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# FOREST FOCUS

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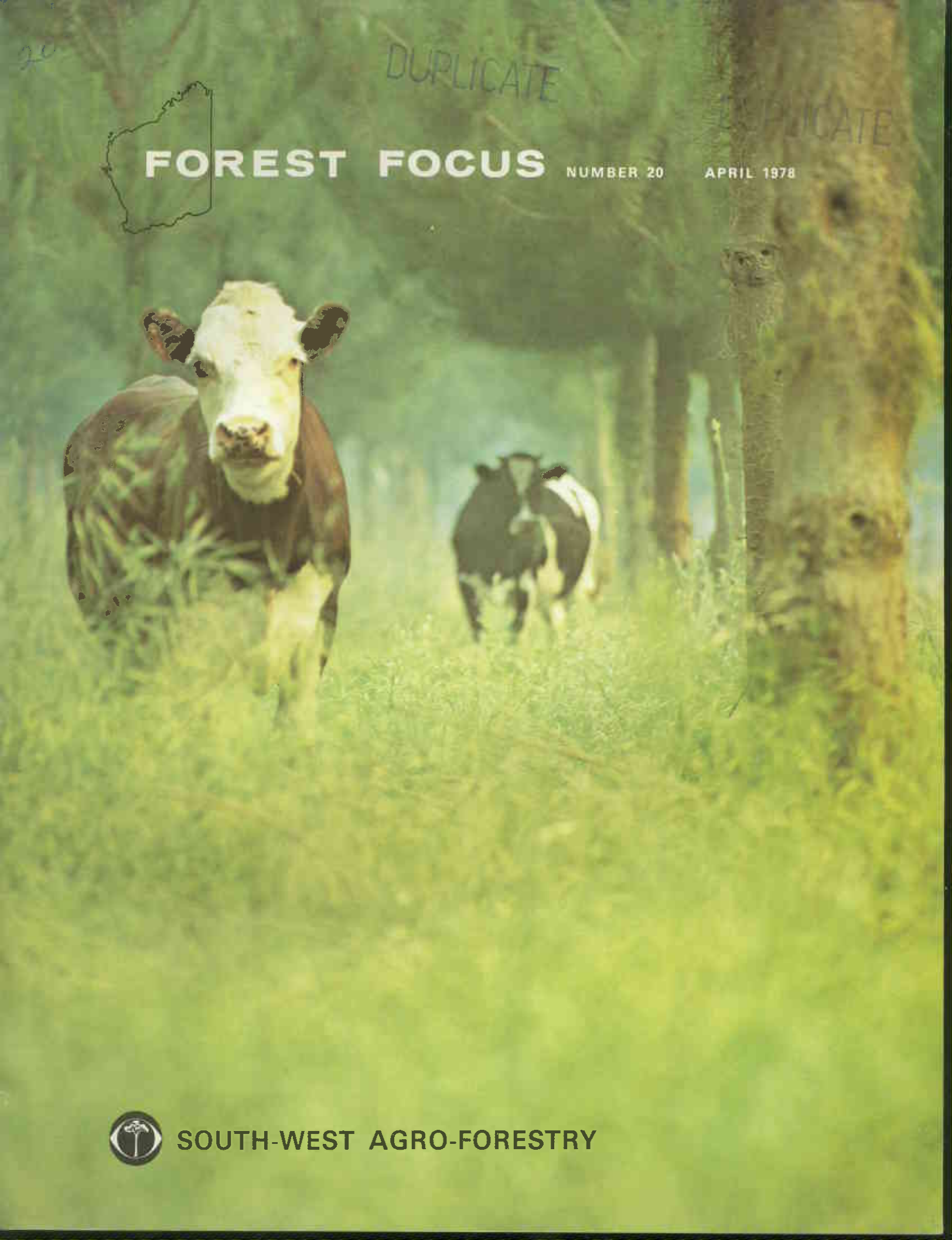

SOUTH-WEST AGRO-FORESTRY

▲ *Effects of overclearing, leading to salination and erosion.* (Dale Watkins)

▼ *A stark reminder of the thousands of hectares of karri forest ring-barked and cleared for the Group Settlement Scheme in the 1920s.* (Dale Watkins)

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*Compiled by* Dale Watkins

# Agro-forestry trials in the South-West

by Dr. F. H. McKINNELL and F. BATINI

For many years foresters and agriculturists have been in direct competition for the use of land resources in the south-west of the state where most of the forests are located.

