Forum

Conserving and Planting Trees on Farms: Lessons from Australian Cases

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Background

Trees on farms can be used for a variety of purposes. These include shelter for stock, crops or pastures with consequent possible increases in productivity, the control of erosion (both gully and wind erosion), aesthetic appeal, the provision of farm wood and timber, the supply of commercial timber as in the case of agroforestry and sometimes farm trees may provide a fodder reserve for drought. They may also be a source of fruit and nuts, honey, eucalyptus, cork and pharmaceutical and chemical supplies and a habitat for wildlife. In some areas, evapotranspiration from deep-rooted trees may keep ground watertables from rising and so keep salting of soils and streams at bay.

One can of course, add to this list of possible benefits of trees on farms but it would be wrong to conclude that trees on farms are always beneficial from an economic point of view. Tree densities can be so high that they reduce the value of the land for grazing or agriculture. Or trees on the property might not be optimally grouped from an agricultural productivity point of view—for instance, they may be scattered and not provide suitable windbreaks or they may interfere with the operation of machinery used in cultivation. The latter factor has been important in decisions to remove hedges in Britain (Helliwell 1969). Very often if net benefits are to be realized from trees they must exist or be planted in a particular pattern.

In assessing the costs and benefits of the provision of trees on farms, it is useful to keep in mind the distinction between private cost-benefit analysis (CBA) and social cost-benefit analysis (Hufschmidt *et al.* 1983). The aim of private CBA is to maximize private net benefits (private gains less private costs) whereas the aim of social CBA is to maximize social net benefits (community-wide gains less community-wide costs). It is, of course, socially optimal to maximize social net benefits of tree provision on farms but private decisions are likely to be based on private CBA and this may result in socially inadequate provision of trees on farms.

In many cases, the community's benefits from tree provision on a farm will exceed the gains to the individual farmer. For example, runoff may be less rapid after rain where there is tree cover and this may mean less silting and likelihood of flooding in drainage areas. Other spillover benefits may include wildlife conservation and aesthetic appeal for passers by.

If social net benefits exceed private net benefits from tree provision, farmers may not retain or provide enough trees from a social point of view (such a divergence provides a rationale for the National Tree Program). This type of market failure is illustrated in Figure 1 for a hypothetical case. There curve *ABC* represents the marginal private net benefit of tree provision on a property. Hence, private net benefits are maximised when x_2 trees are on the property. However, marginal social net benefits

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as shown by curve *DEF* exceed marginal private net benefits, and thus the socially optimal number of trees on the property x_3, exceeds the number provided by the farmer.

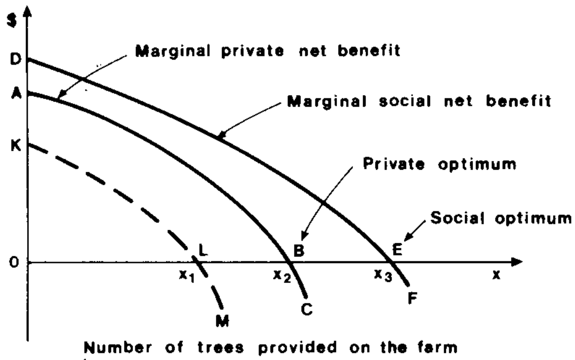

Figure 1: Possible divergence between the private and social optimum in tree provision on farms.

Some farmers may fail to realize the actual extent of private benefits from trees on their farms. For example, a farmer may believe that his marginal private benefits are like those shown by curve *KLM* and provide x_1 trees on his property whereas from his own point of view x_2 are optimal. In such a case it is possible to improve the farmer's choice by providing him with improved information. In this case, the farmer is better off and he also makes a better decision from the point of view of society when given greater information. It is always a happy situation when by providing improved information one can increase private and social gains from environmental decisions. To some extent the strategy (discussed later) of the Victorian Garden State Committee (V.G.S.C.) and the Victorian Farmers and Graziers Association (V.F.G.A.) in promoting farm trees is intended to take advantage of this parallelism.

