Profitability and Salinity: The Role of Agroforestry in Maintaining Sustainable Cropping Systems in Northern NSW

I. Patrick,
Economist,
NSW Agriculture, Gunnedah, 2380

M. Bryant,
Senior Project Director,
Centre for Water Policy Research, UNE, 2351

J. Fargher,
Director,
National Resources Division, AACM, Adelaide, 5000

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1 INTRODUCTION

The Liverpool Plains lies on the western edge of the Great Dividing Range. It stretches from near Murrurundi in the south to Boggabri on the Namoi River in the north. The catchment includes the sub-catchments of the Mooki River and Cox's Creek, together with the internally draining catchment of Lake Goran There are approximately 1 2 million hectares in the catchment

Dryland salinity is a major and increasing problem on the Liverpool Plains. Native perennial pastures and trees in the catchment have been replaced with cropping and grazing systems in pursuit of increased agricultural production The change in vegetative cover has led to increased groundwater recharge In turn, this has led to rising groundwater levels, especially on the flatter plains areas of the catchment In this study the catchment is divided into three land types The black soil plain is predominantly cropping country, it is this area that will be affected by rising watertables and salinity, the lower slopes, less fertile but still predominantly cropping country and the higher slopes where grazing systems dominate.

Over 30,000 hectares (2.5 per cent of the area) are already salt affected and, in addition, approximately 165,000 hectares (13 5 per cent) are considered to be at risk (Broughton, 1994). This represents an annual cost of approximately $6 2 million in lost production (assuming two long fallow crops every three years), with the potential to increase to $34.7 million per year. It is imperative to identify and evaluate farm management systems which will be economical and sustainable both in the short and the long term

Agroforestry has the potential to be integrated with existing farming systems to combat rising groundwater levels The use of deep rooted perennial tree crops can increase groundwater water consumption Agroforestry could, therefore, help maintain or lower current groundwater levels.

This study examines the effect on profitability and groundwater levels of including tree and pasture options in the existing farming systems within both the recharge and discharge areas. The analysis is undertaken using a farming system that is not yet suffering the effects of high watertables, but will in the future. Profitability and water use are compared using a 30 year model which ensures the full benefits of any rotation and the long term effects of rising watertables are included. The model has been constructed using the Excel 4.0 spreadsheet. Sensitivity analysis has been undertaken on important parameters such as initial groundwater height and crop yield which may be influenced by adjoining pasture and forestry enterprises.

This study was funded by the Liverpool Plains Land Management Committee (LPLMC) and is the first part of a broader study which will consider both the implementation and marketing issues that must be considered before a sustainable forestry industry can be established in the area. These will include joint venture options and public sector support. Further work will also be undertaken to include within a catchment plan the means by which the externalities, with regard to dryland salinity, can be internalised in a fair and equitable manner between the relevant stakeholders.

2 METHODOLOGY

2.1 The Model

A spreadsheet model is used to both input data and produce comparisons between base and alternative farming systems The base farming system is that which presently dominates in each of the three particular areas of the catchment This implies that the base system will not change over the next 30 years, the length of the analysis period It is assumed that farmers who will be affected by salinity have no previous experience with the problem or expectation that salinity may become a problem They will maintain their present cropping systems until they become uneconomic It is only when paddocks are no longer productive that alternatives will be sought This has certainly been the case in the past In the future, however, this assumption may no longer hold as farmers are obtaining a greater understanding of salinity effects and control options If this assumption no longer holds this analysis may be underestimating the true opportunity cost

The study is a partial analysis which includes only variable costs, no allowance for overheads has been made This is in keeping with the aim of evaluating systems which fit into the existing farm constraints, i e use the same capital and labour resources For this reason any alternative (eg eucalypt for oil) which uses different inputs cannot be compared directly with the other systems

The spreadsheet provides two major results, firstly a discounted cashflow to compare the relative profitability of the present farming system with the alternative, these are compared using net present values (NPV) Secondly, a comparison of water use requirements, which will have a direct effect on groundwater levels

A maximum of four tree options can be included in both the base and the alternative rotation. These tree options can produce both an annual crop (oil, forage etc) and/or a timber crop at a specified level of maturity They can be included as a stand alone plantation enterprise, or included in an alley or parkland farming system. As with the tree options, four pasture alternatives can be included in the model, these can range from a native pasture to an irrigated lucerne pasture. A pasture can be established in two ways. Firstly, if sown independently, an establishment year of higher costs and lower stocking rate can be included If however, a crop is undersown with a pasture, it is necessary to include the pasture sowing costs in the crop gross margin preceding the pasture Seven crop options can also be included.

