly the same variations have been observed for *E. dalrympleana*.

Dhigelu lies a couple of hundred metres higher than the Project Centre, so we have wondered if the difference in stem form could be caused by the difference in elevation. *E. viminalis* grown at Bekoji at 2,700 metres does, however, show the same poor stem form as those at Asella.

It is, therefore more probable that the variation is caused by differences in the soil conditions. It would make an interesting and useful study to elucidate whether different content of macro-nutrients or more likely micro-nutrients or differences in soil structure have a bearing on this problem.

*E. viminalis* has proved strikingly well-adapted to a variety of site conditions. At the Project Centre, it has grown remarkably fast. After almost 6 years height is 20.0 m. and b.h.d. 22 cms.

On badly gully-eroded land at Wolkesa below Asella growth has been almost as good, 7.3 m. in less than 3 years despite the poor soil conditions. At 2,700 metres at Bekoji, on badly leached grassland it has reached 4.5 metres in the same time. Even at Meraru at 2,880 m., it shows promise. *E. viminalis* has, however, been most interesting for reafforestation at Asassa, where shallow soils, low rainfall and a serious frost problem made it very difficult to find suitable plantation trees. It has
proved frost-hardy enough for Asassa conditions, except in exposed depressions, and it seems to thrive very well on reasonably deep soil, growing considerably faster than *E. camaldulensis*. At Burbura, near Asassa, *E. viminalis* reached 2.5 metres in 20 months compared with 2.0 metres for *E. camaldulensis*. On shallow soils this last species is, however, much safer.

Comparison needs however to be made at Asassa between *E. viminalis* and the most promising provenance of *E. camaldulensis*, that from Lake Albacutia. If this last provenance should prove nearly as fast growing as *E. viminalis*, it would be less risky to plant only *E. camaldulensis* and to avoid the other species which here seems to be at the very limit of its climatic range. It should also be noted here that the heavier and more durable wood of *E. camaldulensis* is by far the best both for firewood and fence posts. There remains, however, the need for some research into finding the most suitable drought and frost-resistant provenance of *E. viminalis* for the Asassa area.

In fact a widespread geographic variation is known to exist in this species, which in its homeland grows from sea level up to high altitudes and is found both near the coast in moist valleys, and in drier inland areas. It is, therefore, quite probable that better adapted provenances could be found for the special conditions prevailing between Asassa and Meraro than those we have introduced, admittedly at random, without looking into the provenance question. It is recommended that this omission should be rectified as soon as possible by some replicated trials at Asassa and higher up with provenances selected for their drought and frost resistance. Especially, higher up towards Sigallo, it would be useful to find such strains since *E. camaldulensis* must be near its upper limit already at Asassa. The wood of *E. viminalis* is neither very strong nor very durable, nor is it suitable for sawing. Its utilization would be limited to firewood, fencing and local house-building. It is, therefore, a species which
should only be planted where its very rapid growth and high productivity could compensate for its defects or where nothing better will succeed.

Coniferous Trees

73. Abies religiosa
Failed

74. Abies guatemalensis
Failed

75. Araucaryia cunninghamii
Seedlings were raised successfully in Gambo nursery but were later destroyed by frost.

76. Araucaryia klinkii
Seedlings were raised successfully in Gambo nursery but were later destroyed by frost.

77. Cryptomeria japonica
Failed

78. Cupressus arizonica
Plots have been established at Dhera in the Rift Valley.
Some trees are surviving after 5 years and look healthy. Possible as an amenity tree but too slow for any production purpose.

79. Cupressus benthamii
Grows successfully at Koke in Munessa forest at 2,770 metres; 4.5 metres in less than 4 years on grassland. We cannot tell yet how its growth rate compares with that of C. lusistanica. It is reported to be more drought resistant than this last species and could, therefore, be better suited for reafforestation of some of the drier sites. Excellent soft wood timber like that of the following species.
80. **Cupressus lusitanica**

Vigorous plantations of this species have been established at the Project Centre and on a large scale in the Munessa forest. On grassland at Koke one of the oldest plots has reached 5.0 m. in just under 4 years. At the Project Centre much better growth has been observed in a plantation which was established on very fertile soil rich in Phosphorus. After nearly 5 years, the height was 8.0 m. and b.h.d., 11 cms. This is in fact a species which thrives badly on grassland and also suffers from any deficiency of N. and P. When such a deficiency exists the plants respond vigorously to the addition of fertilizer.

It seems that it is not the grass as such which is harmful but the compact nature of clay soils trampled by cattle. **Cupressus lusitanica** needs a well drained and well aerated soil. Younger plantations at Munessa established on cleared forest land are, therefore, much more vigorous than the first trial plots at Koke.

The first plantations dating from 1967 and 1968 at Asella and at Gambo were established with commercial seeds bought from Timmers and Leyer in Holland. Later, we switched to supplies from the Forest Department in Kenya and since 1970, we have only imported super select seeds from that source.

In 1971, however, due to failures at the Dagaga nursery, we were forced to buy a considerable amount of seedlings from the Forest Department of the Ministry of Agriculture. The plantations established that year are, therefore, mixed.

Our oldest plantations of "commercial origin" are coarse-branched and should not serve as a future sources of seeds.

It is strongly advised that the import of 'super select' seeds from Kenya should be continued, until sufficient seeds can be collected in the 1972 and 1973 plantations at Munessa. One ought not to give into the temptation to collect cheap seeds in the older plantation raised with
genetically inferior material. *Cupressus lusitanica* is rather frost-tender and should not be planted on frost-exposed sites. In Kenya, it is exposed to a canker disease, *Monochaetia unicornis*, and also to borer attacks, but not on a scale which limits its cultivation. None of these diseases have so far been observed in our plantations.

Productivity in the Munessa forest can be expected to be of the order of 20 m$^3$/ha. per annum of stemwood. The timber is a good quality soft wood, slightly superior in most respects to Zigba (*Podocarpus*). It is suitable for construction, box making, cheap furniture etc. It is difficult to impregnate.

81. *Cupressus macrocarpa*

A small plot has been established at the Project Centre. It is not recommended for reafforestation being very susceptible to canker.

82. *Cupressus torulosa*

Has proved too slow growing in the Munessa forest. Height only 1.4 m. after nearly 4 years. Unless it picks up speed later it can be of no practical interest.

83. *Picea orientalis*

Failed at Gambo

84. *Pinus brutia*

Was introduced both at Dhera and Asassa. It seemed hardy enough at both places but too slow growing to be of practical use.

85. *Pinus canariensis*

Was introduced at Dhera. Some seedlings survived for several years but growth was very slow.
86. **Pinus caribaea**

Three provenances of this important timber species have been tried at Koke in the Munessa forest. Of these the most promising comes from Cuba (reg. 59 (7291) oxen). It has a straight stem and a healthy appearance but measured only 3.5 metres after nearly 4 years. It might be an interesting provenance for slightly warmer localities in Ethiopia.

The provenance *Pinus caribaea*, var. hondurensis, from the British Honduras, (reg. 57 (7282) Oxon 3) shows a more vigorous growth, 4.5 metres in almost 4 years, but unfortunately has too poor a stem form to be worth planting. The third *P. caribaea*, also var. hondurensis, seeds originating from Guatemala (reg. 67 (7281) Oxon), shows poor shape and poor growth; height was not recorded. None of the tried provenances have shown a growth rate which would justify their planting on a commercial scale in the Munessa forest.

87. **Pinus elliottii**

There is some uncertainty about the recording of the trials of this species at Koke. The best provenance, showing fine straight stems and a vigorous growth, 5.0 metres in just under 4 years, probably originates from Queensland to where it has been introduced from Baker and Columbia in Northern Florida. A plot of this origin definitely exists at the Project Centre established on a swampy grass covered area where growth has been very slow. It could, however, become a source for seed collection. The plot at koke has a reg. No. 1830 but the reference to this number has been lost.

Another plot of *Pinus elliottii* at Koke cannot be properly identified, but it is less important as it is clearly inferior both in respect to growth and to stem form.

88. **Pinus kesiya**

Seeds of many provenances of this species were obtained, originating from the Philippines, Vietnam, Thailand, Zambia and commercial sources. The most vigorous growth has
probably been obtained with seeds bought from Timmers and Leyer. A plot at Gambo, 2,160 metres had reached 7.0 metres and 10 cms. b.h.d., for the dominating trees, after nearly 5 years. Similar good growth with the same strain has been obtained at the Project Centre. Provenances from the Philippines and Vietnam, planted at Koke, have also been quite vigorous, 4-5 metres in 4 years.

All the tried provenances of *P. kesiya* have unfortunately been characterized by a large proportion of twisted stems. In this respect the provenance from Timmers and Leyer was probably the least defective. It does not seem to be a genetically induced poor stem form, but some physiological form induced by an unsuitable climate. Some stems are crawling along the ground some are turned like a bugle. The defect is so widespread that it excludes the use of *P. kesiya* in the forest areas of Chilalo Awraja.

89 *Pinus mercusii*

Seeds were obtained originating from Cambodia, the Philippines and Java. The species was found completely unsuitable for conditions at Koke. A few remaining plants are 20 cms. tall after 4 years.

90. *Pinus massoniana*

A provenance of this species has been supplied from China. A plot established at Dagaga in 1972 looked healthy in March 1973 but initial growth had been slow.

91. *Pinus michoacana*

This species grows very slowly at the Project Centre. One metre only after 3 years.

At Asassa, initial losses of plants were heavy, but a few remaining trees seem to resist drought and frost.
92. **Pinus Montezumae**

Shows healthy but very slow initial growth at Gambo, 3 metres height after nearly 5 years, and likewise at the Project Centre. It has a 'grass-stage' after which rate of growth increases, but it seems doubtful that it will grow fast enough later to become an economically interesting species. At Asella, it has been damaged to some extent by rodents.

93. **Pinus oocarpa**

Trial plots were first established from commercial seeds at the Project Centre and at Gambo in 1968. In both cases growth has been unsatisfactory and the stem form very poor.

Much better results have been obtained with the subspecies **Pinus oocarpa** var. ochoteranai. Trees on an almost 4 year old plot at Koke measure 5 metres, show a quite good stem form and appear healthy.

Almost all areas in Chilalo Awraja can nevertheless be considered as too highlying for these species. A plot established in 1972 considerablly lower down than Koke at Dagaga, 2,040 m., shows promising initial growth.

94. **Pinus patula**

This is one of the three most promising coniferous trees we have introduced.

The plantations dating from 1967 and 1968, at the Project Centre and Gambo, were established with commercial seeds. Later we switched to imported "super select" seeds from Kenya. Growth has been excellent both at Asella, 2,300 - 2,400 metres, and in the Munessa forest. At Gambo, 2,160 metres, dominating heights have reached about 8.0 m., 5 years after planting and the average diameter 7.5 cms. At high up as at Gobe, 2,620 metres, **P. patula** has shown healthy growth and perfect frost-resistance.
In the exceptional drought in March - April, 1973 it has however, appeared that *Pinus patula* is less drought-resistant than *Pinus radiata* and *Cupressus lusitanica* and near the limit for its drought resistance both in the Munessa forest and at the Project Centre.

On deep forest soils with a good structure there has been no problem but on grass-covered areas with a trampled compact clay soil, and where only shallow soil covers the rocks, losses due to drought have been severe.

If, however, one keeps in mind that planting should be restricted to deep, well structured soils in areas with a good rainfall, *Pinus patula* can be recommended as one of the most promising timber trees for Chilalo Awraja.

Judging from plantations grown under comparable conditions in East Africa, an annual production of 25m³/ha. of stemwood can be expected.

The timber is not of a quality as high as that of *Cupressus lusitanica*. It is a little soft and woolly and exposed to blue stain. For general construction and boxes it is however perfectly suitable. The higher annual yield per ha. will probably compensate for its inferiority compared with the timber of *Cupressus lusitanica*.

*Pinus patula* is not nearly as demanding on the fertility of the soil as *Cupressus lusitanica* and much more frost resistant. These differences should be kept in mind where plantation areas of these two important reafforestation species are being planned. The pine should be mainly confined to frost-exposed sites and areas of degraded forest while the cypress, producing the best quality of wood, should be given most of the fertile less high-lying areas.

It is strongly recommended that import of super select seeds should be continued until it becomes possible to obtain a local supply of the same origin.
95. *Pinus pinaster*

Found unpromising in Munessa forest

96. *Pinus pseudostrobus*

This species has shown fairly fast growth for the dominating trees both at the Project Centre and at Gambo. There have, however, been big differences between the fastest and the slowest trees in the same plantation. At Gambo, the height after 5 years varied from 5.0 - 7.5 metres compared to 8.0 metres for *Pinus patula*. At Gobe at 2,620 metres the species proved unsuitable. Branch structure is extremely coarse, so early pruning is essential if very bad knots in the timber are to be avoided.

If properly pruned, *Pinus pseudostrobus* produces timber of an excellent quality, and for this reason it might still prove worthwhile to plant the species on a small scale, in suitable areas, despite its rather modest rate of growth.

Further observation of the already established small plantations should show if the species can be used for production purposes.

*Pinus pseudostrobus* has suffered from some die-back of the terminal buds in our plantations. The disease, which has not had very serious effects, has not been identified.

The symptoms are, however, not unlike those caused by Boron deficiency in *pines*. Investigations should be made to see if addition of Boron would improve the growth of the *P. pseudostrobus* plantations and make the die-back symptoms disappear.

97. *Pinus radiata*

This excellent timber tree grows extremely well within most of the Project area. Growth is very fast at the Project Centre, and in the Munessa forest, much faster than that of any other coniferous tree. *Pinus radiata* even appears hardy enough to survive some of the more extreme conditions within the Project area.
A three-year-old plot is surviving not too badly at Asassa on shallow soil, in a dry, wind-swept climate. Under even more extreme conditions a few 4-year-old trees are still alive at Dhera, in the Rift Valley at 1,660 metres, under conditions of drought which kill all but the most hardy provenances of *E. camaldulensis*. *Pinus radiata* thrives fairly well at high elevation at Kachama, Dhigelu and Gobe, 2,620 metres, and seems perfectly tolerant of the severe night frost which occurs in those areas.

The oldest plantation at the Project Centre has, at an age of nearly 6 years, reached the surprising height of 11.5 m and an average diameter of 11.5 cms.