The Forests Department was not formed for almost 100 years after the establishment of the Swan River colony, and in that time very large areas of forested land were cleared for agricultural production.

From the time the department was formed in 1918, it has fought a continuous battle to ensure that suitable vacant crown land was reserved as state forest in sufficient quantities to satisfy the needs of the state's future population.

The Forests Department succeeded in reserving 1851940 ha out of an estimated original area of 6000000 ha of commercial quality forest. This area has since been recognised as being far short of that required to provide a reasonable level of forest products for the state as well as the other multiple-use benefits of forests.

There have been many examples of prime forest being replaced by agriculture which eventually failed. Among the better known were some of the Group Settlement Schemes in the extreme south-west of the state —schemes that ring-barked and cleared thousands of hectares of prime karri (*Eucalyptus diversicolor*) and jarrah (*E. marginata*) forest. Even as late as the 1960s, the department still faced a continuing demand for forest land to be released for agricultural production.

Agriculture has made extensive changes to the landscape and to native flora and fauna in many areas. Recently, its detrimental effects on the water quality of some of the state's major streams have come into prominence.

On the credit side, agricultural products have been key factors in the early development and prosperity of this state. Wheat, beef and wool have been particularly important in the drier areas with beef and dairying predominating in the moister areas of the South-West.

Many farmers have been concerned about the effects of reserves of state forest adjoining their properties. They saw these as a source of pests (such as rabbits, foxes or native fauna), weeds and also a possible source of fire. Others considered that the foresters attitude

**Front cover**

*Cattle grazing on well-grown pasture under five-year-old pines at Kirup.*
(Greg Edwards)

**Back cover**

*Some aspects of water usage by trees in an agro-forestry situation are currently being studied by C.S.I.R.O., P.W.D. and Forests Department researchers at Mundaring and in the Wellington catchment. The centre tree is enclosed in a plastic canopy for transpiration studies.*
(Dale Watkins)

*An example of the high, steep land near Nannup being planted to pines, while the more fertile lowland is retained for agriculture.* (Dale Watkins)

to alienation of more land restricted their farm size to "uneconomic" units.

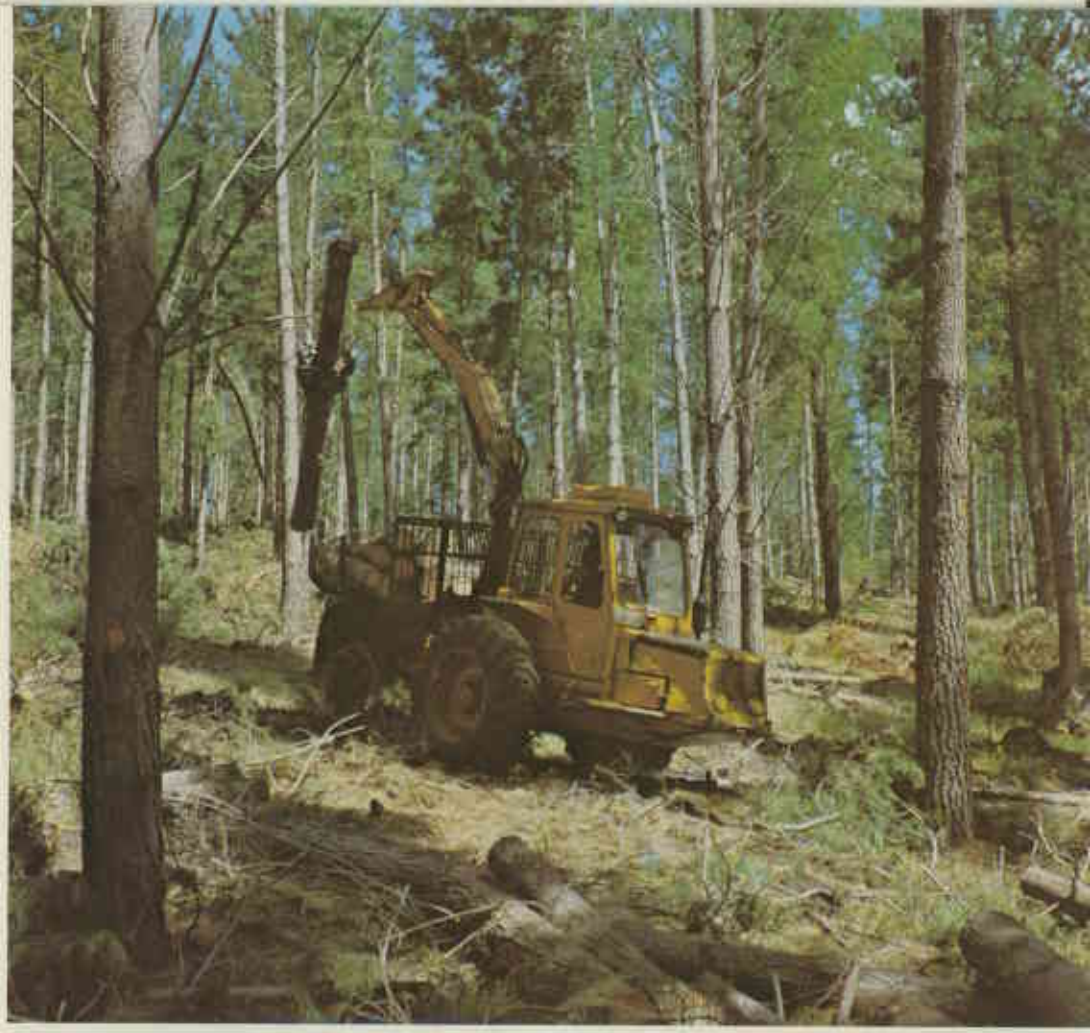
In some cases the wheel then turned its full circle and land cleared for agriculture was resumed or re-purchased and planted again to a tree crop. In water supply catchments (Helena, Collie and Metropolitan catchments) privately owned land was resumed by the Crown to decrease the level of pollutant discharge (e.g. fertiliser, weedicides, faecal matter, salt, etc.). Because of depressed butter-fat markets some farms in the "karri belt" were purchased by the Forests Department and replanted to karri.