The analysis is undertaken on a one hectare unit of land. If within a rotation that unit is being used by two alternatives a percentage use for each option is specified. eg if alley farming is being considered it is possible to specify that 80 per cent of the land is being used by the existing cropping rotation while the remaining 20 per cent is planted with saltbush. The benefits to the crop of this alley farming option, in terms of water use or yield etc, can be included by specifying these crops, run in conjunction with a pasture, as an independent entity listed in the cropping alternatives eg wheat following a long fallow will be a different crop to wheat following a lucerne pasture phase

Each system is modelled at two initial groundwater levels, 4 3 metres and 10 metres At an initial level of 4 3 metres the critical depths which affect yield do become important in the later years of the cropping rotations At 10 metres however, groundwater level plays no role in the yield estimations This will provide a good cross section of results for both high groundwater areas and areas where groundwater levels will not affect yield

Lateral water movement is also an important issue which must be included Broughton, (1994) has estimated that the distribution of this variable across the catchment will range from 20 mm per year to 170 mm per year This study assumes an average lateral water inflow (onto the plains only) of 95mm/yr

The analysis assumes a two per cent annual yield decline within the continuous cropping system If a cropping system includes timber or saltbush alleys, this decline is only one per cent

2.2 Data Sources

There is limited research and development information on different agroforestry systems in the Liverpool Plains Initial results from an agroforestry trial at Breeza (Dickson, 1994) are inconclusive because of differences between pre-planting treatment of different species and the saline nature of the soils Some landholders have experience with different native species but this information is not readily available. Agroforestry system options proposed are therefore based on the documented performance of species elsewhere, and judgements made about their technical feasibility in the Liverpool Plains. Table 1 presents the input data for the relevant forestry options

The data included in the pasture options; Old Man saltbush and native pastures are outlined in Table 2 Planting and maintenance costs have been estimated from NSW Agriculture and specifically for saltbush by Ian Carter (pers. com). Income from pasture is obtained through running breeding cattle, a typical livestock enterprise in the region.

The crop data required includes estimates for price, yield, discharge and variable costs. Income and cost data for these alternatives are taken from the Gross Margin Handbooks for Northern NSW (Patrick, 1994 and Patrick, 1995) and adjusted as required for soil type, watertable height and other rotational effects. The price data is supplied by the Market Intelligence Unit of NSW Agriculture. This data is presented in Table 3.

Table 1 Data for the agroforestry alternatives included in this analysis

	eucalypt - timber	eucalypt - woodlot	eucalypt - oil	eucalypt - parkland
planting costs ($/ha)	1500	800	2,267	100
maintenance costs ($/ha)	35	35	500	35
harvested for timber ?	yes	yes	no	no
years of timber income	10,15,30	10,30	na	na
harvested annually ?	no	no	yes	yes
annual harvest starts year -	na	na	5	10
year of maturity	30	30	5	10
timber harv & transp costs ($/ha)	300	300	na	na
annual harv & transp costs ($/ha)	na	na	1,650	0
timber yield (m^3/yr)	2.5	2.5	na	na
timber price ($/$m^3$)	30	30	na	na
annual yield (kg/ha)	na	na	770	0.5*
annual price ($/kg)	na	na	8	60**
recharge yr 1 (mm/yr)	-50	-50	-50	-30
recharge at maturity (mm/yr)	-300	-300	-150	-250