In the drought of early 1973 *Pinus radiata* has proved to be somewhat hardier than *Cupressus lusitanica* and much more drought-resistant than *Pinus patula*. When in addition to its extreme adaptability, very fast growth and hardiness, we consider that *Pinus radiata* produces excellent timber, notably better than that of *Pinus patula*, despite a more uneven stem form, one would think that this is the ideal tree for big scale timber production. One single defect tends, however, to overshadow all its virtues. This has at least been the case in East Africa. It is there very susceptible to attack by a fungus disease, *Dothistroma pini*, which destroys the needles, and on this account its cultivation has become hazardous and often impossible. Since the climatic conditions here are very similar to those prevailing in the areas of East Africa where *Pinus radiata* has been badly attacked, there is a big risk that the disease might turn up here at any time. So long as it remains an uncertainty whether *Dothistroma pini* constitutes a serious threat or not to *Pinus radiata* plantations in Chilalo Awraja, its cultivation on a large scale cannot be recommended without serious misgivings. One peculiarity of the disease is that it only attacks trees under the age of 9 years and that trees attacked by *Dothistroma* that manage to survive until the age of 9 years will normally recover and grow healthily until exploitable maturity at the age of 30-35 years.
It is thus only during less than \( \frac{1}{3} \) of the life-span of a plantation that it is exposed to attack. Furthermore, the severity of the attack varies. Some plantations are ruined, others stagnate for a number of years but then start growing normally. Because of these limitations of the risk some foresters think that it would not be an unreasonable gamble to plant *Pinus radiata* on a considerable scale in Chilalo Awraja, so long as no attack of *Dothistroma* has been detected here and so long as the possibility remains that the disease never will become so serious here as in East Africa. The gamble would be justified by the superior yield which can be expected from any *Pinus radiata* plantation, which manages to reach the age of 9 years, undamaged by the disease.

The annual yield per ha. of a *Pinus radiata* plantation is expected to be of the order of 30-35 m\(^3\) compared to 25 m\(^3\) for *Pinus patula* and 20 m\(^3\) for *Cupressus lusitanica*.

It is always risky to plant exotic trees which have not been tried over a long period of years. Some unforeseen disease might suddenly raise its ugly head. In Ethiopia much less risk of this nature would be involved in planting Zigba (*Podocarpus*) and Tid (*Juniper*). Unfortunately both these safe trees are so slow growing that one would get a very low rate of interest on money invested in plantations of these trees. The superiority of the fast growing exotic soft wood trees is so obvious in respect of both productivity per ha. and length of rotation that they will have to constitute an important part of any economically planned reafforestation scheme.

Since some risk, however, is involved in planting any of them, common sense indicates that one should not put all ones eggs in one basket, i.e., in forestry terms, one should avoid mono-culture. Instead one should spread the investment risk over three or four of the most promising species.
Since in the case of *Pinus radiata*, the nature of the risk is well known we would advise that at the most no more than 5 - 10% of any reafforestation area is planted with this otherwise extremely promising species.

Planting on a limited scale should under all circumstances be continued, to make it possible to observe whether *Dothistroma pini* is a real threat or not and eventually to provide the necessary material for the breeding of resistant strains of *Pinus radiata*. Research in East Africa seems in fact to indicate that it is possible to breed resistant types. Resistance under one type of ecological condition appears, however, not to guarantee resistance in areas with a different climate, so research to develop locally resistant strains is strongly recommended.

The variation of stem form in *Pinus radiata* plantations has not here been mentioned. The species does not in fact develop nearly as nice a stem form as good quality *Pinus Patula*. Branching is always coarse, so early pruning is needed if bad knots in the timber are to be avoided. That is, however, if there is any branching; some trees become 'fox tails', one long thin stem covered by a dense fur of bushy needles. If a tree remains a 'fox tail' too long it will bend or break and become useless. Some start putting out branches, however, before it is too late and change into normal trees.

Stems often have bends in them and less than half of them are perfectly straight. The tremendous rate of growth and the otherwise good quality of the timber, however, more than covers up for these imperfections.

Due to the variations in stem form between individual trees in a plantation and the straggling somewhat unstable growth of the young trees, thinning operations need to be done with great care. Otherwise the plantations get exposed to wind-damage.
98. **Pinus roxburghii**
   This hardy pine from the foot-hills of the Himalayas was found unsuitable at Dhera. A few specimens can be seen along the roads at the Project Centre. They are healthy but slow growing.

99. **Pinus taeda**
   Failure at Koke

100. **Pinus taiwanensis**
   One provenance from central Taiwan, (reg. nr. 67 (5291) Oxon) is being tried at Koke. It seems unpromising, has a weak appearance and is only 2$\frac{1}{2}$ metres in height after nearly 4 years.

101. **Pseudotsuga flahaultii**
   Failure

102. **Pseudotsuga macrolepis**
   Failure

4.3 **Summary of Introduction of Trees**
   From the above description of our introduction trials with over one hundred tree species it will be clear that only a much smaller number have proved so valuable in one way or another that they now can be recommended for reafforestation.

List below are the most promising according to present observation of the introduction plots.

1. **Eucalyptus biocostata**
2. **E. camaldulensis**, provenance from Lake Albacutya
3. **E.** " " " Alice Springs
4. **E.** " " " Mount Newman
5. **E. dalrympleana**
6. **E. deanei**

S. In the above list of introductions, **Callitris hugeli** was omitted. It proved to be hardy but too slow growing at Dhera.
7. *E. delegatensis*
8. *E. grandis*
9. *E. maidenii*
10. *E. nitens*
11. *E. regnans*
12. *E. saligna* from Wau Wake State forest in New-South Wales
13. *Shoa saligna*
14. *E. saligna* x *E. grandis*, provenance from Limbe - Malawi
15. *E. viminalis*

Other eucalypts showing considerable promise:—
16. *E. botryoides*
17. *E. fastigata*
18. *E. gunnii*
19. *E. johnstonii*

The list of coniferous trees showing promise is dominated by the same three species which have dominated reafforestation in Kenya.

20. *Cupressus lusitanica*
21. *Pinus patula*
22. *Pinus radiata* (with the doubts expressed in the preceding section).

Also worth further consideration are mainly:—
23. *Cupressus benthami*
24. *Pinus elliottii*, the provenance from Queensland S. 1830
25. *Pinus pseudostrobus*

It is suggested that systematic replicated trials are established with these 25 species and provenances, on various suitable localities so that their relative value can be ascertained in a more precise way than has been the case in the preliminary introduction trials. In this investigation *Eucalyptus globulus* ought certainly to be included.
4.4 Tentative outline of suitable localities and growth requirements of some of the more important species:

1. *E. bicostate*
   Medium to high rainfall areas, not demanding on soil, 2,300 - 2,800 m.

2. *Eucalyptus camaldulensis*
   From Alice Springs and Mount Newman, dry areas, 1,600-2,000 m.

3. *Eucalyptus camaldulensis*
   From Lake Albacutiya dry, shallow soils, 2,000-2,300 metres.

4. *E. dalrympleana*
   Medium to high rainfall areas, demanding on soil and probably on micro-nutrients (Boron?), 2,400 - 3,000 metres.

5. *E. deanei*
   Fertile soil, medium to high rainfall, no very severe frost, 2,400 - 2,500 metres.

6. *E. delegatensis*
   Good rainfall, deep soil, 2,400 - 2,900 metres.

7. *E. grandis*
   Fertile soil, medium to high rainfall, no severe frost, 2,000 - 2,200 metres.

8. *E. gunnii*
   Good rainfall, 2,500 - 3,000 metres.

9. *E. johnstoni*
   Requirements not known, probably quite hardy, medium to heavy rainfall, 2,300 - 3,000 metres.

10. *E. maideni*
    Medium to high rainfall, not demanding on soil, 2,300 - 3,000 metres.
11. *E. nitens*

Requirements not known, probably suitable for elevations 2,200 - 2,900 metres.

12. *E. regnans*

Good rainfall, deep soil, but not very demanding on quality of soil. No severe frost, 2,000 - 2,500 metres.

13. *E. saligna*

(from Wau Wake state forest, New South Wales), fertile soil, medium to high rainfall, no severe frost, 2,000 - 2,400 metres.

14. *E. viminalis*

Best results on deep fertile soils in heavy rainfall but thrives not too badly on impoverished soils and will survive in fairly low rainfall areas if soil is deep. Probably affected by presence of micro-nutrients (Boron), 2,200 - 2,500 metres.

15. *Cupressus lusitanica*

Only good results on well drained fertile forest soils. No severe frost. Medium to heavy rainfall, 2,000 - 2,500 metres.

16. *Pinus patula*

Deep soils, but not demanding as to quality of soil. Heavy rainfall, 2,000 - 2,600 metres.

17. *Pinus radiata*

Best development in medium to heavy rainfall areas - not too shallow soils. Little demand on fertility, 2,000 - 2,600 mts.

4.5 Tentative classification according to frost hardiness

It is very difficult to classify trees according to their frost hardiness. Conclusions are often only valid for the locality where the hardiness was observed, and lists of frost hardiness in forestry hand books seem not always to take this into account. Frost hardiness seems to depend on two factors, the first is the genetical adaptation of the species to frost in its country of
origin. The second is the condition which the tree is likely to be in when the frosts occur in its country of introduction.

If the trees are more or less dormant when the frost occurs, they will prove more hardy than would be the case if the frost hit them in a period of active growth.

In temperate climate severe frost almost always occurs during the period when the trees are dormant. In tropical climates with a prolonged dry season, this is also to some extent the case. Here the frost occurs when a period with no rain and low relative humidity of the air has made the trees develop thick leathery leaves and reduced their metabolism to a minimum. In the Project Area there is no such clear-cut separation of rainy-season-growth period and dry-season-dormancy. Although if one looks at average rainfall figures, there seems to be a marked division between rainy season and dry season, scrutiny of the actual monthly rainfall figures will show that considerable amounts of rain may fall during any month of the year.

Due to this irregular pattern, frost occurs not infrequently shortly after rain, when the trees are in full growth with their resistance reduced to a minimum. The coincidence of conditions favouring growth and frost is most likely to happen in areas of heavy average rainfall. The young trees seem considerably less exposed to frost damage in arid areas.

The damage is caused by night frost. This kind of frost occurs in depressions and in flat areas, but hardly ever on steep slopes except above 2,600 metres where all areas are exposed in cold winters. Grass-covered land is infinitely more exposed than ploughed clean-weeded land. The frost is at its most severe up to 2 metres above ground level. When the young trees have grown above this height they can normally be considered safe.

The following classification in decreasing order of frost hardiness can for the above reasons only be considered as a tentative guide.
E. johnstoni  Pinus radiata
E. gunnii       Pinus patula
E. delegatensis
E. dalrympleana
E. viminalis
E. bicostata
E. maideni
E. nitens       Pinus eliottii
E. camaldulensis
E. globulus
E. deanei
E. saligna      Cupressus lusitanica
E. regnans
E. grandis

4.6 Tentative Classification According to Drought Hardiness

The humidity of a plantation site depends on several factors:

The same amount of rainfall will create more humidity for the plants in the cooler conditions of a high lying place, than in a warm place.

Wind-exposure will make a site more arid.

A compact soil will be much more arid for the trees than a loose structured well-aerated soil.

A sandy soil permitting deep root-development, losing no rainfall by run-off and only little moisture by capillary movement towards the surface, will provide more humid conditions than a stiff clay-soil.

An eroded slope, with a hard surface, where most of the rain-water runs off, is much more arid than a soil with a well structured surface.

A soil rich in nutrients permitting vigorous root-development will seem less arid than an impoverished soil.
A thick cover of grass will add greatly to the aridity of a soil. The effect of broad leaved weeds is not nearly so bad.

A swampy badly-drained site must be considered an arid site for purposes of tree growth because it prevents deep root-development and consequently exposes the trees to drought when the water level sinks in the dry season.

**Classification in decreasing Order of Drought-Resistance**

- *E. camaldulensis*
- *E. globulus*
- *E. viminalis*
- *E. maidenii*
- *E. bicostata*
- *E. nitens*
- *E. botryoides*
- *E. dalrympleana*
- *E. saligna*
- *E. deanei*
- *E. johnstoni*
- *E. resinifera*
- *E. gunnii*
- *E. delegatensis*
- *E. regnans*
- *E. fastigata*  

4.7 **Tentative Classification According to Grass and Soil Tolerance**

Some species are notably more sensitive to grass competition and lack of nutritive elements in the soil than others. The most susceptible require a fertile, well cultivated soil and clean-weeding during the first year in order to develop satisfactorily.

**Classification in Decreasing order of Grass & Soil Tolerance**

- *E. globulus*  
  - *Pinus radiata*
- *E. maidenii*  
  - *Pinus patula*  
- *E. bicostata*  
- *E. viminalis*
**Tentative Classification of Fire-Resistance**

Trees are exposed to being killed by ground-fires passing through the undergrowth and the organic material lying on the forest floor. Their resistance varies from species to species, due mainly to the difference in bark-thickness.

More dangerous and very difficult to stop are crown fires which can spread through the inflammable tree tops at a tremendous speed after severe periods of drought. Crown fires can even spread through Eucalyptus plantations if prolonged drought, strong wind and steep slope combine to favour the fire. Eucalyptus leaves contain essential oils which make them burn like petrol if they lose most of their moisture. Crown fires are, however, almost entirely confined to coniferous plantations. They always cause total devastation. If a plantation, however, is systematically pruned with no dry branches sticking out from the stems, there is a good chance that a limited ground fire can be quelled before it climbs up into the crowns.

The following incomplete and tentative classifications only deals with the ability of the trees to survive a ground fire.

**Classification in Decreasing Order of Fire Resistance**

- *E. globulus*
- *E. bicostata*
- *E. maidenii*
- *E. viminalis*
- *E. camaldulensis*  
  *Pinus elliottii*
E. nitens
E. fastigata
E. regnans
E. delegatensis
Cupressus lusitanica
Pinus radiata
Pinus patula

4.9 Tentative Classification According to Growth Rate

Each species only achieves its maximum growth rate when conditions are ideal for that particular species.

A species will, however, often be planted in areas which are far outside its optimum range.

The reason for planting a species where conditions are far from favourable is mostly that its hardiness enables it to survive and produce something where conditions are too severe for other trees.

In the following list, it has been assumed that each species is grown on a site which is almost ideal for that species.

Classification in Decreasing Order of Growth rate

<table>
<thead>
<tr>
<th>Species</th>
<th>Annual prod. m$^3$/ha (tentative)</th>
<th>Length of rotation (yrs.) for timber logs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eucalyptus regnans</td>
<td>50</td>
<td>15</td>
</tr>
<tr>
<td>E. viminalis</td>
<td>45</td>
<td>-</td>
</tr>
<tr>
<td>E. maidenii</td>
<td>45</td>
<td>20</td>
</tr>
<tr>
<td>E. bicostata</td>
<td>40</td>
<td>20</td>
</tr>
<tr>
<td>E. saligna</td>
<td>40</td>
<td>20</td>
</tr>
<tr>
<td>E. grandis</td>
<td>40</td>
<td>20</td>
</tr>
<tr>
<td>E. deanei</td>
<td>40</td>
<td>20</td>
</tr>
<tr>
<td>E. globulus</td>
<td>35</td>
<td>20</td>
</tr>
<tr>
<td>E. delegatensis</td>
<td>30</td>
<td>20</td>
</tr>
<tr>
<td>E. dalrympleana</td>
<td>30</td>
<td>20</td>
</tr>
<tr>
<td>Pinus radiata</td>
<td>30</td>
<td>30 - 35</td>
</tr>
<tr>
<td>E. botryoides</td>
<td>25</td>
<td>-</td>
</tr>
<tr>
<td>E. resinifera</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>Pinus patula</td>
<td>25</td>
<td>30 - 35</td>
</tr>
<tr>
<td>Cupressus lusitanica</td>
<td>20</td>
<td>30 - 35</td>
</tr>
</tbody>
</table>
4.10 Tentative Classification of the Trees in order of their Soil Conserving Characteristics

Hardly any tree plantation provides as effective a protection against soil erosion as the natural forest - with no cattle let in for grazing. The natural forest with its mixture of tall trees, medium size trees, small trees and bushes, and the ground covered by a dense thicket of brambles, nettles and other broad-leaved weeds provides just the perfect cover for soil conservation.