Probably the most interesting phase has been the re-purchase of farmland in the Blackwood Valley system. In this area, some 17000 ha of farmland were re-purchased by the Forests Department on the open market, and were subsequently planted to radiata pine (*Pinus radiata*). The land purchases were concentrated in this area because the soils were known to be of sufficient fertility to grow healthy pine without the need for fertiliser.

Originally, farmers appeared to welcome the re-purchase of the poorer sections of their farms (shallow soils on steep slopes, often covered with bracken) while they retained the more fertile bottom land. Some shire councils and remaining farmers now consider that too much land was re-purchased and that this has had detrimental effects on the social and service facilities for these farming communities.

*Trees are planted on farms for many different reasons, including a shelter-belt near Wongan Hills (middle) and trees for aesthetic and shade purposes around a Koorda homestead.* (Anon.)

*In the long term, plantations will increase both employment and rural services.*
*(Greg Edwards)*



More recently, some farmers have strongly opposed the influx of privately managed pine plantations in the Blackwood Valley. These are seen to raise many problems due to absentee land-owners and these problems are very real. Further expansion of the private pine industry is now viewed by some as a real threat to the survival of the remaining farmers. Bush fire control problems are greater, weed and pest control is more difficult, and there is a loss of social amenities and a reduction in essential services such as school buses.

However, councils have been less opposed to private plantations, since these are liable for shire rates, whereas the Forests Department's are not.

These problems are common to many rural areas and in the short term there is probably some justification for the claims of the opponents of pine planting. In the long term, however, the plantations will increase both employment and rural services, and provide a degree of diversification and stabilisation to the rural economy.

Foresters have been concerned with multiple use of forest resources for many years and this has now been extended to include a mixture of trees and agriculture, both on land held by the Forests Department and on areas which are privately owned. A new word—agro-forestry—has been coined to describe this land management system.

*In addition to increasing the long-term employment situation, plantations provide a degree of diversification and stabilisation to the rural economy.*
*(Greg Edwards)*

*This 20-year-old Mungalup radiata pine plantation was thinned to a density suitable for agro-forestry. The pines were grown under ideal conditions on fertile soils and were heavily thinned.* (Greg Edwards)

## What is agro-forestry?

Agro-forestry is the term given to some combination of silviculture, that is, growing trees, and agricultural activities. It covers a wide range of activities, from grazing merely as an adjunct to the main business of timber production (which is the Forests Department's interest in this situation) to an agricultural enterprise where other products, such as wood or honey, are a sideline.