*dry matter (t/ha) ** $/tonne

Table 2 Pasture input data used in this analysis

	Old Man saltbush	native pasture	native + benefit
planting costs ($/ha)	767	0	0
maintenance costs ($/ha)	0	10	10
returns ($/DSE)	15	15	15
years under pasture	30	30	30
DSE's/ha, year 1	15	3	3
DSE's/ha, years 2 to 30	30	3	4
recharge (mm/yr), year 1	-50	-3	-3
recharge (mm/yr), yr 2 to 30	-100	-3	-3

Table 3 Data for cropping alternatives included in the analysis

	wht-plains	wht plains +yld benefit	sorg-plains	sorg-plains +yld benefit	fallow	wht-slopes	wht-slopes +yld benefit	sorg-slopes	sorg-slopes +yld ben.
variable costs ($/ha)	177	177	180	180	0	150	150	150	150
yield (t/ha)	3 3	3 9	4 1	4 6	0	2.5	3.1	2.8	3.4
price ($/t on farm)	150	150	140	140	0	150	150	140	140
gross margin ($/ha)	323	403	403	484	0	225	315	242	326
groundwater depth yld = 0 (m)	0 5	0 5	0 3	0 3	0	0 5	0 5	0 3	0.3
groundwater depth no yld effect (m)	2 0	2 0	2 5	2 5	0	2.0	2.0	2.5	2.5
recharge (mm/year)	18	18	10	10	22	18	18	10	10

The effects on groundwater levels of the different options is still the subject of much research and debate. Estimates for forestry options range from discharge rates of 110mm/yr at maturity (Greiner, 1994, Bari and Schofield, 1991) through to 500mm/yr (CWPR, 1995). This study uses a median figure of 300mm/yr. While the recharge and critical depth data are, at best, estimates of the true parameters, they do give a good indication of the relative effects on watertable of the alternative systems. Further research in this area will provide more reliable results

Extra information required concerns the susceptibility of each cropping alternative to watertable height/salinity. Two critical measurements are required, the first is at what watertable depth (metres from the surface) will a crop be unable to yield? The second is at watertable depth will yield begin to be affected? If watertable depth moves into this yield affecting zone (via a pre-defined starting watertable depth, lateral water movement assumptions and rotation effects), yield will be discounted accordingly. This critical watertable depth data were inputted after discussions with local agronomists and soil conservationists. Once again, this is an estimation of the true data and an over-simplification of the hydrological issues relevant to the study area. Table 3 provides the data estimates for the cropping alternatives used in this study.

A discount rate of eight per cent was used in the analysis

3. AGROFORESTRY OPTIONS IN NORTHERN NSW

The selection of the appropriate agroforestry options for the black soil plain, lower slopes and higher slopes areas are influenced by the biophysical characteristics[1] of the Liverpool Plains catchment. These characteristics include topography, current land use, rainfall and soils. When deciding between suitable species to be included in the study the following specific factors were considered:

- large areas of the plains comprise cracking grey clays which were originally vegetated by grasslands dominated by Plains Grass (*Stipa aristiglumis*). Trees have never been natural components of the vegetation and therefore tree establishment will be difficult;

[1]Detailed analysis and description of the biophysical resources of the Liverpool Plains are presented in a range of publications including the Liverpool Plains Land Management Committee (LPLMC) strategic plan and hydrogeological studies undertaken by the Department of Land and Water Conservation (DLWC).

- groundwater recharge occurs over most of the region, rather than in specific recharge areas Deep rooted perennial vegetation will be required across the whole landscape to increase water use and lower the watertable,

- intensive cropping on the plains is integral to the regional economy Salinity amelioration strategies must complement rather than compete with this land use if possible, and

- variable rainfall within and between years and limited water resources for irrigation may reduce the range of species which can be grown and the value of products they produce

3.1 Options for the Black Soil Plains

The existing rotation on the black soil plain is a wheat/sorghum/fallow rotation (two crops in three years) This base is compared to three alternatives, Alley cropping[2] eucalypt and saltbush, plus plantation eucalypt for oil production