In providing farm trees, a farmer has many alternatives to consider: Should he concentrate on conserving and maintaining existing trees? Should he consider replacing these trees by other varieties and if so which variety? Would he be better to concentrate on trying to regenerate local trees or to replant with seedlings? What pattern of tree cover should he attempt to establish? There are several complications to be taken into account. Take for instance regeneration. This may require areas to be fenced off or protected from stock while regeneration takes place. Similar costs are also likely to be incurred if planting seedlings. However, regeneration is uncertain—it depends on the suitability of the site and the availability of tree seeds in the area. Weeds, especially near cattle camps (Cross 1984), may interfere with regeneration and there is a risk of rubbish or non-climax trees or shrubs being propagated. Delays in self-establishment, the need for a particular tree pattern and type of tree may all tend to favour planting of tree seedlings. Nevertheless in some cases judicious stocking rates and appropriate spelling of paddocks may do much to encourage recovery of natural vegetation where this is required on large grazing properties, and in the long-term this may be the most effective method of sustaining production levels from grazing (cf. van Rensburg 1983, pp. 51–2).

Australia is a large country with varied environments and several types of agriculture. One therefore, has to be wary in generalizing from case studies carried out in one or a few localities and in applying results obtained in one State to make recommendations for another State in the Commonwealth. Nevertheless, if this proviso is borne in mind, it is useful to consider some case studies that have been done in Australia (*see* also Howes and Rummery 1978; Moore 1983). Four cases are outlined in turn: (1) shelter-belts and an economic study of trees on four Victorian farms, (2) the economic benefits of saving trees from dieback on the New England Tablelands as evaluated by Sinden and others, (3) the economics of agroforestry on the Southern Tablelands of N.S.W. as evaluated by Gisz and Sar, and (4) the economic aspects of dryland salting.

Case (1) is designed to indicate the net private benefits of trees on farms through their complementary impact on pure agricultural production. Case (2) examines the value of trees on farms in view of pure public good or collective good characteristics associated with them. Case (3) considers the private net benefits in particular cases of a system of mixed production involving agriculture and forestry, and Case (4) illustrates possible favourable production externalities on farms from the retention or provision of trees. Cases (2) and (4) concentrate on social dimensions in dealing with possible sources of market failure in tree provision on farms. The other two cases focus on private net benefits and *may* also provide information which improves the decisions of farmers from a social point of view. In the latter respect, two types of social benefits are possible: (a) farmers' decisions may be improved from a private point of view and resource-use improved, and (b) these improved decisions may give side benefits beyond the benefits to the individual farmers, for example, through public-good benefits from tree provisions or favourable production externalities. Improved information may have a social net benefit even if only possibility (a) is present, that is if there are no side or spillover benefits.

Shelter Belts and Trees on Four Victorian Farms

The value of shelter belts in raising agricultural productivity has been demonstrated in many countries. In Jutland (Denmark) and in northern Germany, the sole reason for planting and managing shelter belts and tall hedges is for increased agricultural production (Baltaxe 1961; quoted in Helliwell 1969). Bird (1981) points out that "there is ample evidence from studies in U.S.S.R., U.S.A., U.K., Germany, France, Switzerland, *etc.*, that shelter can improve crop yields by at least 25 per cent, pasture yields by 20–30 per cent, dairy milk production by 10–20 per cent". Bird provides American data (*see* also U.S.D.A. 1957) indicating approximately a 20 per cent increase in crop yields as a result of shelter belts and says that these results are consistent with those obtained at the Frankston Vegetable Research Station, Victoria. He also notes research at Hamilton (Victoria), which indicates that lamb mortality may be reduced by up to 50 per cent, and the survival rate of shorn sheep is raised, by provision of shelter. When stocking rates are approximately adjusted, total wool production can increase by more than 30 per cent and sheep liveweights by 20 per cent as a result of the provision of shelter in cold areas such as Armidale (Lynch, *et al* 1980).