For example, we can graze sheep or cattle under pine plantations established on former grassland with relatively little modification of forestry practices. At the other extreme we can plant pines on very wide spacing so that there will be minimal timber yield from intermediate thinnings, but an annual return from hay, silage or perhaps crop production between the pines.

It is important to differentiate between woodlots, shelterbelts, trees for environmental purposes and agro-forests as very different means of achieving an integration between forestry and agriculture. These all have different objectives and will yield quite different products.

A farm woodlot is essentially a section of a farm devoted to growing trees alone, generally for the purpose of wood production, but possibly

*Tall, dry grass left around these three-year-old pines creates a dangerous fire hazard.* (Greg Edwards)

*Closely planted, dark plantation of limited multiple use.* (Greg Edwards)

with other values as well, such as erosion control. A shelterbelt is an arrangement of trees in such a way as to provide shelter for crops or livestock, with any form of production from the trees being of secondary interest, although such trees often will have a value for honey production, fuel or fodder. Trees for environmental purposes include those planted for aesthetic reasons, for shade and for the amelioration of erosion and salination.

At the present time integration of timber production and agriculture in Western Australia is confined to Forests Department pine plantations established on re-purchased farmland in the Blackwood Valley. In 1977, there were 15 grazing leases covering 1200 ha of plantation and this area will expand rapidly in the next two to three years. Eventually, about 5000 ha of departmental pine plantations will be available for grazing leases at any one time. In addition to this resource, it is possible some of the private pine plantations in the Nannup-Bridgetown area might be managed in this way.

In the past, most pine plantations in Western Australia have been managed on the European model. This involves relatively close planting and frequent, light thinnings to achieve maximum wood volume production from a pine crop rotation of 40 years or more.

In 1970, the Forests Department radically altered its approach to

*There is a very useful amount of grazing available under these pruned five-year-old pines at Kirup.* (Greg Edwards)

*Pines should be three-years-old or more, like these at Whicher, before cattle are put in to graze.* (Greg Edwards)

pine silviculture with the aim of producing more sawlog-size trees in a shorter period of time and reducing the proportion of small logs produced. A further reason for the change was the realisation that many sites in Western Australia were not capable of supporting densely stocked pine plantations in seasons of poor rainfall. In such years there have been severe tree losses from drought, particularly in the Blackwood Valley. The crop rotation is now 25 to 30 years and there are fewer and heavier thinnings.

The purpose of early and heavy thinning is to minimise competition and allow maximum growth of trees and of pasture for most of the rotation. Although the level of pasture production under pines is naturally less than that obtained under open conditions after the trees reach the age of about three years, there is a very useful amount of grazing still available.

The amount of grazing available under the pines varies at different times in the life of the pine crop. In the first two years there is virtually no reduction in pasture production compared with a pure pasture production system. From three years onwards, pasture production falls progressively. It may be largely covered, briefly, by the slash resulting from a low pruning and thinning to waste at five years. After the first commercial thinning at 11 to 12 years the pasture makes a comeback as the remaining trees are over 6 m apart. After the final thinning at 18 years, the trees are nearly 9 m apart. Preliminary research results suggest that pasture production for the final 12 years of the first pine rotation is about half that of the open pasture situation.

## Advantages of agro-forestry to the forester

To the forester there are several major benefits from integration of grazing and pine silviculture. They are:

- Control of pasture and scrub regrowth, thus reducing competition with the pines, giving easier access, better tree growth and greatly reducing the fire hazard. There is no other feasible method of reducing potential fuel for a fire in young pines. Even in old pines, fuel reduction burning, is associated with many more problems than in hardwood forests.
- Needle litter is trampled into the ground, thus hastening recycling of nutrients. Rapid nutrient recyling improves tree nutrition, therefore improving tree growth rates.
- Legume-based pasture, stock manure and periodic superphosphate, which is required to maintain the pasture, would ensure optimum tree nutrition (regular input of biological nitrogen from the legume is preferred to irregular and expensive inputs of mineral nitrogen fertiliser).
- Income from the grazing leases provides an earlier financial return and partly replaces the income

*Experimental oat crop at Wellbucket, east of Mundaring. Under some circumstances, inter-row cropping may be possible.* (Dale Watkins)

from intermediate timber yields. It also offsets annual costs such as fire break and road maintenance and the fire detection system.