Grassland can be almost as good if it is protected against excessive grazing, (which unfortunately it seldom is), and if cattle tracks are not allowed to develop into gullies.

Tree plantations can also provide excellent protection against erosion but quite often they are the cause of sheet-erosion by shading the ground so heavily that no protective cover of grass and weeds can survive there. The degree of shade is not only determined by the tree species but to a large extent by the silvicultural treatment practiced. Well-tended plantations normally give much less shade than the dense 'thickets' belonging to farmers.

In Ethiopia additional sheet-erosion is caused by the habit of removing all the protective litter from the forest floor. Branches, twigs, leaves, bark, are all taken away to the injera kitchen, leaving the soil unprotected, and also exhausting the soil by taking away organic material with a high content of phosphorous and nitrogen and preventing the formation of humus and a good soil structure. This habit of taking away all the forest litter is causing the rapid devastation of innumerable hill-sides.

A special disadvantage of eucalyptus trees is that their leaves, with their high content of essential oils, decompose very slowly and seem, to some extent, to have a toxic effect on the ground vegetation. This rarely becomes vigorous even when the shade is not heavy.
In this respect there seem, however, to be considerable differences between species.

Although tree plantations can, and often do, cause sheet erosion, especially if the silvicultural management is faulty or non-existent, plantation forestry should not necessarily be considered harmful. After all, the dense net-work of tree roots protects against the most harmful form of erosion, gully erosion. It has to be admitted that despite the pitiful picture often observed under dense eucalyptus plantations on slopes, the situation outside the forest is very often much worse. Here it is ploughing and overgrazing of the hillsides that opens the way for sheet and gully erosion.

Classification of Trees which may shade heavily and cause sheet-erosion in descending order of their deleterious effect

Eucalyptus grandis
E. saligna
E. maidenii
E. globulus
E. bicostata
Cupressus lusitanica
E. nitens
E. viminalis
E. dalrympleana
Pinus radiata
Pinus patula
E. delegatensis
E. regnans

Note: To some extent this classification depends on the silvicultural management.

4.11 Possible uses of the produced timber

Until newly introduced species have been grown to maturity, no one can be certain about the quality of the timber being produced. This applies especially to some of the eucalypts which have not yet, to our knowledge, been grown outside Australia for timber production. In Australia timber logs of these species are
obtained from trees of considerable age, growing in the natural forests. Plantation-grown timber can be expected to be of a different, and in general lower quality, especially if a very short rotation is used.

For eucalypts about which information is not available from Ethiopia or from similar mountain areas in East Africa, we are here assuming that the timber quality will not differ so much from that of Australian grown trees, that the wood cannot be used for related purposes.

### Possible Uses of Wood

Code employed for tree species is as follows:

<table>
<thead>
<tr>
<th>Code</th>
<th>Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>E. bicostata</td>
</tr>
<tr>
<td>b</td>
<td>E. camaldulensis</td>
</tr>
<tr>
<td>c</td>
<td>E. dalrympleana</td>
</tr>
<tr>
<td>d</td>
<td>E. deanei</td>
</tr>
<tr>
<td>e</td>
<td>E. globulus</td>
</tr>
<tr>
<td>f</td>
<td>E. delegatensis</td>
</tr>
<tr>
<td>g</td>
<td>E. grandis</td>
</tr>
<tr>
<td>h</td>
<td>E. maideni</td>
</tr>
<tr>
<td>i</td>
<td>E. nitens</td>
</tr>
<tr>
<td>j</td>
<td>E. regnans</td>
</tr>
<tr>
<td>k</td>
<td>E. saligna &amp; hybrids</td>
</tr>
<tr>
<td>l</td>
<td>E. viminalis</td>
</tr>
<tr>
<td>m</td>
<td>E. botryoides</td>
</tr>
<tr>
<td>n</td>
<td>E. fastigata</td>
</tr>
<tr>
<td>o</td>
<td>E. gunnii</td>
</tr>
<tr>
<td>p</td>
<td>E. johnstoni</td>
</tr>
<tr>
<td>q</td>
<td>Cupressus lusitanica</td>
</tr>
<tr>
<td>r</td>
<td>Pinus patula</td>
</tr>
<tr>
<td>s</td>
<td>Pinus radiata</td>
</tr>
<tr>
<td>t</td>
<td>Cupressus benthami</td>
</tr>
<tr>
<td>u</td>
<td>Pinus elliottii</td>
</tr>
<tr>
<td>v</td>
<td>Pinus pseudostrobus</td>
</tr>
<tr>
<td>w</td>
<td>Cupressus benthami</td>
</tr>
<tr>
<td>x</td>
<td>Pinus elliottii</td>
</tr>
<tr>
<td>y</td>
<td>Pinus pseudostrobus</td>
</tr>
<tr>
<td>z</td>
<td>Cupressus benthami</td>
</tr>
<tr>
<td>A</td>
<td>Pinus elliottii</td>
</tr>
<tr>
<td>B</td>
<td>Pinus pseudostrobus</td>
</tr>
<tr>
<td>C</td>
<td>Cupressus benthami</td>
</tr>
<tr>
<td>D</td>
<td>Pinus elliottii</td>
</tr>
<tr>
<td>E</td>
<td>Pinus pseudostrobus</td>
</tr>
<tr>
<td>F</td>
<td>Cupressus benthami</td>
</tr>
<tr>
<td>G</td>
<td>Pinus elliottii</td>
</tr>
<tr>
<td>H</td>
<td>Pinus pseudostrobus</td>
</tr>
<tr>
<td>I</td>
<td>Cupressus benthami</td>
</tr>
<tr>
<td>J</td>
<td>Pinus elliottii</td>
</tr>
<tr>
<td>K</td>
<td>Pinus pseudostrobus</td>
</tr>
<tr>
<td>L</td>
<td>Cupressus benthami</td>
</tr>
<tr>
<td>M</td>
<td>Pinus elliottii</td>
</tr>
<tr>
<td>N</td>
<td>Pinus pseudostrobus</td>
</tr>
<tr>
<td>O</td>
<td>Cupressus benthami</td>
</tr>
<tr>
<td>P</td>
<td>Pinus elliottii</td>
</tr>
<tr>
<td>Q</td>
<td>Pinus pseudostrobus</td>
</tr>
<tr>
<td>R</td>
<td>Cupressus benthami</td>
</tr>
<tr>
<td>S</td>
<td>Pinus elliottii</td>
</tr>
<tr>
<td>T</td>
<td>Pinus pseudostrobus</td>
</tr>
<tr>
<td>U</td>
<td>Cupressus benthami</td>
</tr>
<tr>
<td>V</td>
<td>Pinus elliottii</td>
</tr>
<tr>
<td>W</td>
<td>Pinus pseudostrobus</td>
</tr>
<tr>
<td>X</td>
<td>Cupressus benthami</td>
</tr>
<tr>
<td>Y</td>
<td>Pinus elliottii</td>
</tr>
<tr>
<td>Z</td>
<td>Pinus pseudostrobus</td>
</tr>
</tbody>
</table>

**Use**

**Possible species**

- **Charcoal**: b, m
- **Fire wood**: a, b, c, d, e, g, h, k, l, m, o, p. - the best are underlined
- **Fence posts**: a, b, c, d, e, g, h, k, m, o, p. - the underlined are durable
- **Transmission poles**: d, g, h, k.
- **Chicka houses**: a, b, *, d, e, g, h, k, l, m, o, p.

- @ = very durable
- + = fairly durable
- * = moderately durable.
Use
Possible Species

<table>
<thead>
<tr>
<th>Material</th>
<th>Species Letters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sawn building timber</td>
<td>c, f, i, j, n, q, r, s, t, u, v.</td>
</tr>
<tr>
<td>Boxes</td>
<td>a, c, d, e, f, g, h, i, j, k, n, o, p, q, r, s, t, u, v.</td>
</tr>
<tr>
<td>Agricultural implements</td>
<td>a, c, d, e, h, k. - the underlined are probably most suitable.</td>
</tr>
<tr>
<td>Furniture</td>
<td>a, c, d, e, f, g, h, i, j, k, n.</td>
</tr>
<tr>
<td>Joinery</td>
<td>f, i, j, n, q, s, t</td>
</tr>
<tr>
<td>Flooring</td>
<td>a, c, d, e, f, g, h, i, j, n, q, s, t, u, v. - the underlined are probably well suited for parquet floors.</td>
</tr>
<tr>
<td>Plywood</td>
<td>j</td>
</tr>
<tr>
<td>Match-splints</td>
<td>j</td>
</tr>
<tr>
<td>Paper pulp</td>
<td>a, b, c, d, e, f, g, h, j, k, l, n, r, s.</td>
</tr>
</tbody>
</table>

4.12 Non-coppicing Species

Most eucalypts regenerate by coppice shoots from the stumps after exploitation.

When the trees are grown in short rotation for firewood, poles or pulp, this quality, which makes replanting superfluous, is of great value.

If on the other hand eucalypts are planted for timber production, the ability to coppice is of less importance. Research in Malawi with the E. saligna x E. grandis hybrid has in fact shown that, if the rotation exceeds 10 years, higher yields are obtained by replanting after each exploitation - destroying the coppice shoots.

In small farm plantation, where exploitation of stems of all sizes for various local uses takes place continuously, it is most essential to use only eucalyptus species which regenerate by coppicing. Otherwise such plantations will disintegrate within a short time.

Of the reafforestation species used in Ethiopia, only the majority of the eucalypts, and some of the acacias, notably Acacia cyanophylla, can be regenerated from coppice. None of the soft wood species have this ability.
Eucalyptus species which do not coppice are:

- *E. delegatensis*
- *E. fastigata*
- *E. oreades*
- *E. regnans*

Furthermore, *E. botryoides* coppices poorly.

All other eucalypts that have shown promising growth within the project area will coppice vigorously.

4.13 **Susceptibility to attack by the Eucalyptus weevil, *Gonipterus scutellatus***

This defoliating beetle has made cultivation of *Eucalyptus globulus* uneconomical in most of South and East Africa and accelerated its replacement by *Eucalyptus saligna*.

The pest has to our knowledge not yet arrived in Ethiopia but the construction of a trunk road connecting Kenya with Ethiopia the risk of importing this dangerous beetle will increase enormously. Systematic spraying with insecticides of all vehicles crossing the border might help, but would be difficult to enforce efficiently.

It could be that natural predators would prevent the weevil from spreading here, and the possibility remains that biological control could be established by introducing such predators.

So long as the risk remains that the weevil might be introduced and there is no certainty that it could be stopped from spreading by any natural or artificial means, it represents a not negligible threat to the economy and the well-being of this country.
Both the eucalyptus sp. commonly grown in Ethiopia, E. globulus, (Nech Bahr zaaf), E. camaldulensis, (Kai Bahr zaaf), are vulnerable. Fortunately several of the other Eucalyptus spp. which have been found promising in the project area are either totally resistant or relatively resistant. There is therefore the possibility of reducing the risk of a future disaster by starting planting the resistant species on a considerable scale.

Of the species which are otherwise suitable for planting in Chilalo Awraja the most vulnerable are:

- E. bicostata
- E. camaldulensis
- E. deanei
- E. globulus
- E. maiden
- E. viminalis

Slightly vulnerable

- E. nitens
- E. resinifera
- E. saligna
- E. dalrympleana (slightly resistant in some localities, not in others)

Immune

- E. botryoides
- E. delegatensis
- E. fastigata
- E. regnans

4.14 Honey Production

In Australia bee-keeping in the eucalyptus forests is of considerable importance, as some of the species are excellent honey producers.
Of the species recommended for the project area the best production of honey can be expected from:

* E. bicostata
* E. camaldulensis
* E. maidenii
* E. viminalis

According to some sources, *E. saligna* is a good honey tree, according to others not so satisfactory. There is also some doubt about the quality of the honey produced from *E. globulus.*
5. **Forestry Extension**

In Chilalo considerable areas (several hundred ha.) had already been covered with Eucalyptus trees by local landowners when CADU started its activities in 1966 - 67.

Since then a considerable increase in planting activities has taken place, so that Chilalo Awraja is now one of the areas outside the Addis Ababa region, most densely provided with small farm plantations. The credit for this expansion cannot, however, be attributed to CADU's Forestry Extension activities which only started functioning relatively smoothly in 1972 after a period of running-in difficulties. The area planted with eucalyptus trees in Chilalo Awraja is not known even approximately. It is probably more than 500 ha. and less than 1,000 ha. The distribution is very uneven. In the dry Rift Valley areas there are no plantations, and the vast plains stretching from Mount Kaka down towards the Wabi Shebele depression are almost entirely without trees.

The population of the awraja is approximately 400,000 people. If a population of this size is to be provided with sufficient wood to cover basic needs in a simple rural way of life, i.e. wood for building chicka houses, for simple household equipment, for fencing and for firewood, for cooking and heating in cold weather (assuming that the unfortunate practice of burning dried cow dung is be abandoned) an estimated 400,000 m$^3$ of wood will be needed every year, or 800,000 stacked cubic-metres. If the average yield of a farm plantation is estimated to be about 14 m$^3$/ha., then 27,000 ha. of eucalyptus plantations would be required or about 0.5 ha. per farm as there are an estimated 60,000 farmers in the area.

For the next 10 years considerable quantities of wood can still be drawn from scattered trees remaining in what was previously high-forest or dense savanna. But thereafter the supply from the natural vegetation will become very scarce almost everywhere so that whatever wood is needed will have to be supplied from the farm plantations.

In the above we have not considered the needs for sawn timber for construction of bigger buildings, making agricultural implements, boxes, furniture, floors etc.
Consumption of sawn timber is probably going to remain modest for some time to come. It does, however, seem reasonable to assume that 10 years from now, at least 4,000 m$^3$ of logs will be needed to cover the annual requirement for sawn timber within Chilalo Awraja. Such saw logs could be supplied from 200-300 ha of well tended plantations. Possibly the whole Awraja could get all its requirements from the Munessa State Forest, if CADU's plan are there carried out.

Another possibility is the development of numerous small wood industries located in the bigger villages. These could get their supplies from plantations of good sawable eucalyptus species. Cutting into planks could either be done by pitsawing or by using a mobile circular saw powered by an agricultural tractor.