3.1.1 Alley Crop - Eucalypts

Naturally occurring eucalypt species in the Liverpool Plains, for example *Eucalyptus albens* (White Box) and *E. populinea* (Bimble Box) are slow growing and not suitable for short-term commercial production. However, they are highly suited to planting for long-term amenity and habitat values in the farm landscape Several eucalypt species are propo ed, based on the experience with *E. globulus* (Tasmanian blue gum) belts in Western Australia and limited trial information from the Liverpool Plains. These will grow in areas with 500-600 mm rainfall and some are also salt tolerant. Species proposed include *E. tereticornis*, *E. melliodora*, *E. camaldulensis* and *E. sideroxylon*. The proposed arrangement is three rows of trees in each belt (three metres between trees and four metres between rows) and 100 metres of alley between each belt This equates to 100 trees per hectare.

These alleys would cover 20 per cent of the area and be harvested for pulp from between eight to 20 years Trees were harvested for timber with 20 per cent of the income in year 10,

[2]Alley cropping involves the planting of trees/pastures in widely spaced belts usually taking up 15 to 20 per cent of the area, crops are grown in the alleys between the tree/pasture belts.

40 per cent in year 15 and the final harvest in year 30. Trees may also be grown for pulp with income in years 10 and 15

3.1.2 Alley Crop - Saltbush

Atriplex nummularia (Old Man Saltbush) is also considered for alley cropping *Atriplex nummularia* is suitable for both recharge and discharge areas because it tolerates saline watertables The proposed arrangement for salt bush is four rows of shrubs in each belt (two metres between shrubs and two metres between rows) and 100 metres of alley between each belt This equates to 200 shrubs per hectare These alleys require 15 per cent of the area Returns to saltbush have been estimated from $365/ha to $460/ha on a yearly basis (Table 2, I Carter pers com, 1995) Initial costs of planting are $767/ha, with no annual maintenance costs

3.1.3 Plantation Eucalypts for Oil

Eucalyptus radiata and possibly *E. cneorifolia*, are suitable species for production of eucalyptus oil Plantations could be established on the flats or slopes greater than three per cent The harvesting and transport of leaf for distillation and the proximity of distillation facilities are important technical factors which need to be examined when assessing the detailed feasibility of this option In general terms, harvesting can be mechanised with existing forage harvesting equipment, and distillation facilities need to be within 50 kilometre for viable eucalyptus oil production The proposed arrangement is blocks of trees established at one metre to 1.5 metres between trees and one metre to two metre between rows, the equivalent of between 3,300 and 10,000 trees per hectare. This alternative requires extra capital (harvesting equipment and distillation apparatus), plus extra labour. Other factors which must also be considered are the marketing issues and the high initial investment required to plant A detailed feasibility study would be needed to examine this option because of the high investment costs involved

3.2 Options for the Lower Slopes

The lighter slopes country is defined as the area covered by the clay loams over red clays on basalt The existing rotation will be the same rotation as for the black soil but with a lower expected yield The three alternatives analysed in this land classification are saltbush, plantation eucalypt for oil (both using the same data as for the plains) and eucalypt species grown as a farm woodlot, that is over 100 per cent of the area.

Farm woodlots are most suited to sites on slopes greater than three per cent where there is less cropping potential and lower opportunity costs of establishment. There are also opportunities to establish farm woodlots in the riparian zones of the Mooki River and Cox's Creek. In addition to the alley cropping timber species mentioned above, *Casuarina cunninghamiana* and *Callitris hugelii* are species suited to inclusion in farm woodlots. Farm woodlots are appropriate for long-term timber production particularly for specialty timbers for high value markets such as craftwood and furniture timber. The proposed arrangement is blocks of trees established at 2.5 metres between trees and 2.5 metres between rows which is equivalent to 1,600 trees per hectare. This would be thinned over time to about 500 mature trees per hectare.

A higher planting cost is the only major difference between the farm woodlot budget and the alley cropping eucalypt option. The farm woodlot is an alternative to the existing system and not grown in conjunction with a crop or pasture rotation, that is, the woodlot is planted on 100 per cent of the area. While the woodlot may provide yield benefits to neighbouring hectares, no yield benefits are included in this analysis, unlike the alley farming systems where the alleys directly benefit crops/pastures on the same parcel of land.