## Social and economic aspects

There are also benefits to society in general from this integrated form of land use. A resource, namely the grass, which would otherwise be wasted, is utilised and maximum land use efficiency is achieved. While the forester will be relieved by the reduction in fire hazard in his plantations, there is also a regional benefit in respect of improved fire prevention.

Farmers who lease forest areas for grazing will be able to carry more stock without the large capital investment required these days to purchase more land. They will therefore be in a better economic condition and rural areas as a whole will be more prosperous. At present the leases are for one year only. To enable the farmer to plan his activities to take advantage of more land, longer term leases are desirable. In the near future three or five year leases are likely to become more common.

One of the basic problems with the Forests Department's farmland purchase policy, from a local government point of view, has been the loss of council rates on land owned by the Crown. When a plantation area is leased for grazing, the lessee is liable for rates, so the shire council also gains from integrated land use.

Integration of livestock grazing and silviculture promises to provide a cushioning effect to the local economy from the impact of withdrawal of land from agricultural to forestry use. Whereas under a more classical silvicultural system, there would be little return to the local economy (apart from the employment of forest workers in the establishment, tending and protection of the plantations) until the first commercial thinning at about the age of 15 years, agro-forestry does permit much earlier inputs to the economy.

▲ *New, ungrazed pasture under heavily thinned and high-pruned pines, Wellbucket.* (Dale Watkins)

## Research

Although agro-forestry is used operationally in Forests Department plantations, there is still much to be learnt and many areas where our knowledge is deficient. Active research is continuing in the South-West and near Perth in co-operation with the C.S.I.R.O. Division of Land Resource Management.

The concept of agro-forestry for timber production was initiated in W.A. in 1972 by Forests Department research officers, although there had been isolated examples of unofficial grazing as early as 1960 in a radiata pine plantation near Nannup.

For many years, grazing in parts of the indigenous eucalypt forest has also occurred. In many cases, grazing pre-dated the dedication of state forest and was then allowed to continue. The tuart (*E. gomphocephala*) forest has been grazed intermittently for over 140 years where it is a useful means of reducing the fuel hazard. In this area, some degree of damage has occurred. In the eastern jarrah and wandoo (*E. wandoo*) forest, considerable grazing has also occurred, apparently with minimal adverse impact.

Various aspects of grazing in pine plantations have been studied at the Forests Department's Busselton Research Station since 1972. Early work was aimed at the evolution of field practices to permit use of grazing mainly as a fire prevention measure. More recently research has turned to evaluation of herbage production under varying methods of silviculture, such as wide spacing and extra high pruning, and the effect of such silvicultural practices on tree growth habits and wood quality.

The following guidelines are now used for grazing livestock in departmental plantations:

- Sheep may be grazed between the pines from the time the trees reach an average height of 2 m (that is, an age of two to three years depending on site quality).

Some browsing of lower limbs will occur but this is not serious while the pasture is green. When pasture is dry, bark biting may become prevalent and the sheep must be removed from the pines at once.

- Cattle can be grazed in the pines only after most tree heights exceed 4 m, or a minimum age of three years on good sites.

There have been relatively few problems with the stock browsing pines in Western Australia provided these guidelines are adhered to. However, it must be stressed that careful supervision of the grazing is necessary in young pines to enable withdrawal of the stock if any unforeseen problems arise.

There is a period of at least two years from the date of planting where no grazing in the pines is permitted due to the danger of browsing by stock. Since it is highly desirable to utilise the grass in those two years, some of the current research is focussed on that problem. Two options seem to present themselves: either determine the factors which pre-dispose the pines to browsing by stock and find a way around them; or avoid browsing by cutting hay, silage or even cropping between the rows of pines.

The first approach holds much promise since early work in Western Australia and in New Zealand has shown that sheep, at least, can be successfully grazed in very young pines—sometimes! There are probably several factors involved, such as sheep age and breed, preconditioning of grazing habits and pasture composition. Some of these factors are currently under study by the C.S.I.R.O. team from the Division of Land Resource Management at Floreat Park in a co-operative project with the Forests Department. There is clearly much to be learnt in respect of pasture and grazing management under our conditions. Some successful trials using calves in young pines have also been carried out, but their general use cannot be recommended at this stage.