The wood supply situation as outlined above, (including or not including sawn timber in the considerations), shows clearly that reafforestation is needed on a huge scale in the project area, vastly exceeding the 50-100 ha, which are at present being planted by farmers annually. Hence, the need for forestry extension. CADU's efforts in the field of forestry extension have several aims which are briefly outlined here:

a) To increase planting of trees, especially in the areas where there is already a shortage of wood and where the planting of eucalyptus trees has not yet become commonly practiced.

b) To arrest already-advanced erosion and to prevent its initiation by advocating the reafforestation of exposed slopes.

c) To diversify the planting of eucalyptus trees by the introduction of several new species. There are several reasons for aiming at such diversification. It seems possible to introduce faster growing species than the already existing E. globulus. There is furthermore a need for frost-hardier or drought-hardier types for localities which are too rough for E. globulus. Finally it seems possible to grow trees with more interesting timber properties than the common Bahr zaaf. Then we have also in mind that diversification will serve as an insurance against total disaster, if the eucalyptus weevil should enter the country and severely attack the existing eucalyptus plantations. See page 89.
d) To teach people better silvicultural management of their eucalyptus plantations.

e) To demonstrate to people how to make better use of the timber of $E.\ globeus$.

f) To pioneer more rational use of wood fuel and to discourage the burning of cow dung.

g) To encourage the planting of sheltering trees on the wind exposed sides of houses, the establishment of dense rows of trees along roads and tracks to stop travelling cattle and vehicles from entering the fields, and the planting of trees along boundaries to provide these with a clear permanent demarcation.

The idea of wind-breaks was discussed but it was considered doubtful if crops could be improved on the high lands by planting shelterbelts between fields. This problem deserves further investigation, especially in the Asassa region.

In the Rift valley there can hardly be any doubt that shelterbelts would be beneficial. Here, however, we had to overcome the obstacle that until very recently, we neither disposed of a hardy enough tree species nor knew an appropriate planting technique which would enable us to demonstrate the planting of shelterbelts.

Forestry extension got started very slowly. A precondition for influencing farmers to plant more trees, better trees, in the right way and on the right areas, was that we disposed of the necessary knowledge ourselves - and of trained staff who would be able to pass it on. It took several years and many difficulties to get the basic inputs ready.

When information had become available about suitable plantation species to be recommended to the farmers for various site conditions and the necessary extension staff had been trained, the problem arose of how to organize the practical distribution of seedlings from our nurseries.
Further progress was blocked until we had found an answer to this seemingly very easy but in reality very tricky problem. The commonly employed method for planting eucalyptus in Ethiopia, is to use naked-root seedlings. If the distance from the nursery to the planting area is short and weather conditions favourable at the time of planting, the method gives reasonable results in the case of *E. globulus* and *E. camaldulensis*.

It is, however, almost impossible to distribute naked-root seedlings in big quantities over large areas. Too many seedlings will die or at least get their roots badly damaged during transportation.

Nevertheless, in our effort, to stick to the cheap Ethiopian custom of using naked-root seedlings we tried by various improvements to overcome the disadvantages inherent in the method. We dipped the roots in a protective chemical compound, Agricol, which has proved valuable in European forestry, but we did not achieve the expected increase in survival rate. We then tried packing the plants in a plastic covered paper bag, especially developed for the transportation of tree-seedlings in Sweden. Contrary to our expectations, this method proved disastrous. The eucalyptus seedlings virtually suffocated within the bags. Having a very active metabolism at the onset of the rainy season, they needed much more oxygen than the type of seedlings for which the bags were designed.

There remained then only that possibility of distributing potted Eucalyptus seedlings as is customary almost everywhere outside Ethiopia, where eucalypts are planted.

Here the main problem was cost. Potted seedlings could not be supplied for under Eth.$20 per 1,000. The farmer, who normally was a poor man, and who knew that when naked-root *E. globulus* seedlings were occasionally traded between neighbours the price was around $2 per 1,000, would not even consider buying potted seedlings at that price. It did not impress him that, whereas he would normally plant upwards of 40,000 naked-root-seedlings per ha. at a spacing of 50 cms. x 50 cms. or less, our advice was to plant one-eighth the number of the potted seedlings, 2,500 per ha. at 2m. x 2m. The cost for seedlings to cover areas of equal size would therefore be practically the same, if he planted in his traditional way, or if he used potted seedlings our way.
The argument did not work for the simple reason that the farmer did not believe that it was sensible use of a piece of land only to plant seedlings as widely spaced as 2 x 2 metres. To convince him we would have to demonstrate the superiority of our planting methods.

To achieve this two approaches were followed. The first was to start establishing demonstration plots planted by the project, well distributed over the project area.

The second was to organize co-operation with "forestry model-farmers" who would plant tree plots on their land under our supervision, having been provided with seedlings and fertilizer free of charge.

If demonstration plots and forestry model farmer plots develop in a promising way, it is hoped that enough interest ultimately will be generated to make people buy our seedlings at cost price and plant them according to our instructions.

Differences of opinion about planting methods other than those concerned with planting distances and the use of pots, arose between us and the farmers. Traditionally the most successful tree growing farmers used to cultivate the soil very carefully before planting their E. globulus seedlings and afterwards they would keep the area absolutely clean-weeded during the first year. Some would even fertilize the trees heavily with manure, and if there was danger of night frost, they would protect the young plantations with branches and straw. When conditions were favourable enough plantations were sometimes established directly by sowing. All together these were excellently developed methods to which we could fully subscribe.

But, whether planted or directly sown these plantations would always be very dense, 40,000 - 80,000 seedlings per ha. When we advocated wider spacing, it was very difficult to convince the farmers that cultivation and weeding of the whole area was no less essential for a good result, and that spot weeding round each seedling would be absolutely insufficient.
Another innovation which it was difficult for the farmers to accept was the use of artificial fertilizer in tree plantations. It only seemed to be common sense to reserve such a luxury for the agricultural crops. If tree planting is confined, as mostly has been the case, to typical agricultural land and to the fertile patches round the houses, no fertilizer is indeed necessary to obtain good results. The situation is however entirely different if the planting of trees is 'banished' to the agriculturally marginal land which we recommend that farmers should first of all reafforest. Typically such land comprises steep slopes, cleared sometime ago of their forest cover, and therefore with leached impoverished soils; land damaged by sheet and gully erosion and therefore with even more impoverished soils which furthermore have been denuded of most of their vegetative cover so that they are not able, any more, to retain more than a fraction of the rainwater which falls in their 'cemented' surface; areas with a low and erratic rainfall, as in the Rift Valley and at Asassa. On all such recommendable reafforestation sites, satisfactory results just cannot be obtained without helping the seedlings to make a vigorous start with an initial boost of fertilizer. What is required is 50 grams 18/46 N.P. fertilizer per seedling, i.e. 80 - 120 kgs. per ha which is about the quantity normally used for an agricultural crop.

The only way of convincing a farmer about the justification for spending so much on a tree plantation is by demonstration, and unfortunately a demonstration in forestry requires 3 - 6 years to become convincing: that is the time taken to produce a valuable pole or something else of market value. To demonstrate to the farmers the value of planting 'saw-timber eucalypts' would require 10 - 15 years.

Forestry extension activities, (which until then had come under the Forestry Section) were transferred at the end of 1972 to the Department of Extension and Training. At present the Forestry Extension subsection consists of one Forestry Extension Supervisor assisted by a field staff of 7 forestry demonstrators, of whom two are in addition trained in nursery work. Forestry Extension operates its own nursery at Asassa. For the areas lying farther North supplies of seedlings come from Asella nursery which is run by the Forestry Section.
About 120 - 150 forest model farmer plots are being established annually, each covering \( \frac{1}{10} - \frac{1}{4} \) ha. In 1973 there is still free issue of seedlings and fertilizer. In 1974 it is expected that enough understanding and interest will have been generated to make it possible to discontinue the free issue, and induce farmers to buy potted seedlings either at cost price or at a lower, project-supported price. The cost of fertilizer they will have to meet in full, but alternatively they might be encouraged to use natural fertilizer in the form of cow-manure.

The Forestry Section is continuing to establish trial and demonstration plots throughout the Project Area, each covering 1 - 4 ha., so that farmers in each area can see on an impressive scale the advantages of planting the best kind of tree, at the correct spacing etc.

The Forestry Section is also maintaining close contact as consultants and advisors on all technical matters with the forestry staff of the Extension and Training Department.

Emphasis in forestry extension has, naturally enough, been on encouraging people to plant more and better trees and especially on reafforestation on erosion exposed slopes.

It remains to teach the farmers how to manage their tree lots in a more rational way.

They should learn to thin the coppice shoots which sprout very densely after exploitation, so as to obtain stands of ideal density from the point of view of maximizing their 'value growth'. They should be made to understand that a dense stand just does not produce more wood than a heavily thinned one, so long as the canopy remains well closed, and that the latter has a much greater value growth rate, because its stems reach a marketable size several years earlier.

Then when thinning their plantations they should be taught to take out the most crooked stems first, - instead of always doing the opposite - leaving the straightest and finest stems to grow bigger and therefore become more valuable.
To teach the farmers to leave twigs, leaves and bark on the ground to maintain the fertility and to protect against erosion is going to be a very hard task.

Demonstration to farmers of the possibility of making good sawn timber from *E. globulus* is just being started, by showing them agricultural implements, chairs, tables etc. made of Bahr-zaaf. This should be combined with information to local carpenters about how to saw and season eucalyptus wood to get satisfactory results.

Extension work to introduce more rational use of wood fuel has also only just begun. The idea is to pioneer the introduction in houses, with corrugated iron roof, of the wood-stove with chimney pipe replacing both the open cow-manure-cum firewood fire on the floor and the charcoal brazier.

A not negligible benefit of introducing the wood-stove would be to eliminate the practice of burning cow-manure.

A parallel effort is however needed by both forestry demonstrators and agricultural extension agents to convince farmers never to burn manure if they can get hold of wood, for despite its undeniable virtues in the kitchen, it is such a valuable fertilizer returning phosphorous and nitrogen to the soil and helping to maintain a high content of humus and a good soil structure.

Forestry extension is still at a tentative building-up stage. Information, which has to be disseminated to the farmers, is continuously being improved and extended as the result of practical experience.

It is therefore essential that the forestry extension staff is brought in at least once annually to refresher-courses where they can be taught the newest "inputs" and exchange views about their experience in the field.
6. Timber Utilization

One of the striking features about *Sawmilling* in Ethiopia is that although *E. globulus* (Nej Bahr-zaaf) is the only large-size tree found in over half the country (including the most densely inhabited parts) this species is hardly being used at all for saw timber.

*Eucalyptus globulus* is not only being sawn in its home-land, Australia. Plantation-grown *E. globulus* is used in South America on a large scale for furniture and high class *parquet* flooring (imitation of oak).

It was therefore from the very beginning considered as an important goal for CADU to develop and disseminate the special technology which is required for the successful utilisation of *E. globulus* timber. This activity has mainly been carried out by the Engineering Section.

It was soon found that *Eucalyptus globulus* logs of not too young trees could provide timber of an excellent quality. It was just a matter of using an adequate sawing and seasoning technique, somewhat different from the method used for zigba and tid.

In brief, the time lapse between the felling of the trees and conversion of the logs into planks must not exceed one week — in other words the logs must not start drying out before they are sawn. The initial sawing should at once reduce the planks to the smallest size which will be appropriate for their final utilization. Very wide planks should be avoided altogether. Sawing should be planned in such a way that the central core, which is the most defective part of a eucalyptus stem, can be discarded.

A long seasoning period, with the timber carefully stacked and shaded, is afterwards needed before the timber becomes dry and stable and can be used for further processing — that is if one does not ressort to artificial seasoning in a drying kiln.

The Ethiopian-grown *Eucalyptus globulus* timber, treated this way, proved to be of excellent quality, not only for coarse, strong items such as carts and *harrows* but also for quality furniture. The grain and colouring of the wood was beautiful, not unlike European oak. In physical properties it resembled ash although it is considerably heavier. Because of its strength it would make ideal school furniture.
To develop and disseminate the techniques involved it was decided more than two years ago that CADU should start a small pioneer eucalyptus wood industry. It has taken a very long time to plan and prepare this enterprise and the initial labour-pains cannot be said to be over yet.

Of items other than agricultural implements which almost certainly could be made from eucalyptus wood, the following deserve particular attention: boxes, school furniture, and simple chairs - eventually with bent-wood components supporting seats. *Eucalyptus globulus* is well suited for bending. CADU's main task would be to develop the best prototypes and production procedures. The production side could then be handed over to private saw millers and carpenters.

*E. globulus* timber is, as stated above, excellent for many purposes. Nevertheless it is a hard, heavy wood much more difficult to season, saw and nail than most of the present-day commercial timbers. This is the back-ground for the CADU Forestry Section's efforts to introduce several other species of eucalyptus renowned for the better quality of their timber, as described in section 4.

Plantations have been established at the Project Centre of the following timber-eucalypts:

*E. dalrympleana, E. fastigata, E. johnstonii, E. nitens, E. regnans, E. resinifera* and *E. saligna*. After 3 - 6 years logs exceeding 50 cms. in diameter should become available of all these species. It is of great importance that investigations are then made of the timber quality. Then it can be more definitely assessed if some of the species would deserve planting on a large scale for timber production. In the case of *E. regnans* though, research into the properties of Kenya-grown timber is being undertaken this year by the wood technologist in Nairobi, in collaboration with CADU. The results of this investigation are not yet available. It can fairly safely be assumed that Ethiopian grown timber of *E. regnans* will not differ in any important way from the Kenya grown material. Later, when the trees here have grown bigger, research should of course, be undertaken on local material, taking into account possible differences between provenances, and especially between plantations established with seeds from Tasmania and those established with seeds from Victoria.
Timber utilization research should not only cover the basic timber properties of these new species and possible uses. As in the case of *E. globulus* it should include investigation of sawing and seasoning methods, durability and possibilities of chemical impregnation. Air drying should be compared with kiln drying. The Uganda solar kiln probably deserves particular attention as the large number of sunshine hours of the Ethiopian climate would favour its use.
Erosion Control

The saying "Prevention is better than cure" applies particularly well to erosion control.

When a steep hill-side has been deforested from bottom to top and cultivated for some years and overgrazed and criss-crossed by cattle tracks, then sheet erosion will be succeeded by gully erosion which will ultimately wear away the last remaining flesh of the earth, down to the naked skeleton, the bedrock.

When this stage has been reached the "patient" can be considered as dead beyond hope. No "artificial erosion control" will bring him back to life. An area of productive land can be mourned as lost for ever.

Ideally the Ethiopian countryside ought to be classified according to the 'vocation' of the land, viz.: valley bottoms; pasture land vocation; plains and gently rolling hills: agricultural vocation; medium steep hills: pasture land vocation; steep hills: forestry vocation; abrupt hills: protective forest vocation. Utilization should then only be permitted according to designated vocation.

Also, no such rational land-use system has ever been imposed anywhere in Ethiopia. Valley bottoms (the natural drainage canals), steep hills and abrupt precipitous mountain-sides - all the places which should have been carefully protected have instead been deforested, ploughed and overgrazed.