Nevertheless, economic evaluation of shelter belts requires a number of productivity elements to be taken into account which are neglected in the above studies. Possibly the brief economic study of trees on four Victorian farms reported by V.F.G.A. and V.G.S.C. (1984) should also be put on a sounder economic basis than at present. Reported claims appear to exaggerate the private benefit of trees on farms.

Variations in yields of crops and pastures as a result of the provision of shelter belts are typically estimated from the inside *edge* of the shelter belt (Bird, 1981; Seipen, 1983; Sturroch, 1981; Breckwoldt, 1983; Forest Commission, Victoria, 1972). While crop/pasture yields near the shelter belt decline due to shading and competition, yields further out increase considerably due to the protection afforded from wind by the shelter belt. A typical pattern might be like that shown in Figure 2 (*cf.* Breckwoldt, 1983). On the leeward side of the shelter belt, crop/pasture production may on balance increase by 20 per cent. Increased crop/pasture production may occur for a distance of approximately 15 times the height of the shelter. However, realistically potential production on the areas occupied by the shelter must be subtracted from total production. In many cases, this is equal to the height of the shelter. If this is so the net increase in yield over the areas subject to the shelter belt amounts to 12.5 per cent rather than 20 per cent. However, if the increase in yield on the leeward side is only 10 per cent the net overall gain in crop yield is only a fraction over 3 per cent. If yield on the leeward side increases by less than 6.67 per cent (on balance), overall crop/pasture yield falls in the area modified by the shelter.

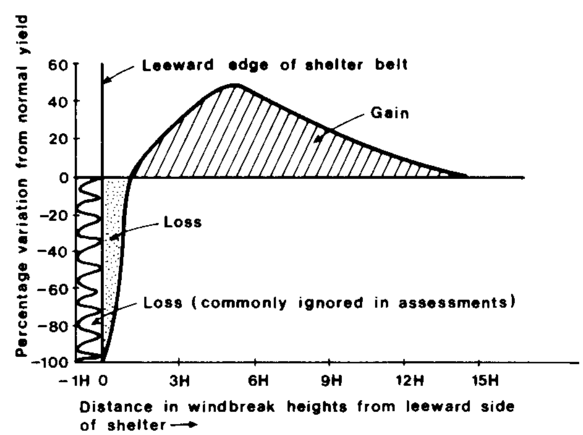

Figure 2: Yield variation of a crop or pasture as a function of the provision of a windbreak or shelter belt.

In order to obtain the long-run private benefits to the farmer of a shelter belt, it is necessary to take into account the change in his/her *profit*. Increases, say, in total revenue from greater production may overstate gains. This will be the case if higher costs are involved in greater production. Most studies only consider the increase in total production as a result of the provision of a shelter belt but this is inadequate from an economic point of view.

If a shelter belt has to be established, costs are involved in establishing it. Table 1 sets out the costs which the V.F.G.A. and the V.G.S.C. suggest are involved in establishing a three-row shelter belt. The actual cost, however, can be expected to be much higher because a number of years has to elapse before the shelter belt grows and provides effective shelter. During this period, interest is foregone on the money invested in establishing the belt and this should be taken into consideration as part of the cost. Furthermore, if the area in which the shelter belt is being established has to be fenced off from stock and/or withdrawn from cropping, the *net* value of production foregone on this area during the period of establishment has to be added to the cost of establishing the belt. When account is taken of such considerations the cost of establishment is much increased.

Table 1: Cost per 100 m of a Typical Three-row Shelter Belt

Cost Item	$
Fencing	180
Cultivation	40
Trees	50
Planting	40
Replacements (10 per cent)	5
Follow-up weeding	25
Weedicide	10
Vermin control (home-made wire guards)—	
materials	40
labour	30
Total (per 100 m)	$420

Therefore, to establish a shelter belt on one side of a 20 ha square paddock (450 m) costs $1,890.

Source: V.F.G.A. and V.G.S.C. (1984).

Table 1 indicates that the costs of establishing a shelter belt on *one* side of a 450m square paddock are $1,890. But one shelter belt is unlikely to shelter the whole paddock. If the shelter belt is 10m high and provides protection for 15 times its height, three shelter belts would be required to shelter the whole paddock. On this basis the cost could be of the order of $6,000. When account is taken of foregone production and interest during the establishment period, this cost could well increase to $12,000 to $15,000 per 20 ha paddock.