3.3 Options for the Higher Slopes

Silvopastoral systems integrate livestock production and forestry enterprises with trees arranged to provide shelter and shade as well as browse - either as a pasture supplement or drought reserve. Parkland shelter points are proposed to provide shelter and drought reserves of feed for livestock. Tree and shrub species proposed include *Brachychiton populneum* (Kurrajong), *Acacia aneura* (Mulga) and *Atriplex nummularia*. *Atriplex* has the added advantage of being salt tolerant.

On the higher slopes which traditionally has been a native or semi-improved pasture, the major alternative is to include tree varieties in the existing pasture to provide shelter, a drought reserve and a means of reducing recharge into the catchment. At maturity the trees will cover 25 per cent of the area and produce feed valued at approximately $30/ha. Income will begin in year 10 (Table 1). Possible varieties for inclusion in a parkland setting are *Brachychiton populneum* (Kurrajong) and *Acacia aneura* (Mulga).

4. RESULTS

Results are presented in both graphical (Figures 1 to 16) and tabular (Table 4) form. The discounted cumulative cashflow information is presented as four different scenarios for each alternative They are,

1 A general cashflow assuming no watertable effects (initial groundwater level at 10 metres) and no crop or pasture benefits due to adjoining crop or forestry enterprises (eg from windbreaks, improved soil structure etc)

2 A cashflow with an initial watertable of 4 3 metres Systems which encourage recharge may suffer yield effects due to rising groundwater levels These high water table effects only influence farming systems on the plains No yield benefits from adjoining crops or pastures

3 As for 1 but a yield benefit of 0 5t/ha for the adjoining crop

4 As for 2 but a yield benefit of 0 5t/ha for the adjoining crop

Further results indicate the potential effects on watertable depth of the various rotations, not including any lateral movements or respecified water table heights This provides a good indicative measure of the potential "non-profit" objectives of the alternative systems
The following discussion presents seven examples of agroforestry/pasture options which will cover the black soil plains, the lower slopes (cropping) and the higher slopes (pasture) country. It will provide initial results as to the economic potential for these alternatives on the Liverpool Plains

The rotations have been selected under the assumption that producers are adopting these alternatives in order to maintain the sustainability of their cropping system

Table 4 Summary of results, NPVs and groundwater levels

	total expected recharge (mm)	NPV, no watertable effects($/ha)	NPV, initial watertable 4.3m ($/ha)	NPV; no watertable + yield benefits ($/ha)	NPV; initial watertable 4.3m + yield benefits ($/ha)
Plains.					
saltbush - alleys (15%)	-15	3,400	3,300	4,000	3,700
eucalypt timber - alleys (20%)	-620	2,200	2,200	3,000	2,800
(eucalypt oil *)	-4,000	30,000	na	na	na
wheat/fallow/sorghum	500	2,800	2,550	2,800	2,550
Slopes (arable).					
saltbush - alleys (15%)	-15	2,500	na	2,900	na
eucalypt woodlot	-5,500	-664	na	na	na
(eucalypt oil *)	-4,000	30,000	na	na	na
wheat/fallow/sorghum	500	1,900	na	1,900	na
Slopes (non-arable).					
native pasture + parkland	-1,600	290	na	430	na
native pasture	-10	490	na	490	na

* **Note:** eucalypt oil cannot be compared directly with the other alternatives because of the extra capital and labour required. Distillation apparatus and harvesting equipment will cost up to $350,000 and must be available no more than 15km from the plantation. The present study is a partial analysis which only includes changing variable costs, the overhead costs for the other agroforestry options are the same as the existing pasture and cropping overheads.