Everywhere the steep hill-sides have become rocky and unproductive. Probably more than half of the area originally covered by deep soils in Northern Ethiopia has been totally devastated by erosion. And the loss was not only of productive land, the side effects were serious too. With less and less soil on the mountain to absorb rain water, the water supply in the valleys has deteriorated. Springs have dried up and the flow of water in the streams has become erratic and muddy - the women have to go further and further with their pitchers.

This distressing, but not exaggerated picture, applies to one half of Ethiopia, the Northern half.
South of Addis Ababa the devastation is not as advanced yet, but the same forces which ruined millions of ha. of productive land further North are at work here at full speed, remaining forests are being burned, hill-sides ploughed etc.

In Chilalo Awraja the situation as a whole is disquieting but far from disastrous yet. Most hill-sides have already been deforested. Leaching and sheet-erosion have impoverished the soils on sloping land, and even gully erosion has begun to show its ugly head in many places.

Most of the hills are, however, still covered by deep soils and if proper land-use and soil conservation measures were applied from now on, the disaster which has be fallen other parts of the country need not arrive here.

To bring the forests back on all steep hills which have a "forestry vocation" seems, unfortunately, completely unrealistic. Many small farms are almost entirely confined to steep slopes and it is inconceivable that the farmers should use most of their land for planting trees; nor would it be possible to move thousands of farmers away from such areas.

Soil conservation will therefore have to aim mainly at the introduction of better farming and animal husbandry practices and not at large scale reafforestation of all erosion-prone slopes.

Forestry's role would be limited to protection and development of the remaining forest land on slopes and reafforestation of particularly exposed areas and land on which erosion has already reached an advanced stage.

Apart from protection of the slopes covered by the Munessa State Forest which constitute part of the catchment of several perennial streams, CADU's Forestry Section has, where erosion control is concerned, mainly concentrated on developing techniques for planting the steep hillsides on which the soils are already degraded and impoverished, and reclaiming gully-eroded land before it is too late.
Our findings can briefly be outlined as follows:

On steep deforested slopes, the soils are always leached and impoverished. Furthermore, they have a poor structure which causes most of the rain-water to run-off without seeping into the ground. For three growth these are unfavourable conditions, and it was found that reafforestation would only succeed if drought-hardy tree-species tolerant of poor soil were used, and then only if they were given an initial boost with N.P. fertilizer, to enable them to get deeply rooted before the end of the first dry season. For species drought-resistant tolerant of poor soil see page 81 and 82. Where gully erosion had already opened deep gashes into the soil and exposed the raw reddish subsoil, we first thought of going in for some kind of terracing.

This method is commonly used in other countries for soil conservation but we soon had to abandon the idea as it was too expensive for local conditions.

Instead, we found that in areas of medium and high rainfall it was possible in most, if not in all cases to encircle and stop the advancing erosion by simpler and cheaper means.

It proved in fact possible, to get the drought-resistant and soil tolerant eucalyptus to grow directly on the eroded slopes if a booster dose of fertilizer was applied as described above. A ground-cover between the trees could in most cases surprisingly easily be reestablished by sprinkling N.P. fertilizer on the ground at the beginning of the rainy season. Albeit barely visible, a few weeds persist on these denuded slopes, and the effect of the fertilizer is a dramatic proliferation in all directions, sufficient to recover the ground within a month.

In very bad cases it was necessary to plant grass turfs at a spacing of 1 x 1 metre. In this case also, fertilizer had to be applied to enable the grass to spread.

Where the gully was rapidly expanding due to a heavy flow of water coming down over a small waterfall after each heavy shower, it might be necessary to go to the extreme of building a grass-turf 'channel' for the water. The "channel" should have the shape of
a broad staircase, each step being built entirely of grass-turf and being a little lower at the centre so that the flow of water would follow the middle of the staircase.

In some cases it was possible to direct the stream of water away from the gully-eroded area altogether either by a small dam or a canal or by both. In that case reclamation became much easier but it was naturally a precondition that the stream of water could be diverted safely without causing erosion somewhere else.

**Planting of trees and reestablishment of a ground-cover** does not immediately stop the erosion as does the terracing method. Steep cliffs caused by the erosion continue to collapse for some time until the trees and grasses have solidly tied the land behind them. Gradually these cliffs will level out and themselves become grass-covered.

It is, therefore, indispensable that the area included in the erosion control measures stretches well outside the area already damaged by erosion. Normally, a buffer zone of a width of 10 - 30 metres is sufficient.

In 1971, it was agreed that CADU should obtain control of a hill farm of about 20 ha, in size and there develop and demonstrate proper land-use and soil conservation methods. The farm would also serve as a training ground in soil conservation measures for the extension staff. Unfortunately this excellent idea has still not been realized at the time of writing.
8. NURSERY AND PLANTING TECHNIQUES

8.1 Potted Versus Naked-root Seedlings

CADU's nursery and planting techniques are now entirely based on potted seedlings. Our objective has been to obtain a plantation survival rate of at least 80% under average weather conditions; it was not found possible to use naked-root seedlings either in the case of eucalyptus or of soft-wood species. Some eucalypts could under favourable conditions be planted as naked-root seedlings and give satisfactory results, but the method was risky and initial growth never as good as for potted seedlings.

*Cupressus lusitanica* also constituted a border-line case. Transplanted naked-root seedlings of this species with a bushy root-system, and preferably 20 - 25 cms. tall, would give excellent results if planted out in the forest by experienced well-supervised labourers in favourable weather conditions. When it came to planting on a large scale it was however nearly impossible to operate in this way. Some areas would necessarily be planted under somewhat adverse weather conditions. In other cases supervision would not be strict enough, with the result that the roots of the seedlings would be exposed to sun and wind before going into the ground.

These misfortunes would not, normally, kill the *Cupressus lusitanica* seedlings which are very tough, but they would check their growth seriously. The tender top-shoot would wither and root development would get delayed. The result of this would be two-fold. Some seedlings would not get deeply enough rooted to survive the following dry season, entailing expenses on beating-up in the following rainy season. Others would grow so slowly that weeding over a much extended period would become necessary until the seedlings would eventually reach up above the competing vegetation.

We tried to improve the naked-root method by the use of *Agricol* root-dipping compound and also by packing the seedlings in a plastic covered paper bag which has been developed for the transportation of seedlings in Sweden. None of these
methods, however, led to the anticipated improvement. In the end we became convinced that it was most economical to use potted seedlings for all species. The higher cost of nursery production would be more than off-set by:

a) reduced expenses of weeding
b) no need for later beating-up and
c) a gain in productivity by fast start of the plantation – a gain often amounting to one years growth.

8.2 Seed Preparation

Some of the eucalypts recommended for planting have seeds which require cold-stratification. This applies to E. delegatensis, E. fastigata and E. regnans. They should be submerged in cool water for 24 hours. After that the water should be left to drip off. The "drip-dry" seeds should then be kept in a refrigerator for 6 - 8 weeks, at a temperature just above 0°C. After that they are ready for sowing.

Seeds of most Acacias, Pterolobium stellatum and, notably, Prospis juliflora have a hard shell and need hot-water treatment to give good germination. The seeds are put in a thin layer, not more than 3 cms. deep at the bottom of a tin. Water, just off the boil, is then poured on until the depth of the water is twice that of the layer of seeds.

The seeds should be left in the water for 12 hours and then sown immediately without being allowed to dry out.

8.3 Sowing Time

Successful planting depends very much on having seedlings of the right size, – neither too small nor too big – at the on-set of the planting season. The planting season does not however begin at any fixed date. On the highlands the possible starting time varies from the first week in June until the end of July. In some years it is even possible to do some successful planting during the early rains from mid March until the middle of April. This variation of planting time has to be taken into account when nursery activities are planned.
Another practical consideration is the necessity to spread nursery activities as evenly as possible over the dry season. Especially in the cases when seedlings later have to be transplanted into pots, it is very important that sowing is organized at such a rate that no more seedlings will reach the transplanting stage within one week than can be transplanted within the same period by the experienced nursery staff.

**Recommended as practical sowing dates:**

- **Pinus patula:** end of September
- **Cupressus lusitanica:** during October
- **Pinus radiata:** during December
- **Eucalyptus:** mid-December – mid February
- **E. regnans,** which is fast-growing in the nursery, should not be sown before mid-January.

### 8.4 Planting Pots

Pots, or more correctly tubes, of polythene are used for raising plants directly from the seeds of some species. For most species, however, small seedlings from trays or beds are transplanted into the pots.

As an alternative, Japanese paper pots were tried on a considerable scale. Their main advantage, compared with the polythene tubes, was that filling with soil was much less labour-demanding. This advantage was, however, far from being important in a country with very low wage rates. In fact, it could not compensate at all for the considerably higher price of the pots. Another disadvantage is that the paper pots disintegrate too fast under Ethiopian conditions, unless one uses the even more expensive plastic-reinforced paper-pots. The standard pots became so soft at the onset of the planting season that they got torn and fell to pieces during transportation to the planting site.

Regarding the polythene pots, it was found practical to use two different sizes. The smallest was made from ange 0.08 mm tubular film. Lying flat it would have a width of 7 cms.
corresponding to a diameter of 4.5 cms. Before being filled with soil the tubular film was cut into 15 cms. lengths. The bigger tube was made from gauge 0.1 mms. polythene film. Lying flat it measured 10 cms. corresponding to a diameter of 6.5 cms. This bigger size was cut into 18 cms. lengths before filling.

The smaller the pot the less the expenditure on polythene, soil mixture, filling, nursery space, watering and most important, transportation. The disadvantages of the smaller pot are that only smaller, seedlings can be raised in them with a good balance between root and top, and not nearly as much water can be stored in them, by heavy watering or submersion, to provide the seedling with a good reserve in the case of no rain falling within the first week after planting.

Small 7 cm. pots can be recommended for Cupressus lusitanica, and for eucalypts due to be planted on grassland areas of medium and high rainfall. Raised in small pots the seedlings should preferably be 10 - 15 cms. tall at the time of planting.

Big, 10 cm. pots are preferable for raising big vigorous seedlings of the more tender eucalypts and pines for planting in forest areas where competing undergrowth makes it advantageous to start the plantations with tall seedlings, 25 - 35 cms.

Big pots are also the best for planting in arid areas. In this case one should not use big seedlings in big pots. Seedlings not exceeding 10 cms. are here preferable, as they are able to survive for surprisingly long on the water storage in the pot if the rains are delayed.

Some foresters are advocating the removal of pots at the time of planting to allow for a better development of lateral roots but we have not been doing this. We have in fact been convinced that it is quite possible to obtain satisfactory planting results without cutting the pot, and in the event of adverse dry weather at the time of planting, there is no doubt that it is a clear advantage that the polythene film remains there to retain the moisture contained in the pot soil.
8.5 **Sowing and Raising of Seedlings**

Sowing is done either on seed-beds, in sowing-trays or directly, in polythene pots. In all cases it is fundamental that the soil which receives the seeds permits good drainage, as insufficient drainage is the principal cause of fungus attack on the young seedlings - damping-off. Generalised soil mixtures cannot be indicated to the nursery staff, as the raw-materials vary from nursery to nursery.

For this reason the only direction given is that soil used for filling trays and pots should fine-grained and rich in humus and at the same time contain enough fine sand that it does not become plastic when wet but maintains a loose structure, and will thus drain freely. Pot soil, on the other hand, must not be so loose structured that it will tend to fall out through the bottom of the tubes.

The proportion of the constituents included in the soil mixture is decided in each nursery according to the nature of the clay, sand and sifted 'forest top soil' or other available humus material.

NP 18/46 fertilizer is added to the soil mixture at the rate of 50 grams per 10 kgs. soil.

In Dagaga nursery, there is a suspicion that some micro-nutrient is lacking in the nursery soil - most likely Boron. Addition of this element might therefore, be advisable.

In the case of the seed-beds it is not quite so necessary to go to the same lengths to mix a well balanced soil as in the case of soil for trays and pots, but the principle is the same; a well-drained soil, fairly rich in humus ensures the best results.

One of the most severe problems in the nursery is, as already mentioned, the frequent attacks of damping-off on both pines and several of the eucalypts.
The risk can be reduced considerably by heat-sterilizing the soil used for filling the trays and pots before sowing. The sterilization can be achieved very simply by 'cooking' the wetted soil mixture in a big container, e.g. half of an oil barrel.

Sterilization with formalin has also been tried but seems less effective.

Damping-off is more likely to occur in sowing trays than anywhere else because the seedlings can there be so easily exposed to overwatering and too damp conditions. To ensure against this, the drainage of the trays must be arranged carefully. First of all they must be provided with holes in the bottom. Then to prevent these holes becoming clogged by soil and to ensure that excess water can easily reach them, a 3 cms. thick layer of coarse gravel, or charcoal, must be interposed between the bottom of the tray and the seed-bed soil. Despite all precautions, damping-off may still occur. Once it has started it is extremely difficult to stop.

The most effective measures are:
1. to reduce watering to a minimum
2. to increase light and ventilation
3. to soak the soil with \( \frac{1}{4} \) solution of a copper fungicide.

As out-door seed-beds we have mainly been using the traditional raised nursery bed.

Better results with some of the more demanding species seem to have been achieved this last season with a sunken nursery bed, introduced from Kenya. In a 50 cms. deep excavation a layer of coarse gravel was first placed to provide drainage. On top of this the soil mixture prepared for sowing was spread. The sunken bed was then surrounded by a wooden frame and shaded with a grating of bamboo splits. This rather intricate and expensive bed provided an excellent micro-climate for raising delicate seedlings.
Before sowing, the seedbed must be made firm and damp but not wet. Good results can be obtained both by line-sowing and by broadcasting. With very fine seeds, the last method probably ensures the best distribution. After broadcasting, seeds should be covered thinly by sprinkling the bed with a mixture of sterilized sifted sand and forest top-soil.

When sowing directly in pots 2 or 3 seeds are put in each pot, according to the viability of the seeds. A hole about 1 cm. deep is made in the pot soil with a small stick. The seeds are then dropped in and the soil firmed over them.

The traditional seed-bed is covered with straw, after sowing, to provide shade and prevent the wind from drying out the surface. Trays are covered with polythene sheeting (gauge 0.12 mm. is suitable) to provide a saturated atmosphere over the seed bed until germination takes place. In the case of pine seeds, sown directly in pots, light shading may be provided by covering the pot-beds with grass or bamboo-splits supported by some simple frames. If the pots have been placed in sunken beds with the top of the pots well below ground level, (to provide protection against dessicating winds), it is however, preferable not to use any shading, as shade will always increase the damping-off risk.

Watering after sowing must be done frequently and lightly; outdoors with a watering can with a fine sprinkle; indoors preferably with a knapsack sprayer providing ‘mist-watering’. No rule can be made about the frequency of watering. To vary watering correctly according to the weather, and the species concerned, requires the art of the experienced nursery man. As a rule the seed-bed should be kept continuously damp but never become really wet.