Furthermore, the estimates used by the V.F.G.A. and V.G.S.C. may paint an inadequate picture in another respect. Benefits have not been estimated as increased private net profits in these case studies. For example, one of the benefits to farmer C from shelter is said to be a 15 per cent increase in carrying capacity of ewes on a 20 ha paddock. It is claimed that since the *market value* of a ewe is $25 and an extra 26 ewes can be carried on a 20 ha paddock on farm C, the annual benefit to the farmer is $650. But this exaggerates private net benefits, if the net *income* per year per ewe is less than $25 as seems likely. Values of assets and sizes of income flows should not be confused in cost-benefit analysis.

Calculations of private economic benefits from shelter belts on Australian farms need to be based upon acceptable economic principles which often differ from accounting practices. It could well be (in fact, it is likely) that the provision of shelter belts on many farms is still privately profitable but the picture appears to be less rosy than that painted in this case study. There is also a need to supplement adequate economic analysis by further scientific and experimental work in Australia so that we have more knowledge about possible variations in yields for different crops in different localities as a result of the provision of shelter.

From a social point of view, other benefits from the provision of shelter belts need to be taken into account. For example, belts may reduce water run-off (thus reducing water-erosion, siltation and flooding), reduce wind-erosion, provide a suitable habitat for wildlife which is valued, and over a wide enough area may result in favourable climatic effects. In addition they may have aesthetic appeal. These possible benefits need to be measured and to be carefully calculated from an economic point of view. Sinden and collaborators have examined these in relation to Eucalyptus dieback in the New England region.

Eucalypt Dieback and Farm Income: A New England Case Study

An economic evaluation of the dieback problem in the New England area has been undertaken by Sinden, Jones and Fleming (1983). Their approach is based on willingness to pay principles and takes account of income benefits to farmers from a reduction in tree cover plus the willingness of the community at large to pay for the retention of tree cover on farms (Sinden and Jones 1983). The private farm income benefits from reduced tree cover were estimated from a cross sectional sample of farms in the area. The willingness of householders to pay for the retention of tree cover was *inferred* from a sample survey designed to elicit the maximum amount which households would be prepared to contribute towards research to prevent dieback in the region.

The results of Sinden *et al.* (1983) indicate that dieback in the New England area has been a net benefit to the community. Dieback has permitted stocking rates of livestock to be increased (for example, due to greater pasture cover) and this has meant, on average, a $2,000 increase in annual income per property in the area. The total increase in net farm income in the shires of Dumaresq, Uralla and Walcha as a result of woodland decline is conservatively estimated at $1,666,000 by Sinden and Jones (1983). They estimated that each household in the area (most households were in urban centres such as Armidale) is prepared to pay (on average) $6.84 per year to preserve trees in the area and that the aggregate amount they would pay is $79,000 per year. On this basis, they concluded that dieback to the extent that it has occurred in New England has been socially beneficial.

However, their calculations take no account of the possibility that residents outside the Tablelands area might be prepared to pay something for tree preservation in the area. The effect of trees on run-off, pest control (Davidson 1982; Tisdell 1983), and soil erosion is also neglected. They do suggest, however, that if dieback should proceed further, it could impose a net social cost on the community. Nevertheless, their conclusion is that it would not have been economic to save the trees that have so far disappeared in the New England area due to dieback. This of course does not show that it would be uneconomic to plant shelter belts in the New England region or even engage in agroforestry there—even though there is independent evidence to suggest that widespread agroforestry is not likely to be economic in the New England region at present (Sinden, pers. comm.).

The research by Sinden and collaborators represents the first attempt in Australia to take specific economic account of public good or collective good characteristics associated with tree cover. Their case illustrates the point that public good characteristics are not in themselves *sufficient* to justify a policy of tree conservation. Their analysis is also based upon the premise that tree cover on farms constitutes a mixed good (Barkley and Seckler 1972) that is a good with private characteristics for the landholder and with pure public characteristics for the community at large.