4.1 Black Soil Plain

alley farming saltbush

Figure 1 illustrates the important effect that the introduction of saltbush on 15 per cent of the area can have on groundwater levels Saltbush alleys may stabilise the groundwater level when lateral flows etc are not included The existing cropping rotation may lead to rise in groundwater levels of 500mm over the 30 years (ignoring any external influences on the groundwater level) compared to a decline of 15mm from the alternative system (Table 4)

Figures 2 and 3 indicate what will happen to the discounted cumulative returns at varying initial groundwater levels At both initial groundwater levels the alternative alley farming system is more profitable The returns are similar however for the first seven or eight years, with the improved sustainablity an issue in later years At the initial 4 3 metre level the existing system will be unsustainable by about year 25 The alternative will probably last an extra 15 years Neither system can in the long term redress the groundwater problems At best including saltbush alleys can control recharge on the plains but cannot cover the recharge from lateral flows from other areas

With yield benefits, the advantage of the saltbush alleys become even more pronounced (Table 4) The conclusion is that where rising watertables are a problem, saltbush is a efficient way of improving the sustainability of the area Where salinity is not an issue, saltbush is still very useful in terms of profitability, flexibility (availability as a drought reserve) If saltbush can also have positive effects on the yield of the adjoining crops, saltbush becomes an even better option

Another option not yet considered is alley cropping plains grass This may also be a viable alternative

alley farming eucalypt species

Alley cropping eucalypts for timber will have positive effects on the watertable (Figure 4) and will not lead to significant declines in profitability (Figure 5 and 6). If the trees can have positive effects on crop yield by providing wind breaks, better soil structure etc, the long term profitability may be the equivalent of a conventional cropping rotation (Figure 7, Table 4)

Low expected yields (2 5m^3/yr MAI) do not make the growing of eucalypts an independently profitable option, however, when grown as an alley crop, the benefits in terms of groundwater use may outweigh the costs of a lower return Once again management of the alley is important to ensure the alleys do not interfere with existing crop management practises.

plantation oils

If harvesting and distilling equipment is available plus the markets have been established and feasibility studies undertaken, growing eucalypts for oil may well be a feasible option on a small scale on the plains. As with any plantation, there will be a significant discharge of ground water at the site (Figure 8) In terms of income, it will take around five to six years to breakeven with regard to variable costs (Figure 9) and maybe twice as long if overheads are included In the long term, if price and demand remains at present levels, this could be a very profitable sideline for producers on the plains.

4.2 Lower Slopes; Arable

alley cropping saltbush

As with the discussion of saltbush on the plains, alley farming saltbush on the lower slopes is a viable alternative with respect to both profitability (Figure 10) and groundwater use (Figure 1) These benefits (as with the plains) are even greater if there are accompanying yield benefits arising from the alley cropping system to the adjoining crops (Figure 11)

eucalypt woodlot

This option is uneconomic at the expected yields and prices used in this study (Figure 12). A negative NPV (Table 4) of -$620 reflects a large outlay in year one with income insufficient to give a positive return Expected yields for plantation timber are too low in this area to provide a viable timber industry The woodlot for timber production will have significant benefits in reducing groundwater levels (Figure 13) and should be planted with these benefits paramount This activity has the greatest influence of any alternative on groundwater level.

plantation oils

As for plantation oils described in the plains section

4.3 Higher Slopes; Non-arable

native pasture plus parkland

These higher slopes are the major areas of recharge. Trees planted here will have not only benefits to the existing livestock in terms of shade and windbreaks etc but will have significant benefit to producers in the discharge areas. The planting of trees in these areas will provide significant positive externalities in the form of decreasing lateral flows to other producers on the lower slopes and plains.

Tree planting costs ensure that the NPVs for a native pasture running cattle are always higher than the alternative (Figure 14). If however the trees can increase the carrying capacity of the remaining pasture by 1 DSE/ha (Table 2), the returns to both systems will be approximately the same (Figure 15)

Once again planting trees will have positive effects on groundwater levels (Figure 16)