Once the seeds have germinated the straw cover on the open beds should be removed fairly soon. Shading should then be provided by straw-covered frames raised some 10 cms. above the bed.
Seeds and especially seedlings are vulnerable to damage by rodents, insects and birds. Rat poison and insecticide should always be in stock to make a rapid counter-attack possible. Bird damage can be prevented by covering the beds with wire netting.

Some time after germination shading should be decreased and then gradually it should be removed altogether.

If pine seeds are sown in non-sterilized pot soil, some soil from the root zone of a healthy pine plantation should be included in the soil-mixture to ensure inoculation with mycorrhiza. If sterilized soil is used, inoculation of the seedlings will have to be done later. In the latter case it is preferable to wait until the seedlings are beyond the risk of damping-off. This is normally after the first 'true' leaves have developed. Inoculation can then be done by sprinkling the seedlings with sifted fresh 'pine root soil', followed by watering. It is advisable to repeat the treatment 3 times.

Seed beds used for raising *Eucalyptus regnans* seedlings should also be inoculated with soil from the root zone of a *E. regnans* plantation. Such treatment is probably not required for any of the other eucalypts recommended for planting.

8.6 Transplanting into Pots

Seedlings raised in trays or in nursery beds should later be transplanted into pots. The interval of time from sowing to transplanting varies according to the species and the altitude, but is normally about 2 - 2½ months.
Eucalyptus seedlings must never be transplanted when they have only cotyledons. One should always wait for the true leaves to appear. The best moment, by far, is to transplant when the seedlings have developed 4 leaves. If they have more than 6 leaves, the tap-root will be too long, and will have to be pruned when transplanting. Only under very favourable weather conditions can such big seedlings be repricked with an acceptable result. Cupressus seedlings are easy to transplant. It is preferable to reprick them when they are about 3 cm. tall. Transplanting should preferably take place on calm cloudy days. If no such favourable weather occurs, transplanting must be confined to the cool periods of the early morning and the last afternoon, the latter being by far the best time for transplanting work.

There must be strict supervision to ensure that the tiny roots of the seedlings do not get exposed to sun and wind for more than a few seconds when they are taken from the seed-bed soil and pricked into the pots.

A hole is punched in the moistured pot soil with a stick the size of a ball-point pen. The seedling is slipped into this hole with its root-collar just below the soil-surface. If the tap-root is too long the tip of it must be pruned with two finger nails. The labourer must not touch the root-collar of the seedling but should hold it higher up, on the leaves.

After placing the seedling in the hole the soil must be solidly firmed round its roots all the way down.

Watering must follow within, at the most, 5 minutes after planting, to make the soil settle closely round the fine root-hairs.
Progressively as the pots in the nursery bed are filled with seedlings they should be covered by frames supporting shading grass or bamboo splits.

This shade is maintained for as long as the seedlings are suffering from the shock of transplanting. As soon as they have recovered it should be reduced and fairly rapidly removed altogether.

8.7 Planting time

Superficially it might seem fairly easy to decide when to start planting the tree seedlings. One should obviously wait until the main rainy season has got properly started and the soil has become moist, well down below the depth of a planting hole.

In Ethiopia, however, it is not ready so simple as that. There are two rainy seasons, one short and one long, followed by a clear-cut dry season.

It is of paramount importance to plant sufficiently early that the seedlings are able to get deeply rooted before the beginning of the dry season.

On the highlands, the dry season normally starts towards the end of September but in some years hardly any rain falls after the end of August.

To develop a root-system sufficiently deep to withstand the rigours of the dry season a seedling needs, at a rough estimate 1½ - 2 months of rainy season growth. To allow for the incidence of short duration rains planting should never be done later than mid-July and it would be safer if it could be terminated round July 1st. In an average year, planting until the end of July will normally succeed, but the trouble is that the forester never knows beforehand if the rainy season is going to be normal. One cannot, therefore, wait for abundant rains and nice moist soil but, on the contrary, one is obliged to plant as early in the rainy season as can be risked.
Our advice is to plant as early as June 1st if really abundant rains are falling at that time. If no heavy rains come during June and July is commencing with a clear sky, one should be prepared to gamble and plant as soon as the first really heavy shower has moistened the soil down the length of a pot, 15 - 18 cm., under the assumption that in July there will never be very long intervals between showers. It is a gamble to decide on early planting under such circumstances, and sometimes the result is disastrous, but to delay planting is even more risky.

In the dry Rift Valley the time-limit within which planting must take place is much narrower than on the highlands, if one shall hope for any survival. It is rarely possible to plant before July 10th and not at all safe to plant after the 20th.

In the light of the preceding comments it will be appreciated that the best plantation results may possibly be obtained by planting during the short rains, provided that the interval between the short and the long rains does not become too long and too dry. Since maize with its deep-going roots can survive from the short to the long rains, why not hardy forest trees?

Some of the most successful of CADU's forestry plantations have in fact been planted during the first week of April. If the early rains are heavy, this is the ideal planting time for the more hardy species.

8.8 Transportation of Seedlings

For transport to the planting site the potted seedlings are loaded into either a pick-up or a trailer.

The loading method is the simplest possible. It is sometimes called the "sardine method". Before loading, the seedlings are watered very heavily, if possible even submerged in water, so that the pot soil gets almost muddy. In this condition the soil is less liable to shake out of the pots and at the same
time the seedlings are provided with the largest possible reserve of water.

Before loading it is advisable to cover the bottom of the pick-up with a layer of grass. It is especially important to put a thick layer over the exhaust pipe, otherwise heat may destroy some of the seedlings.

The seedlings are loaded lying flat on the back of the pick-up or on the trailer. When one layer of seedlings covers the bottom, another layer is put on top of it. Layer by layer, loading is continued until the loading capacity of the vehicle has been reached.

If transportation is of some duration, the load is covered by a layer of grass and a tarpaulin. Seedlings will, surprisingly enough, survive in this type of dense packing for up to 3 days without showing any signs of suffocation.

Packing must be done very carefully with the tops of the seedlings in one row lying smoothly over the pots of the preceding rows. It is most important that the packing is so dense and regular that there is no risk of the load shifting on a bumpy road.

Off-loading is done on a level smooth area. Here the pots are put standing closely together in a circular group. When off-loading is completed, soil must be banked up against the pots in the outermost row, so that they do not get desiccated by wind and sun.

It is important that the pots are placed standing and not lying, as otherwise they will be unable to benefit from any fortuitous rain-showers, and furthermore cannot be watered if that should prove necessary.
8.9 Soil Preparation

A loose well-aerated soil with no competing weeds of any kind offers, under most circumstances, the ideal planting site. Such conditions can be obtained by ploughing and harrowing the land.

Strip cultivation rather than complete tilling of the soil would reduce the cost of soil preparation, and it is a common belief that as trees are going to be planted in rows such strip cultivation is quite sufficient. This is, however, far from being the case. Neither strip nor spot cultivation will give nearly as good planting results as complete cultivation of the whole area.

The cause of the disproportionately harmful affect of some grass being left behind on a planting area is the capillary movement of soil water. The remaining grass first takes the available water and nutrition from the soil surrounding its roots. This makes the soil dry out under the grass-covered area quite early in the dry season. Under the neighbouring ploughed and harrowed area the soil has meanwhile remained humid, since little water is transpired by the small tree seedlings and lost from the loose soil surface by evaporation. But this soil moisture will migrate, by capillarity, to the dried-out soil where it will be taken up by the roots of the grass. This 'capillary pull' will dry out the soil for as far as 2 metres from the grass-covered area.

The tremendously harmful effect of some remaining grass was demonstrated strikingly in a plantation of E. regnans at the Project Centre. On the ploughed and clean-weeded part of the plantation, the young trees had reached 3.5 metres 12 months after planting. On the other hand, however, a growth of only 35 cm. was reached by seedlings planted at the same time in holes dug into a grass-covered area, although helped by careful spot cultivation and weeding around each plant to a distance of 30 cm.
However, grass competition is not equally harmful to all species. See page 82.

On slopes the complete tilling of the soil may expose the area to erosion. In that case it is advisable to let 5 metre wide strips of ploughed land alternate with 2 metre wide grass-covered buffer zones. Planting should only be done on the ploughed strips and the nearest row of trees should be aligned at least one metre from the edge of the grass-buffer, even if this leads to very irregular spacing. On very steep slopes even this kind of strip cultivation may not be possible. One will then have to resign oneself to planting holes and spot-weeding. The deeper and the wider the hole, the better the result of planting.

Drainage is poor on clay soils that have been puddled by cattle trampling, and consequently they are often swampy during the rainy season. This situation obtains on many of the available grassland planting sites.

Such sites can be reafforested by planting on mounds. The best results are obtained by first ploughing the whole area, afterwards mounds are raised at the intended planting espace- ment. Each mound should be 60 cm. in diameter and 25 cm. high.

If large scale reafforestation of swampy land is considered, raising ridges by means of a crawler tractor and a ridging plough would probably be more economical than the preparation of mounds.

When reafforesting forest land, ploughing and harrowing is rarely possible. Preparation here normally consists of felling and burning the remaining tree and bush vegetation. It is best to fell the trees a full year before the intended burning, so that they can dry out properly.
Burning is normally best done between mid-December and mid-January, as there is no certainty that a sufficiently long period of dry weather will occur between the end of January and the onset of the big rains. Burning in May-June is sometimes possible. After burning the espacement of the planting holes is marked with sticks. The holes can be dug out either before the planting season or at the time of planting. Pre-dug holes give the best results.

8.10 **Planting Distance:**

It can be considered a basic law (No. 1) in forestry that the wood production in m³/ha of a plantation is a function primarily of the tree-species, the climate, and the soil. It does not vary with the density of the stand, so long as there are enough trees on the area to cover the ground and constitute a closed canopy. For example, at *Asella* it should be possible to obtain an average annual production of 35 m³/ha. from *E. globulus*. If the farmer plants 50,000 seedlings per ha. (45 cms. between seedlings) as is customary, or 2,500 seedlings per ha. (2 metres between seedlings) he will in both cases obtain a production of 35 m³/ha./yr.

The production will, however, not be of the same nature. In the first case he will, after perhaps 4 years, have produced tens of thousands of walking sticks. In the second case all 2,500 trees will have reached fence post size. This exemplifies forestry law No. 2 Viz. The greater the spacing between trees, the sooner will marketable size be reached and hence the greater the value of the annual growth.

This law applies only so long as enough stems remain to maintain full ground-cover.

Consequently under most circumstances it is advisable to plant just enough trees in an area to ensure that a closed canopy can be reached within a reasonable time.
If there is a good market, or domestic use, for stems of small dimensions it may, however, be economical to plant more densely. When a usable size has been reached the number of stems can be reduced.

If on the other hand, no market can be foreseen for the produce of early thinning, one would be inclined to increase spacing to the extreme. One should also take into consideration whether it is essential to produce knot-free timber, and if so whether the species is a good self-pruner or requires artificial pruning.

Experience in East Africa has shown that the ideal planting distance for coniferous trees and most eucalyptus is $2\frac{1}{2} \times 2\frac{1}{2}$ metres. However according to circumstances the planting distance may be varied from $2 \times 2$ metres to $3 \times 3$ metres.

For closed plantations it is not advisable to go outside this spacing. The case is different when we come to planting of shelter belts, protective strips along roads etc. If a single row of eucalyptus is planted, 1 metre between seedlings is adequate. If the strip is constituted of 2 or 3 rows, spacing should be increased to $1\frac{1}{2} \times 1\frac{1}{2}$ metres. Some spacing trials have been laid out in the plantations of Cupressus lusitana and Pinus patula in the Munessa forest.

8.11 Planting

Planting potted seedlings is extremely simple. The pot is slipped down into the planting hole. Soil is filled in until it covers the pot. It is then firmed by the feet on each side of the seedling. Finally a little loose soil is raked over the planted area.

If it is decided to boost the initial growth of the plantation with fertilizer the application is made after planting. 50 grams of 18/46 NP fertilizer is given to each seedling. On
fairly flat ground the fertilizer is applied as a ring around the seedling at a distance of 10 cms. from the stem. On sloping ground it is put some 15 cms. above the seedling. In both cases it is raked into the ground. This is to prevent it being washed away or, even worse, carried in towards the seedling by a heavy rain-shower. It is important not to apply this heavy dose too near the seedlings as they will be killed if undiluted fertilizer comes into direct contact with them. Badly supervised application of fertilizer has been seen as the cause of very heavy losses in some newly established plantations.

In the Rift Valley it is not only necessary to use fertilizer to boost the growth during the short rainy season; it is even more important to apply insecticide to protect the seedlings against termite attack.

If there are any living termite colonies in mounds on the planting area they should be destroyed first. This can be done either by digging out the queen or by chemical means. A very small amount of Dieldrex 18, say a coffee cup full, is enough to destroy a termite colony, if sufficient water is applied to get some of the poison to seep all the way down to the queen. The poison and about 10 buckets of water are poured into a hole opened at the top of the mound. But it is not enough to destroy the colonies in the mounds. Dusting of the whole planting area with Aldrin or Dieldrin is essential on almost all planting sites in the Rift Valley. Without such treatment termites will destroy most of the young seedlings. None of the eucalyptus we have been trying have shown any resistance to termites during their first year of life. But it seems that at least E. camaldulensis becomes unpalatable for the termites, after two years growth - possibly even after only one years growth.

One treatment with insecticide should be enough as both Dieldrin and Aldrin remain effective in the soil for several years.
Weeds are harmful to the young plantations in several ways. They compete with the young seedlings for water and nutrition and, because of the capillary movement of water in the soil, this effect stretches far outside the area actually occupied by the weeds. On clay soils tree seedlings will suffer from the competition of weeds growing up to 2 metres distant from the seedlings.

Weeds also compete with the small trees for light. If they are allowed to grow up unchecked they may overshadow the tree-seedlings and eventually completely suppress them.

On old forest land a particularly bad weed is found in the shape of the creeper. Creeping or climbing weeds are particularly harmful to young plantations of Cupressus lusitanica. They will strangle the stems of this species, cover the branches completely and weigh the tops down towards the ground. Pines are not quite as exposed to this kind of damage and for some reason the creepers seem to avoid Eucalyptus regnans.

Last, but not least, weeds seem to have a decisive influence on the occurrence of night-frost. On clean weeded areas harmful a night frost hardly ever occurs except in very exposed depressions. On the other hand thick cover of grass seems to invite the frost.

For all these reasons frequent intensive weedings are the principal key to successful plantation work.

It is true everywhere that the more completely the weeds are suppressed, the faster will be the growth of the tree seedlings. Some trees are admittedly more sensitive to grass-competition than others, (see page 82) but even the most hardy are seriously retarded in their growth if surrounded by weeds.
The more the conditions are marginal for the species the more important is intensive weeding. To achieve a successful plantation of eucalyptus at Asassa or in the Rift Valley, the area must be kept almost totally clean of weeds from the day of planting and throughout the first year.

Where frost threatens the young seedlings clean-weeding may be necessary as an insurance against frost damage.