Mixed good characteristics of tree cover on farms can be illustrated by Figure 3. This represents a simplified example. Suppose AB represents the marginal cost of altering tree cover (in practice, as pointed out by Tisdell and De Silva (1983) this is likely to be asymetric) and let curve CEF represent the marginal private on-farm benefits of altering tree cover. If farmers are well informed one would expect tree cover to be adjusted to x_1. However, there may be a collective demand for tree cover from urban dwellers and others for instance to enhance the scenic beauty of the countryside. If the sum of the social marginal evaluation of the characteristics of tree cover that can be collectively enjoyed is as shown by curve D_1D_1, the marginal social value of providing tree cover is represented by curve GEF. Ignoring the possibility of production externalities, well informed farmers will provide a socially optimal amount of trees. The collective demand element is irrelevant in this case from a Kaldor-Hicks point of view.

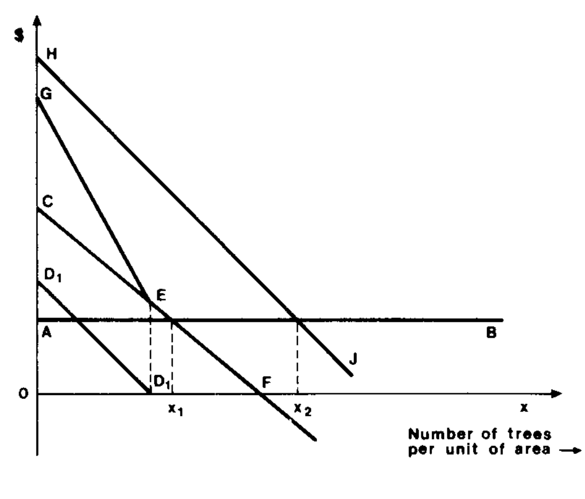

Figure 3: Illustration of the mixed good characteristic of trees on farms.

However, if the social marginal evaluation curve of public characteristics of trees is positive at x_1, farmers will not provide a socially optimal amount of tree cover. For example, if the demand for public characteristics amounts to the difference between curves *HJ* and *CF*, the marginal social value of tree provision is represented by curve *HJ*. In that case, the socially optimal amount of tree cover is x_2 and farmers will undersupply tree cover by $x_2 - x_1$ from a Kaldor-Hicks viewpoint. The public good characteristics of trees on farms are Paretian relevant in this case whereas they are Paretian irrelevant in the previous case. The problem parallels that for Paretian relevant and irrelevant externalities (Tisdell 1970; Walsh and Tisdell 1973). It should be noted that production-type externalities from tree provision are not taken into account in the above exposition but could also be allowed for. They are the main focus of attention in the dryland salting case considered below.

Agroforestry: A Southern Tablelands (N.S.W.) Study

Gisz and Sar (1980) and Gisz (1982) have considered the economics of agroforestry on a property near Tarago on the Southern Tablelands of N.S.W. They consider the alternatives of operating a purely sheep-grazing enterprise involved in wool production with the alternative of an integrated enterprise of widely spaced radiata pine and sheep grazing. It is assumed that the radiata pine is managed for saw logs and the sheep are managed basically for wool.

In their 1980 analysis they found that the "sheep only" alternative was more profitable than agroforestry at a rate of interest of 9 per cent or more. In 1982, however, Gisz was able to revise these estimates in the light of actual experience with costs and productivity of the agroforestry enterprise. When this was done, the economics of the agroforestry enterprise from the point of view of the farmer was more favourabie. The new estimates indicate that agroforestry at the Tarago property is more profitable than the sheep only alternative at a discount rate of less than 12.75 per cent.