The second approach is applicable only in relatively gently sloping country suitable for tractor working, but has no real problems and could be utilised at any time. Inter-row cropping with, for example, linseed, may be possible in the first few years but at later stages there could well be damage to tree roots by any cultivation required to establish the agricultural crop.

In the near future it is more likely that hay or silage could be cut between the pines. To facilitate this the rows could be widened to 5 m apart instead of the 3·5 m spacing currently used in Forests Department plantations. Under these conditions, the herbage yield is likely to be very little different from open pasture for at least four years after the pines have been planted. Some experimental harvesting of hay was successfully carried out in 1977.

One aspect of interest at the present time is to what extent we can accept some loss of timber production to gain the maximum possible grass production. One of the main factors restricting grass production under pines is light availability at the soil surface. If all trees were high pruned to 5 m above the ground light availability would be significantly improved. One could, of course, continue to prune the trees up as they grow to heights of 15 m or more, although this would be very expensive. The increased grass production should, in theory, pay for this over the succeeding few years but there is no data yet available to confirm this. A number of field studies are in progress at Wonnerup, near Busselton, and at Wellbucket, east of Mundaring. The latter has been partly funded by a grant from the Reserve Bank.

The other major tool available for improving the grass production is to reduce the tree stocking, either by planting at very wide spacing, or by thinning more heavily than usual. There are limits to thinning intensity as wood quality can be affected. An immediate tree response to wider spacing is increased branch development. The lack of competition for light by closely adjacent trees permits branches to remain growing vigorously for a much longer period, thus forming larger knots in the timber. Although these large knots are "green" knots and therefore remain tight (dry knots sooner or later fall out of seasoned timber) they greatly reduce timber strength. Large knots are one of the most serious defects of pine timber and all timber grading rules relegate pieces containing them to the lowest grades, which give lower financial returns and have poorer marketing opportunities.

*Pine boards degraded by large knots, one of the most serious defects of pine timber. Larger board 170 mm wide.* ▲

(Greg Edwards)

*The hydraulic high-pruning tools in use here were developed by the Forests Department from horticultural pruning implements.* (Greg Edwards)

To produce high quality timber in a widely spaced tree crop it is essential to prune off the limbs in the lower part of the tree trunk before branch size has become excessive. Strict timing of the pruning operations is therefore very important.

The wood which is laid down on the pruned section of the bole after pruning will be clear of all knots and thus of high value. It can be used for joinery and is also highly suitable for exacting engineering purposes, since clear timber has higher strength, due both to the absence of knots and the higher wood density which results from the intensive pruning treatment.

## Agro-forestry for farmers

If agro-forestry is to have any large scale appeal to farmers, it is essential the tree component of the system be readily saleable, or produce a readily saleable item. While the use of fruit or nut trees can be visualised under some circumstances, it is likely that timber yield will be most important under West Australian conditions, where a shortage of locally grown hardwood timber is forecast for the next 20 to 30 years.

For most sites in Western Australia where agro-forestry is likely to be successful, the principal tree species will be radiata pine, due

*The importance to successful tree establishment of strong planting stock and complete control of grass competition cannot be over emphasised.* (Dale Watkins)

to its high growth rate and the ready marketability of its timber.

So far the major expansion of agro-forestry has taken place on former farmland purchased by the Forests Department for pine planting. To what degree is it applicable to a farming enterprise?

There is considerable scope for farmer planting of pines, provided the planting is carried out in an area where:

- The soils are suitable. The best pine soils are the best pasture soils, that is, red loams or sandy loams with a minimum effective depth of 90 cm. Slopes steeper than 14 degrees should be avoided as such areas pose difficulties in later harvesting of the timber.
- The rainfall is a minimum of 850 mm per year.
- The plantation is within a reasonable distance (say, 50 km) of a likely processing plant. A mill is likely to pay less for logs which have to be transported greater distances.
- A minimum area of at least 4 ha is planted. Smaller areas are not attractive to a logging contractor.

Advantages to the farmer would be a diversification of farm activities and, in the long term, increased income with comparatively little input of his time.

The economic value of agro-forestry to a farmer is the subject of much debate and considerable disagreement. One analysis of pure beef farming with an integrated beef/pine enterprise in the southern tablelands of N.S.W. indicated that the integrated management system had more than twice the present net worth of the beef-only-system. That is, in the long term an integrated pine/beef management system was more profitable.