5. SUMMARY AND CONCLUSIONS

Agroforestry systems and alternatives such as eucalypt oil plantations and saltbush were selected for their ability to be grown on either the black soil plain, the lower slopes or the higher slopes country of the Liverpool Plains catchment, their capacity to draw water from shallow watertables, and the potential (in most cases) to be integrated into existing farming systems. In some cases alley cropping farming systems were assumed to afford a degree of weather protection to neighbouring traditional crops In those situations, existing crops were considered likely to achieve marginal yield benefits Because of uncertainty about the likely extent of such benefits, however, economic analyses considered both yield benefit, and no yield benefit scenarios

The model developed for this study provided a useful means of assessing the economic viability and likely impact of agroforestry options for the Liverpool Plains catchment. It must be remembered, however, that the results provided are only indicative of potential performances of these options Also, the assumptions used for the alternative crop components of the analyses could not be based on data from the Liverpool Plains as these were not available.

A summary of the major results follows

4.1 Black Soil Plain

Where the presence of saltbush alleys provided yield benefits to traditional crops this option were more profitable than present cropping rotation. Eucalypt oil plantations may offer the highest profitability of any option, but the assumptions used did not include overhead costs. More research is needed on production and marketing costs before this option can be seriously considered.

Saltbush systems had a positive impact on water table levels, reducing the predicted rate of rise. For the traditional farming system scenario, where the initial watertable was assumed to be 4.3 metres below the surface, it was predicted that the rate of watertable rise would render it unsustainable after 15 years. The saltbush scenario could not avoid farming operations from succumbing to high watertables, but it may extend their productive life for a further 15 years.

The alley farming of eucalypt scenario had the most beneficial impact on watertables, but was not economically viable.

5.2 Lower Slopes

The situation for the saltbush scenario on the Lower Slopes was similar to that on the Plains. In the medium and long term the inclusion of saltbush in the rotation was economically viable. While there were no direct benefits from decreased recharge to farmers on the slopes, as high watertables are not an issue in these areas, the inclusion of saltbush on the slopes should, however, provide benefits to producers on the Plains, in terms of decreased lateral water flows from the Lower Slopes.

The planting of trees in woodlots or plantations should provide significant benefits in terms of decreasing recharge levels. However, the planting of woodlots for timber production is not economically viable in this area. This alternative returned a negative NPV and a B/C ratio of less than 1.0.

As with the Plains, eucalypt plantations for oil production may be viable, but more work needs to be done with regard to capital costs, processing and marketing systems before this alternative could be seriously considered.

5.3 Higher Slopes

The economic performance of woodlots on the Higher Slopes was similar to that reported for the Lower Slopes, and therefore is not elaborated here.

The planting of trees on the higher slopes would be beneficial in terms of decreasing both surface water flows and recharge. If the planting of trees in a parkland setting could improve the carrying capacity by 1 DSE/ha, then this would be economic. This should be a viable option in terms of both watertable recharge and profitability.

5.4 Conclusions

The results do indicate that the present catchment management system, will be unsustainable in the long term. Increased runoff from the slopes areas and less vegetation cover on the plains has led to higher groundwater levels and salinity problems. While it is simple to state that systems which include trees and pasture must be adopted on the Liverpool Plains in order to ensure long term economic and environmental sustainability, the major issue is how to ensure this adoption occurs.

This study has shown that for farmers with no present salinity problems there is little short term economic benefit in planting trees. These farmers must continue to be made aware of the future risks of salinity and encouraged to begin to consider alternatives before they begin to feel the effects

Long term solutions, however, are a catchment issue Farming systems on the slopes affect groundwater levels on the plains Although, in the short term, there are no direct benefits in changing from the existing systems, farmers in these slopes areas must also be encouraged to consider sustainable systems This encouragement could be through mutually beneficial joint venture forestry contracts, community/government support or compensation to those suffering the effects of the negative elasticities from those causing the externalities The equitable distribution of costs and benefits is the next step in assessing the role of agroforestry on the Liverpool Plains

ure 1 Comparison Of Groundwater Levels For Existing Rotation Versus
bush Alley; Slopes And Plains