On forest land clean weeding is mostly not possible for economic reasons. It will here have to be limited to spot-weeding round the seedlings, accompanied by slashing of weeds and bushes growing further away when these become so tall that they start over-shadowing the neighbouring seedlings and make it difficult to penetrate into the plantation.

Regular weeding and slashing of bush-vegetation will normally have to continue for the best part of two years.

Cutting creepers may even have to continue till the fourth or fifth year of a plantation.

Weeding and cutting creepers constitutes by far the biggest single item on the reafforestation budget for old forest land. To keep it down it is very important that the right tools are employed. Labour output is probably doubled when well-designed tools are employed instead of the relatively cheap hoes and bush-knives found in the local shops.

For both planting and weeding operations we have found that hoes with a rounded blade (like a section of a cone), are vastly superior to flat-bladed hoes. Two models of Swedish made hoes seem almost equally efficacious. 'SFI hackan' is probably the best for forest areas and 'Boden hackan' preferable for grassland. For slashing competing bush-vegetation and cutting creepers we have selected a Swedish-made bush-knife - 'Vedlanda risten', after having tried several other models.
Another approach to weeding would be to kill the undesired vegetation with chemicals. Trials with the common herbicides were, however, unsuccessful in the Munessa forest. The method is used extensively in forestry in cold temperate climates. It is there favoured by two circumstances which are not found in the Munessa forest. The competing trees and bushes are limited to one or two species. The chemical can be applied during spring time when the tender leaves of the 'weeds' have just sprouted.

This is not the case here. In the Munessa forest the ground is covered with a dense metre-thick brush constituted by an entanglement of numerous species. Many of the species have very leathery leaves, and there is no definite spring time when all the species will expose tender leaves at the same moment. For these reasons it seems that for chemical weeding to succeed, repeated application of very heavy concentrations of herbicides would be required and, on this account, be prohibitively expensive.

Another possible solution to the weeding problem should be tried in the 1973 planting season. The idea is to surround each plant with a circular piece of black polythene sheet about 60 cms. in diameter. The seedling is planted through a slit in the centre. It is expected that the black plastic, by keeping the light out, would prevent weed growth near the tree-seedlings. Furthermore it would maintain moisture and increase the soil temperature during day time. This could result in faster growth but it might eventually have some adverse effects.

8.13 Up keep of Plantation

After the successful establishment of a plantation, pruning and thinning are the principal silvicultural operations by which the forester tries to maximize the economical return.
The main argument for pruning is to obtain timber that is knot-free and therefore more valuable. As a not unimportant side-effect pruning reduces the risk of a grass-fire climbing up into the crowns of coniferous trees.

Pruning eucalyptus trees is normally not practiced. In the case of eucalyptus being grown for production of sawn timber or plywood, it would, however, be worth starting some investigations to find out if some light early pruning would not be beneficial. Most eucalyptus are good self-pruners, so, after the canopy has closed, artificial pruning would hardly serve any purpose.

In this context our experience with a 5-year-old E. regnans growing down at Gambo should be mentioned. This tree, due to a misunderstanding, got pruned quite heavily. As a result it started axenic gum from all over the stem. For this species and, may be for other eucalyptus as well, there is, therefore, some indication that heavy pruning may have an adverse effect on the timber quality.

All the soft wood trees recommended for planting here must be pruned if the timber quality is to be acceptable. It is advisable to do the first pruning when the branches from neighbouring trees have reached each other and have started to suppress some of the ground-vegetation. For Cupressus lugitanica this will normally be the case 2–3 years after planting and for Pinus patula a year later. The branches should be removed to just over half the total height of the tree. The remaining live crown should always cover at least ½ of the height, as heavier pruning will cause a severe drop in growth-rate.

The branches must be cut with a pruning saw absolutely flush with the bark of the stem. No stumps should be left protruding.
In Kenya it is found advisable to prune *Cupressus lusitanica* during the rains, as this appears to expose it less to fungus attack. *Pinus patula* can be pruned throughout the year. By successive prunings, at intervals of 2 - 3 years, the stems are gradually cleaned of branches up to a maximum height of 12 metres. The same principle as above should be followed throughout. The live crown should never be reduced to much less than half of the total height. Furthermore the stem should always be pruned before it exceeds 10 cm. in diameter, so that one can be sure that the useless core of knotted wood in the timber log will remain within that size.

High pruning, above 8 metres, should perhaps be limited to selected trees which can be expected to remain until the final exploitation at the age of 30 or 35 years. Pruning is wasteful unless a layer of clean wood of a thickness of at least 10 cm. can be expected to cover the pruning scar before the tree is felled.

We deal only very briefly with the principles of thinning, as CADDU's Forestry Section so far has acquired little experience in this field.

Forest plantations are thinned for two reasons:

1. To maintain diameter-growth and thereby value-growth at a maximum. A continuous reduction in the number of stems on a given area must take place as the trees grow bigger. If this reduction takes place gradually, so that the canopy remains almost continuously closed, the reduction in the number of stems will not result in a decrease in productivity of the plantation. What happens is that the yield in m³/ha., instead of being derived from many trees with a modest diameter-growth, is obtained from fewer stems with a much faster diameter-growth. Since price is closely linked to diameter for timber logs, this results in a maximization of value-growth. By gradually reducing the number of stems, diameter-growth is kept at a maximum.
on the remaining trees. The production in m$^3$/ha. remains the same if the number of stems is reduced progressively in such a way that a closed canopy is maintained almost continuously.

2. **To obtain as much marketable timber at an early stage as is possible, without reducing the long term productivity of the plantation.** In a world where high interest rates are paid on capital, it is obvious that the sale of cheap fence posts after 5 years might be as profitable, or even more profitable, than the sale of veneer logs for which one has to wait 20 years.

3. **To optimize the relationship between annual value-growth and the value of the stock of standing timber.** By reducing the capital invested in standing trees and at the same time increasing the value-growth, the rentability of the forest plantation can be maximized.

Systematic thinnings, at not too long intervals, must be carried out both in eucalyptus and soft-wood plantations to obtain the best economical return. Despite the widespread planting of Bahr-zaaf in this country the idea of systematically thinning eucalyptus plantations seems so far almost unknown. We shall, therefore, briefly outline how a eucalyptus plantations ought to be thinned.

Most eucalyptus 'plantations' start as coppice after exploitation of an existing plantation. On each stump 20 or more coppice shoots sprout, making it look like a dense bush. To get the best out of such a 'plantation' the number of coppice shoots on each stump ought within 6 months to be reduced to 3. At the latest at the age of 2 years a further thinning should bring the number of stems down to one on each stump. At the next thinning at the age of 4 or 5 years it should be possible to remove about a quarter of the remaining stems for use as fence posts or chicka-house material.
At each thinning the principle to be followed strictly is that the most crooked stems are cut and the straightest are left to grow bigger.

From then on thinning should take place every 3 or 4 years. At an age of 8 - 10 years transmission poles can be cut.

After exploitation for transmission poles, the plantation will have become so open that the stumps will begin to coppice vigorously. Those new coppice shoots should also be thinned down to 3 on each root. They can then be left to grow to fence post size under the shade of the remaining big trees.

How long one shall continue to thin and produce bigger and bigger trees in the upper storey depends on the future market for big size eucalyptus timber. If production of sawn timber from Bahr-zaaf becomes more generalized in a few years, as we expect, it should be profitable to keep a few very straight and clean stems until they reach saw timber size, 45 cm. in diameter, at the age of 15 or 20 years.
The best charcoal in Ethiopia is made from Acacia trees growing in dry lowland areas, and this source accounts for the bulk of the production. The big centre of consumption is Addis Ababa. Some charcoal is also used in the smaller towns and villages, but it is almost unknown as fuel in the rural areas. To try to stop the deforestation of that part of the Rift Valley which lies within the project area, CADU's Forestry Section has investigated if it is possible to replace acacia charcoal by charcoal made from *Eucalyptus* wood.

To obtain as good a product as possible and a higher yield than is obtained in the traditional earth kilns, two mobile iron kilns were imported from France. The eucalyptus charcoal proved to be inferior to the acacia charcoal. It was lighter, burned faster and more irregularly.

It could, however, be produced at lower cost than acacia charcoal. It was, therefore, hoped that if it could not beat acacia charcoal on quality it might do so on price. But even this proved to be impossible. It was not possible to sell eucalyptus charcoal at a price high enough to cover the cost of production.

Information was obtained from an expert on charcoal production, Mr. Derek Earl of the Commonwealth Institute of Forestry in Oxford, about the possibility of making good quality charcoal briquettes using *Eucalyptus globulus* as the basic raw material.

This seemed technically quite possible. By first crushing the charcoal and then compressing it very hard into briquettes one can obtain a charcoal which is at least as good as acacia charcoal and which furthermore offers the advantage of coming in lumps of exactly equal size. There is, however, one drawback. Briquetting requires heavy initial investment in machinery. Large scale productions and efficient marketing are, therefore, absolute preconditions for economical operation. It seems very doubtful that it would be possible to find investment funds for a venture on a
sufficiently large scale as long as good acacia charcoal can be produced cheaply and almost without restriction in the Rift Valley.

It was, therefore, considered unnecessary for the time being to follow up the preliminary investigation with a more detailed feasibility study.
Three types of domestic fuel predominate within the Project area: dried cow-manure, firewood and charcoal. Probably they are in that order of importance. Cow-manure and firewood are used for cooking. Charcoal on the other hand mainly serves as a source of heat in the houses of relatively well-to-do town dwellers. Besides providing warmth in cold weather, it is also used for boiling coffee and roasting kollo within the living room. As a whole the domestic heating methods are most unsatisfactory.

Cow-manure would be better used as fertilizer on the fields than as fuel in the kitchen. Open kitchen fires made on the floor with manure or wood, fill the house with smoke. This is especially annoying to the women, who do the cooking, and constitutes a serious risk for small children. A surprisingly large number of children fall into these fires, and suffer more or less severe injury.

The charcoal brazier provides undisputably a pleasant cozy source of heat, free from smoke. But charcoal is nevertheless a very expensive fuel and as a consequence only available to the better-off people. During the coaling process, especially in the primitive earth kilns, a very big proportion of the calories contained in the original firewood are lost — going up into a cloud of smoke over the Rift Valley. A much more rational way of burning fuel for cooking and for heating is provided by the wood-stove. Wood-stoves offer both the advantages of the charcoal brazier - pleasant heat and no smoke - and they do this consuming whatever fuel is available at a cheap price, in most cases eucalyptus firewood. For cooking, the stove is better than the brazier, except for injera which needs very special kind of cooking arrangement.

The stove utilizes the firewood in a much more economical way than the open fire on the floor, as the adjustable louvre in its door makes it possible to regulate the draught. If the louvre is left open, water can be brought rapidly to the boil. If it is closed, a little firewood can be kept smouldering for a long time, providing a gentle
heat at very low cost.

Since the smoke goes out through a chimney pipe through the roof, the stoves cannot be installed in houses with grass-roofs. Houses with corrugated iron roofs are, however, now completely predominat­ing in towns and villages and are very widespread in the countryside, so this restriction would not prevent the stoves from becoming widely used.

CADU has recently imported from Sweden 13 wood-stoves of a simple cheap type. They are being installed in various typical households at Asella so we may study how well the model is adapted to Ethiopian conditions. This needs following up to determine whether the manu­facture and marketing of wood stoves in Ethiopia would be worthwhile
11. WOOD PULP FOR PAPER

Only a very preliminary investigation has been made into the possibility of producing pulp wood within the Project area. The only paper factory in Ethiopia is located at Wonji, some 10 km. north of the border of Chilalo Awraja. To date it is only manufacturing paper from imported pulp.

The consumption of pulp and paper in the country is in fact still so low that a local pulp industry could hardly be made viable. It is, however, expected that paper consumption will climb so much within the next 10 years that in the early eighties the necessary preconditions will exist for the establishment of national pulp industry.

Planting of trees for pulp production would have to start 8-10 years before a factory utilizing these trees could go into full-scale production. It is therefore high time that a study is made of the possibilities for establishing pulp plantation. It seems that only within Arussi Province are there places, within easy reach of the present paper factory, where pulp wood could be grown. To produce pulp wood on a sufficient scale to support a modern pulp factory, an area of somewhere between 5,000 and 12,000 ha. would probably be needed.

Suitable thinly inhabited areas of this size could probably only be found at two localities within Arussi Province: at Lukiche south of Sagure and at Koshemeda east of Sire. Lukiche lies about 125 km. from the Wonji paper factory, Koshemeda about 75 km. Both areas are somewhat swampy plains used mainly for extensive grazing with but hardly any cultivation. They could therefore be used for plantation forestry without causing serious social disruption. The thinly populated area at Lukiche covers only some 300 ha. Only Koshemeda seems really to be of the size needed for large scale development - some 40,000 ha.
When it comes to large scale production of pulp wood - possibly hundreds of lorry loads going out every day - plains offer obvious advantages. The establishment of an internal network of roads will be cheap and easy, soil preparation before planting can be mechanized, even extraction of the wood might be done mechanically by specially equipped vehicles moving up and down between the long straight rows of trees.

One basic problem must, however, be investigated before any such development can be seriously considered. Will it effectively be possible to obtain satisfactory yields from good pulp trees on these swampy, frost-exposed plains?

CADU started trials at Gusha on the Lukuche plain in 1971 to try to find answers to this question. So far encouraging results have been obtained with *E. dalrympleana* and *E. viminalis*, both of which possess the right type of wood. In 1973 it is intended to extend the trial to also include *E. maideni* and *Pinus radiata*. Trials with the same species should also be initiated as soon as possible on the Koshemeda plain. It is of great importance that these trials are followed closely over the coming years. If the growth-rate of one or more tree species prove interesting further research should be made into the pulping quality of the wood.

Regarding the vast Koshemeda plain, it is worth noting that it is located close to the Awash River and to the new highway to Assab. There might be possibilities for exporting pulp.
12. TAN BARK

It can now be considered unfortunate that CADU's Forestry Section did not start any investigations into the possibility of producing tan bark in Chilalo Awraja. The reason for our attitude was that in East Africa, industries based on wattle bark were struggling with the problems of over-production when we planned our activities 1966. The world markets could not absorb their full production and plantations had to be up-rooted. Even so we should have investigated whether there would be an internal market for tanning bark in Ethiopia. This country has the biggest herd of livestock in Africa and the need for tanning materials must be very considerable.

There is no doubt that the most important tan bark trees, Black Wattle, *Acacia mclissima*, could be grown successfully here. A species which is closely related to Black Wattle *Acacia decurrens* thrives wonderfully well where it has been planted around houses in numerous places within the Project area.

The possibility of establishing a tanning industry ought not to be over-looked in the future.
Nearly two hundred farmers have been resettled by CADU on the treeless plains surrounding Asassa. To make wood available for these people CADU's Forestry Section has started reforestation with eucalyptus on some areas of government owned land. So far plantations have been established successfully on some 50 ha. Plantation species are *E. camaldulensis* and *E. viminalis*. Another 25 ha. ought perhaps to be planted, as the productivity of these plantations can be expected to be rather low, and we have some direct responsibility to satisfy the farmers’ need for wood.