Gisz (1982), p. 10) concludes his study as follows:

> For the case-study farm, the analysis shows that agroforestry compares favourably with the sheep-only alternative when evaluated in terms of N.D.R. (net discounted return) per hectare at discount rates of less than 12.75 per cent. To generalize from this to other sites is hazardous because of the specific assumptions and limitations underlying the analysis.
>
> As a potential land use alternative for farms suitably located in relation to processing facilities, factors which should be considered include: availability of labour and management skills needed to produce high-quality saw logs; the relative profitability of alternative enterprises; the availability of capital to establish the agroforestry enterprise; the investor's assessment of risk and attitude to long-term investment; and potential benefits derived from agroforestry in mitigating soil erosion problems and buffering against periodic slumps in markets for agricultural products.

One needs to keep in mind that the economics of land-use alternatives is subject to variation so updating of calculations is required on a continuing basis. One may also need to consider from a social point of view the spillover or externality qualities associated with particular species of trees and types of agroforestry, for example, roles of these in preserving wildlife. There has been some criticism of the use of *Pinus radiata* in Australian plantations on the grounds that it does not provide suitable habitats for native wildlife.

Production possibility curves can in principle be used to analyze the economics of agroforestry or mixed productive systems involving trees as explained by Filius (1982). However, since the usual rendition of these concepts is static, time is not adequately accounted for. From a practical viewpoint one has to consider alternative time-paths of production strategies as done by Gisz. Nevertheless, some useful conceptions do follow from a consideration of production possibilities.

Five alternative types of production possibility sets are indicated in Figure 4 for a landholder. Assuming that the landholder does not influence the price of the products, it is only in cases (4) and (5) that mixed production (agroforestry) will always be optimal for profit maximization. In these cases forest production is complementary to agriculture. For the production possibility sets marked (2) and (3), agroforestry may maximize profit. It does not, however, do so when a corner solution at *A* or *B* prevails as will arise when the price of agricultural products is high relative to forest products. In case (1), there are increasing returns to specialization in production and agroforestry never maximizes profit—it pays to specialize either in agriculture or in forestry depending upon relative prices. Note that in cases (4) and (5) forest or tree products may as such have no commercial value yet it would be privately profitable to grow trees on farms. These cases would be in accord with the Victorian case studies mentioned earlier.

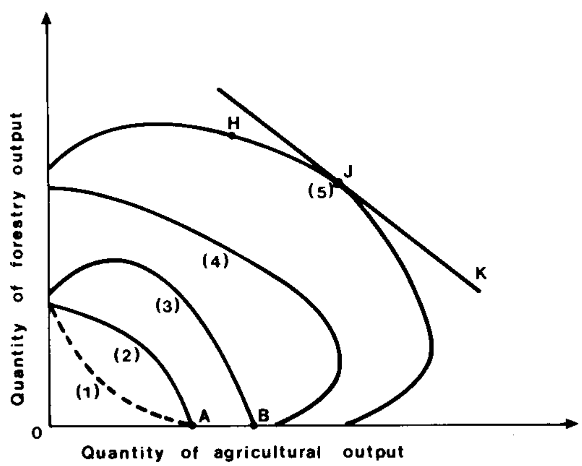

Figure 4: Implications of some different types of production possibilities curves for agroforestry.

Naturally, agroforestry or a system involving trees on farms need not always be socially optimal. For example, if the price line indicated by *KJ* in Figure 4 prevails and the production possibility curve is as indicated by (5), the combination at *J* is privately most profitable. However, if trees on farms have positive productive spillovers or public good characteristics (relevant for the quantity of trees associated with *J*), a greater quantity of trees may be socially optimal. For example, the combination at point *H* may be socially optimal from a Kaldor–Hicks viewpoint.

Dryland Salting

The removal of trees from farms can have adverse production externalities. When this occurs the private net benefits of tree removal are liable to diverge from the social net benefits. In some areas of Australia, the removal of trees gives rise to dryland salting. The process of dryland salting as the result of the removal of deep rooted trees in parts of Western Australia and Victoria is well-known (Bennett and Thomas 1982; Hodge 1982; Batini 1982; Mulcahy 1983; Nulsen and Baxter 1982; Greig and Devonshire 1981; Trotman 1974). Approximately 0.82 per cent of the cultivated land area of Australia has been reported to have been affected adversely by dryland salting. The clearing of land in areas subject to salting has unfavourable externalities on agricultural production on other properties and on the water quality in streams. The salting of the soil may result in bare patches of ground without pasture or with sparse or unpalatable pasture and limit the range of crops that can be grown. The salting of streams may result in the quality of water being unfit for irrigation, for human consumption or for animals. In addition, fish may be killed and the scenic qualities of streams impaired.