However, there is no way of overcoming the major disadvantage from a farmer's viewpoint—that of the long wait (at least 15 years) between the time of planting and the first harvest. The financial returns from the first thinning are, in any case, not great. The major income is realised at the clear felling stage—about 30 years in the case of radiata pine.

With such a long time scale there could also be problems with maintenance of owner interest. This is especially important in view of the need for strictly timed pruning to control branch size development.

What levels of timber yield might a farmer expect from widely spaced trees grown on his pasture?

This is a difficult question to answer, since no one has been managing land in this fashion for more than a few years, and the yield in any case is highly dependent on the quality of the site. Site quality is affected mainly by soil fertility and moisture availability as determined by rainfall and soil depth.

One of the Forests Department's thinning experiments does, however, include a treatment which is in the range which could be considered for agro-forestry. The pines were planted in 1957 on a former farmland site near Collie. About 1000 trees a hectare were planted and they were all low pruned (all branches removed to a height of 2·1 m from the ground) at five years, then high pruned to 5 m at eight years and again at 12 years to 10 m.

The stand was thinned to waste at eight years from 1000 to 500 trees a hectare, then two commercial thinnings were carried out at 12 and 20 years, from 500 to 250 and from 250 to 125 a hectare respectively. The first thinning at 12 years produced 32 $m^3$/ha of pulpwood and 77 $m^3$/ha of case logs suitable for sawing into rough cases or pallet material. The thinning at 20 years produced a further 30 $m^3$/ha of pulpwood and 145 $m^3$/ha of high quality sawlogs, and in the 125 trees a hectare still remaining there was a further 197 $m^3$/ha of sawlog size material.

If fewer trees were planted in an agro-forestry enterprise the yield would probably be reduced in proportion. It must be emphasised that this was a very high quality site and there are not many areas which would provide yields of this magnitude. Nevertheless, these figures do illustrate the potential production.

It must be stressed that successful production of sawlogs under these conditions is vitally dependent on strict timing of pruning treatments and the early thinnings. Timing of later thinnings is more flexible.

It is also important that the initial establishment of the pines in pasture be carried out efficiently. Strong planting stock and complete control of grass competition for the first 12 months are essential. Competition can be readily eliminated in grassland by spraying a band about 1 m in width with a suitable weedicide, and planting the pine seedling in the centre of the band. Some soils which have been compacted by livestock may also require ploughing, preferably with a chisel plough.

## Further aspects of tree planting on farmland

Not all tree planting on farmland need be undertaken with the primary object of timber production. There are other benefits from tree planting, such as control of soil erosion, the reduction of flooding and siltation in streams and reservoirs, and the provision of shelter for homestead and livestock.

Shelterbelt planting is not widely practised in Western Australia, which is surprising in view of the known benefit to livestock from provision of shade in our hot, dry summers. Properly designed and maintained shelterbelts could be

expected to significantly reduce wind speed, and wind is a major factor affecting water consumption by crops and pasture. Decreased evapotranspiration would mean improved crop or pasture production.

The benefits of systematic shelterbelt establishment have been extensively studied in North America and Europe, and they are widely used in the Great Plains of the U.S.A. and in Russia.

For many years, farmers have improved the aesthetic appeal of their homesteads by planting with trees and the Forests Department has, for over 70 years, provided nursery stock at or near cost. In more recent years, sales depended largely on farmers' affluence, but quantities around the 150000 to 200000 seedlings a year have been sold.

The Forest Department has established over 60 arboreta, covering a wide area of the south-west of W.A., to demonstate the most suitable trees for shade and shelter planting, and will provide advice on selection of species and establishment practices.

A major potential use of tree planting on farmland in Western Australia is for the amelioration of salt-affected land, particularly in catchment areas supplying domestic or irrigation water.

The major streams of south-western Australia: the Swan-Avon system, the Murray and the Blackwood are brackish or saline, largely as a result of agricultural clearing. Other streams in major catchment areas, such as the Collie and the Warren, are of marginal quality as the result of agricultural clearing. One of the techniques to avoid increases in salinity has been to resume farmland. This has occurred on the Helena and the Collie catchments but the cost of resumptions is high and there are limits to the use of this approach. If, however, a suitable system of integrating forestry and agriculture could be found, such that the agricultural potential was retained and the trees reduced the flow of water and salt into the streams, then a solution that was economically, socially and politically more acceptable might be achieved.