The above calculation assumes the continuation of the present standard of living, from the wood-consumption point of view. If better days lie ahead with bigger houses, equipped with wood-stoves etc., more wood will obviously be needed. Consequently our policy should not be just to reforest the 75 ha. considered basically necessary. There is a good argument for planting trees on all marginal erosion-exposed agricultural land in the area which comes under CADU's control. The extra production would cater for any increase in the farmers' needs, and any eventual surplus of wood could always find a market as there at present are no trees for miles around.

Management of the young plantations is at present assured by CADU's Forestry Section. Assuming that a farmers' cooperative gets started in the area, it would probably be good to transfer to this organization the responsibility for the maintenance of plantations, cutting trees and marketing the wood.

Beside planting trees on government-owned land CADU is also making an effort through its extension service to get farmers in the area to carry out reforestation themselves; this effort ought to be continued and intensified.
Asella gets its water-supply from the Dosha stream.

This small water-course is made up of three streams which come together just above a small dam from where a pipeline leads over to the storage lake at the Project Centre.

All three streams have their sources up on the Chilalo mountain. Down to a point near the small collection dam they pass through very sparsely inhabited mountainous country.

Until recently, very little farming took place even on the lower part of this important catchment area.

With a view to ensuring that the hills would not get deforested and lose their rain-absorbing layer of soil, CADU's Forestry Section proposed in 1970 that about 250 ha. of the land adjoining the three streams should be expropriated and made into a forest reserve. Protective forest would be maintained on the steepest slopes and the less abrupt hills used for production forestry. The proposal would have involved the displacement of 17 small farmers, but it was assumed that they and their families could be given employment in reafforestation work if they so desired.

Within the proposed area about 200 ha. were suitable for plantation forestry. An area of that size was considered just adequate for ensuring a continuous supply of timber to local wood industries in Asella.

Protection of these 250 ha. inside a forest reserve would help to preserve a regular water-supply in the Dosha and reduce the risk of silt being carried into the storage lake. Ideally, to ensure really effective protection of the catchment, an area of some 500 ha. ought in fact to be protected against deforestation, farming of steep slopes and overgrazing. It was however, considered prudent to be not too ambitious to start with and to leave the reservation
of the least exposed part of the catchment area for some later action.

Unfortunately no resources were found for carrying cut any part of this proposal. No part of the catchment was protected; no area became available for timber plantations. This was a great pity. Within the last two years ploughing and crop-growing have spread over a much bigger part of the area than before, and deforestation along the Dosha is steadily denuding more and more of the steep slopes. It seems only a matter of relatively few years before the stream will be bordered by rocky slopes as are most other water courses within the Project area. This development is certainly not going to improve the water-supply capacity of the Dosha, and further more the water flowing into the storage lake will be more polluted, needing greater expenditures on filtering and disinfection.
Shortage of trained people is seriously impeding current attempts to organize modern forestry in Ethiopia. The lack of staff trained in forestry work is felt at all levels. It is not only at graduate level that there are too few people to fill the more senior positions and to work. The lack of Forest Rangers, trained to supervise the daily work in the field, is equally serious. And at the junior level there is a no less serious shortage of skilled nursery men. It is not always recognised that to be successful nursery man requires a strong sense of vocation coupled with at least 5 years of training under proper guidance.

CADU's Forestry Section has not been able, during the 7 years of its existence, to recruit any Ethiopian with a degree in forestry. When the writer of these lines departs shortly there will be no Ethiopian counterpart who can take over. The recruitment of an expatriate successor has been much delayed and it may be some months before a suitable person arrives.

When CADU's forestry activities started in 1966/7, it was necessary to employ people who had had no previous experience in Forestry, and train them ourselves.

To fill the more senior positions we employed university graduates in agriculture. For middle level positions we selected people with an agricultural background who had been trained at the College of Agriculture in Jimma. For the lower levels we employed young men directly from school. Those we selected mainly according to natural inclination, rural background and intelligence, not giving much weight to their school level. Starting like this with an utterly inexperienced staff, as far as forestry was concerned, it was necessary to employ several expatriate forestry officers. At the time when we were engaged not only in the Munessa investigations and forestry experimentation, but were also responsible for the enforcement of forest legislation within Chilalo Awraja, the department employed three expatriate foresters. In 1971 the number of...
foreigners was reduced to two, and since July 1972 only the head of the forestry activities has been an expatriate.

It has not been possible by in-service training for agriculturists to qualify for senior forestry appointments. For the purpose of the day-to-day administration it has been possible to provide them with most of the basic knowledge required. When it comes to planning, research and conception of new approaches, this kind of training is just not adequate.

On the junior level very satisfactory results have been obtained in training people for forestry extension and for supervision of plantation and timber exploitation activities. The training of skilled nursery men has been most difficult. This activity not only requires intelligence and practical sense but a special flair commonly called "green fingers", plus several years of experience so as to be acquainted with the minute details which must be known to make nursery work succeed. Only 3 or 4 people seem to have acquired the skill up to the time of writing, too small a number to safely ensure the continuation of planting activities.

Two junior staff members, with good experience in nursery and plantation work, were sent to Londiani in Kenya in 1970 where they studied for 2 years to become qualified forest Rangers. They returned as valuable additions to the staff in May 1972. It would be of great value if more of the staff could be given opportunity to attend the Londiani school.

For those of the junior staff who cannot be sent abroad on such a course their in-service training ought to be followed up by a short formal course which could possibly be organized in collaboration with the extension and Training Department.
At the time of the departure of the expatriate head of section the forestry establishment is as follows:

1. Acting head of Section (Jimma College of Agriculture)
   1 Research Assistant
2 Forest Rangers (Kenya Trained)
2 Nursery men
2 Nursery Assistants
1 Forest Overseer in Charge of various activities at the Project Centre. Approximately 20 foremen and permanent labourers.

(CADU Department of Extension and Training)

One forestry extension organizer supervising 7 forestry demonstrators, of which two are qualified nursery men.

(Transfered from Forestry Section in 1972)
16. THE NEED FOR POSITIVE ACTION.

All natural forests have already disappeared from the Northern half of Ethiopia. The last remaining forests in Southern and Western Ethiopia are disintegrating fast. If the trend is not reversed, within the near future, there will be no high forests, worth speaking of, left 30 years from now and with the forests will have disappeared the wild life they sheltered and their marvellous beauty.

Replanting to replace the vanishing forest has hardly started despite the excellent growth conditions for many valuable timber trees in this country.

CADU's Forestry Section can claim to have done some spade work to get forestry on the move. Numerous introduction trials have shown which reafforestation species are most suitable for a variety of different site conditions. Nursery and planting techniques adapted to the Ethiopian highland have been developed. Possibilities for making better use of the wood of the commonly grown eucalyptus have been shown. One area of government forest has been demarcated and brought fairly well under control, and plans for its rational development for plantation forestry and as a nature and game reserve are under preparation. If all these activities are continued and followed up they constitute an important pioneering job - but, seen in the national context, not much more.

To serve the country as a whole and help to reverse the unhappy trend in Ethiopian forestry, our experience must be extended outside the relatively small Project area, adapted to conditions in other Provinces and compared with results obtained by others.

So far the work of CADU's Forestry Section has been fairly isolated from other forestry activities in Ethiopia. There have been some contacts and exchanges of views but not to any great extent. This isolation must be brought to an end both for the benefit of forestry
in Chilalo and for the making of our know-how available to the country at large.

To save forestry from impending disaster all who work in this field must pool their resources of staff, experience and knowledge and pull together.

The organizations mainly involved are the Department of Forestry of the Ministry of Agriculture, the State Forest Development Agency, the Soil Conservation and Water Development Division, and the Institute of Agricultural Research.

It is already late afternoon for the Ethiopian forest. May all men of good will and influence get together and save the last tree-covered hills before it is too late and darkness covers the rocky ground.
A. Project Preparation Period

1. Report No. I on the establishment of Regional Development project in Ethiopia, October, 1966
   - Part I General Background
   - Part II Project Outline
   - Part III Appendices
   (A reprint of the Summary is also available)


3. Trials and Demonstration Plots at Kulumsa in 1966, July, 1966


5. Creation of a Forestry Administration in Arussi Province, March, 1967


7. Results of Trials and Observations Plots at Kulumsa 1966/67, May, 1967

8. Sagure, a Market Village, June 1967


B. Implementation Period

1. Government Agreement on Plan of Operation

2. Some Reflections on Water Erosion in Chilalo Awraja, October, 1967

3. The Taungya Afforestation Method, November, 1967


8. CaDU (Pamphlet in English and Amharic)


10. Cultivation Practices and the Weed, Pest and Disease Situation in Some Parts of the Chilalo Awraja, March, 1968

11. Introductory Agro-Botanical Investigations in Grazed Areas in the Chilalo Awraja, June, 1968
12. Results of Trials and Observations on Fields, Forage Crops at the Kulumsa Farm and in asella 1967/68, June, 1968
13. Crop Sampling in the Chilalo Awraja, Arussi Province 1967,June 1968
15. CADU Statistical Digest, May, 1968
17. Field Trials and Observations 1968/69
18. Feasibility Study on a Farm for Breeding of Grade Cattle at Gobe, Arussi Province, September, 1968
22. A Case Study of Peasant Farming in Dighelu and Yeloma Areas, Chilalo Awraja, Ethiopia, January, 1969
24. Results of Demonstrations 1968/69
25. CADU Plan of Work and Budget 1969/70
27. Feasibility Study on Sunflower Protein Concentrate and Fafa Mixing Plant, May 1969
28. Results of Trials and Observations 1968/69 May, 1969
29. CADU Evaluation Studies, Health Education (Base-line study) May, 1969
31. CADU Evaluation Studies, Training of Model Farmers (Base-line Study) May, 1969
32. Progress Report No. 1, Implement Research Section, June, 1969
33. Feasibility Study on Local Roads and Market Places in Chilalo Awraja, by Lars Leander August, 1969
34. CADU Annual Report 1968/69
36. Census in Golja (Ketar Genet), by Gunnar Arhammar, March, 1969
37. Sanitary Survey in Golja (Ketar Genet), by Gunnar Arhammar April, 1969
38. Kap Study of Mothers in Golja (Ketar Genet), by Gunnar Arhammar April, 1969
39. Food Survey of Pre-school Children in Golja (Ketar Genet), 
  by Gunnar Arhammar, April 1969
40. Health Survey of Pre-school Children in Golja (Ketar Genet) 
  by Gunnar Arhammar, April 1969
41. Report on a Combined Food and Health Survey in Yeloma Farming 
  District, by Gunnar Arhammar, May 1969
42. Census in Eckoji Village, Asella, by Gunnar Arhammar, September 1969 
43. CADU Preliminary Final Report for the Period 1967-70 
44. CADU Semi-annual Report 1969/70, February 1970
45. CADU Work Programme and Budget 1970/71 (With Preliminary 
  Estimates for the Period 1971/72-1975/76) 
46. Report on Surveys and Experiments, Crop Production Department, 
  Asella, 1969
47. CADU Work Programme and Budget for the Period 8.7.70-31.12.70 
48. Results of Demonstration, 1969/70
49. CADU Evaluation Studies, Crop Sampling 1969
50. Land ownership, Tenancy and Social Organisation in Wajji 
  Area, by Arne Lexander, March 1970
51. CADU Annual Report 1969/70
52. Progress Report No. II, Implement Research Section, July 1970
53. A Master Plan for Water Resources and Supplies within CADU's 
  First Project Area, Nov. 1970 
54. Report for the Period 8.7.70-15.11.70 
55. CADU Work Programme and Budget for the Period 1.1.71-7.7.71 
  Section, June 1970
59. CADU Work Programme and Budget for the Period 8.7.71-7.7.72 
60. CADU Evaluation Studies: Training of Model Farmers, Oct. 1970 
61. Sanitation Survey of Bekoji, September 1970 
64. CADU Evaluation Studies: Crop Sampling 1970, July 1971
65. CADU Annual Report 1970/71
67. CADU Work Programme and Budget 1972/73, Asella, October 1971
68. Health Survey in Sagure Village and Yeloma Farming District, April 1968, by Gunnar Arhammar and Roland Eksmyr
69. Assessment of Status of Health in an Ethiopian Rural Community (Experience of Two Years' Public Health Work in Chilalo Awraja, Arussi), by Gunnar Arhammar, May 1970
71. CADU Evaluation Studies: General Agricultural Survey 1970 (Base-Line Study for Evaluation of Impact of the Project), Planning & Evaluation Section, Asella, July 1971
72. Feasibility Study on the Establishment of a Rural General Store in Kentere, by Mehari Tesfaye, Planning & Evaluation Section, September 1971
73. Feasibility Study on the Establishment of a Saw-Mill in Asella and Connected Workshop for Wood Processing, Planning & Evaluation Section, November 1971
74. Investigations on Mechanized Farming and Its Effects on Peasant Agriculture, March 1972
75. CADU Work Programme & Budget 1973/74, Asella, October 1972
76. CADU Evaluation Studies, Co-operative Activities Before Measurement by Arne Floth, Planning & Evaluation Section, December, 1972
77. CADU Evaluation Studies Crop Sampling 1971
78. Case Study on Farm Households in the Asella Area, April 1972
80. Report on Surveys and Experiments Carried out in 1971 Crop & Pasture Section, Asella April, 1972
81. Master Plan for the Evaluation of CADU, by Johan Holmberg, Planning & Evaluation Section, October 1972

82. General Agricultural Survey 1972, Planning and Evaluation Section, February 1973

83. Continued Research on Water Resources & Supplies Within CADU's Project Areas by C-G. Wenner, Asella April, 1973

84. CADU Forestry Activities by Gunnar Poulsen, Asella, May, 1973
MINOR RESEARCH TASKS AT CADU

1. Farm Management Studies of Model Farmers in the CADU Project Area, by S. Bergholtz, July, 1969

2. The Munessa Forest, a Plant Ecological Study, by Lill & B. Lundgren, June 1969


4. Local Varieties of Wheat in the Chilalo Awraja, by G. Widerstrom, November – December, 1968

5. An Inventory of Feeding System and Feed Stuff, Chilalo Awraja, Ethiopia, by Oscar Eraldsson

6. Comparative Study on the Possibilities for Different Farm Produce in the Chilalo Area in Ethiopia, by Bo Anselmsson, February, 1972

7. An Agrobotanical Investigation of Leguminous Species in Chilalo Awraja, Especially at higher Attitudes, by Mats Thulin, May, 1972

8. Mobilizing Savings in Chilalo by Martin Lundquist Asella, April, 1973
Special Studies

S.S.1  A Preliminary Survey of Soil Erosion in the Chilalo Awraja, by Kebede Tato, September 1970

S.S.2  Decision Making in the Family, by Pia Bergman, Asella, July 1971


S.S.4  SOCIOLOGICAL PROFILE OF PROVINCIAL ELITES IN CHILALO AWRAJA by John M. Cohen, Addis Ababa, 1972