Hodge (1982) illustrates the type of market failure that occurs when unfavourable agricultural production externalities arise from tree removal which results in salting, and I shall not repeat his diagram here. Hodge (1982, p. 199) also outlines economic factors that should be taken into account in government regulation of the clearing of land in areas subject to dryland-seepage salinity. He concludes however, that:

> the issue of whether restrictions over clearance of land would show a positive economic return has not been considered. The evidence suggests this to be the case (*e.g.*, Lumley 1982), and it appears that landholders face incentives to clear an excessive land area. The value of restrictions over clearance has been assumed in this paper but would benefit from further empirical testing.

Dumsday *et al.* (1983) suggest that as far as dryland salinity control in Victoria is concerned the problem could be alleviated "by relatively minor changes in existing farming systems. More drastic approaches such as reforestation may only be required in limited areas." They suggest that greater use of lucerne (a deep-rooted salt-tolerant plant) in combination with deep-rooted perennial pastures would go far in controlling the salting problem and could be privately more profitable than present farming patterns as well as socially more satisfactory (*see* also Dumsday 1983). However, this approach cannot be used in all areas subject to dryland salting, *e.g.*, environmental conditions for the successful cultivation of lucerne are not satisfied in all areas.

In Queensland, salting of non-irrigated land has been observed in areas subject to higher rainfall (Hughes 1984) and this has been a contributing factor to rural tree dieback (Johnston and Wylie 1984) which is on the increase in Queensland. Several other factors as listed by Wylie and Johnston (1984) have also contributed to this, including stock damage from rubbing and soil compaction. Feral animals such as the feral goat and the feral pig have also played a role in this process (Tisdell 1982).

Conclusion

More scientific data and knowledge are required to help us evaluate the value of trees on Australian farms. The case studies mentioned in the text illustrate the diversity of issues that need to be taken into account in determining the costs and benefits of tree conservation, maintenance and planting on farms. The appropriate economic estimation of the private costs and benefits of trees on farms is more complicated than is commonly recognized and social cost-benefit analysis is even more complex. Nevertheless, considerable progress has been made and can be made in measuring the costs and benefits of trees on farms in Australia. A moderate amount of determination and a small amount of resources for research if used systematically could quickly improve our knowledge about the social net benefits of farm trees in this country. It could enable us to decide the extent to which we should act on a recent editorial comment, namely,

> a plan should already be formulating similar to the treeing of American farm land during the depression or the present taming of deserts in China. It is an enormous task and would not begin to show fruit for another 20 years. Australia certainly has the labour force and the need (Ball 1983).

Enthusiasm needs to be tempered by knowledge and logic. Much more economic expertise needs to go into the assessment of the value of farm trees in Australia and more scientific facts need to be gathered in specific Australian environments. Such information as we do have should also be used wisely in giving advice.

It may be pertinent to note that in searching for suitable case studies of the conservation of trees on farms, I found no case studies for the coastal and wetter regions of N.S.W. including the eastern slopes of the Great Divide. Some studies are however, being done of similar areas in Queensland (*see*, Johnston and Wylie 1984; Wylie and Johnston 1984). Particular studies of the higher rainfall areas are needed because tree cover in many of these areas is still substantial, the areas are favourable for tree growth and problems such as landslides or slumps are more acute in such areas. Such areas are also close to major population centres so the amenity value of trees is likely to be most important in the eastern coastal region.

In conclusion, the case studies discussed in this article illustrate the complexity of assessing the economic value of the provision of trees on farms. Apart from the need to more accurately assess private net benefits from tree conservation and planting on Australian farms, considerable scope exists for estimating the public economic dimensions of tree provision. These include the public good characteristics associated with trees and the various externality consequences of their provision or retention.

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