Some aspects of water usage by trees in an agro-forestry situation are currently being studied by C.S.I.R.O., Public Works and Forests Department researchers at Mundaring and in the Wellington catchment.

Since the increase in stream salinity can be correlated with degree of clearing in catchments, it would seem logical that reforestation of cleared land should reverse the salinity trends.

For example, it has been recognised that reforestation within the Collie catchment could partly or completely restore original salinity levels. On present knowledge, particularly if only partial restoration is the object, it is expected that an appropriately designed programme could succeed with considerably less than 100 per cent reforestation. Thus it has been variously assessed that replanting of between 100 and 300 $km^2$ of the total cleared area of 640 $km^2$ in the Collie catchment could attain a target mean annual salinity of 400 to 500 mg/l. This compares with the present expectation that the salinity will stabilise around 1100 mg/l under present catchment conditions. Such a reforestation strategy if selected would constitute a major programme and take considerable time (15 to 20 years) to achieve its full effect.

Agro-forestry is a flexible concept which can be oriented to satisfy the particular requirements of the farmer or the forester. It is a technique of land management which is uniquely suited to Western Australian situations. If it is used extensively by farmers it might contribute usefully to the state's timber production in an era when our timber resources may prove inadequate for our needs. It promises to stabilise the income of farming communities, particularly in the central South-West. It will improve the fire protection of state pine plantations and it may possibly be the means by which river catchments may be managed to produce a balanced yield of wood, agricultural products and potable water.

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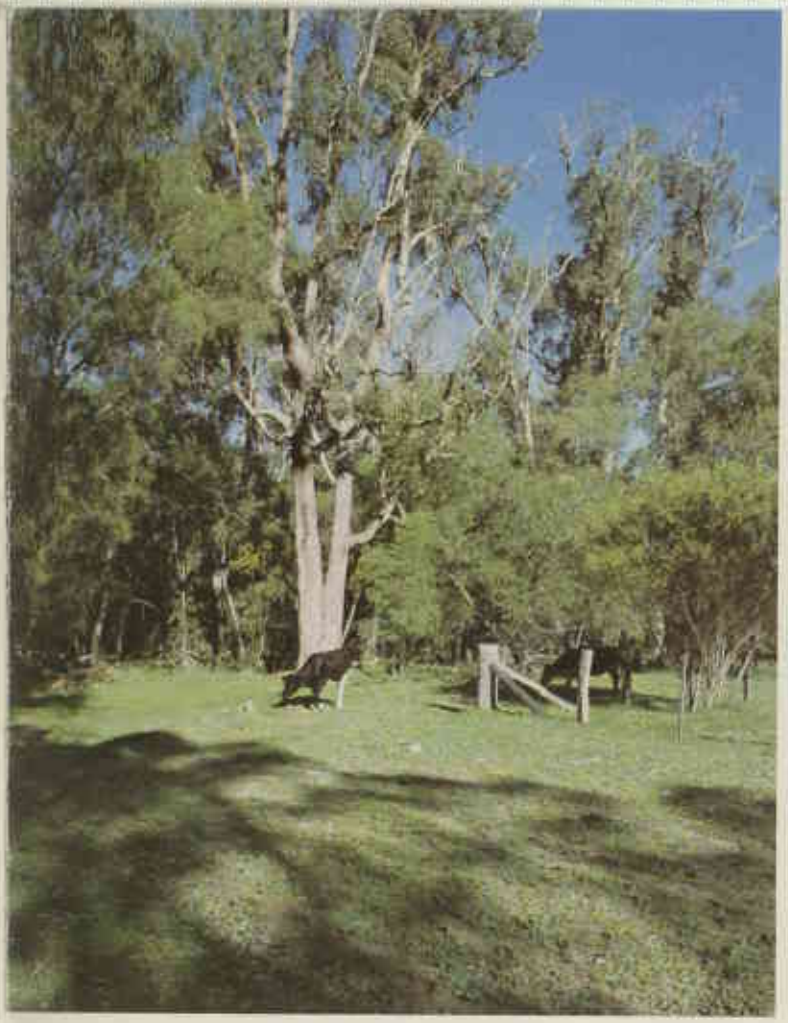

*For many years, grazing has occurred in parts of the indigenous eucalypt forest. The tuart forest, above, has been grazed intermittently for over 140 years. The crop, below, is grown under thinned marri forest on Cook Bros.' property, Coondle, north of Toodyay.* (Dale Watkins)