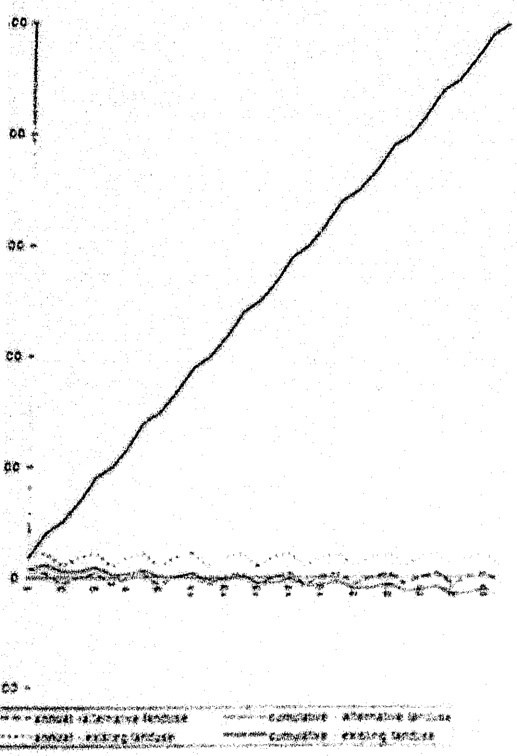
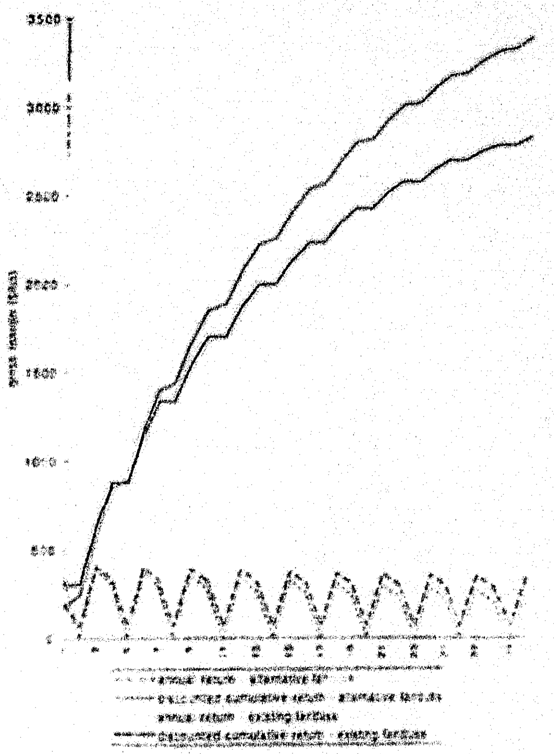


Figure 2 Comparison Of Cash Flows For Existing Cropping Rotation Versus Saltbush Alleys, Assuming No Watertable Effects, And No Yield Benefits; Plains



ure 3 Comparison Of Cash Flows For Existing Cropping Rotation Versus
ltbush Alleys, Assuming Watertable Effects Where The Initial Watertable Level
s © 4.3 Metres, And No Yield Benefits; Plains

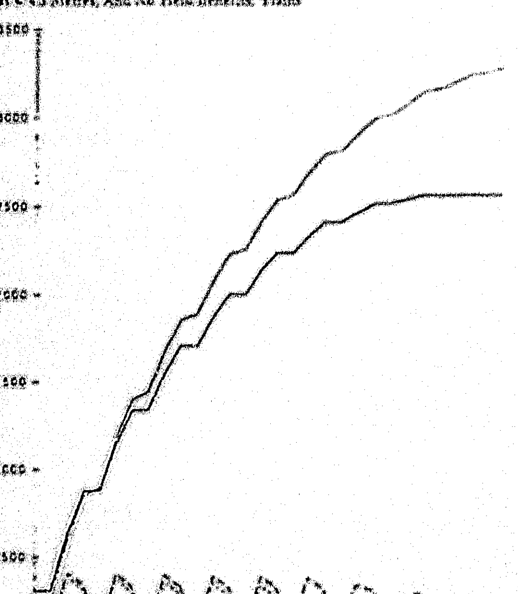


Figure 4 Comparison Of Groundwater Levels For Existing Rotation Versus Eucalypt Alleys

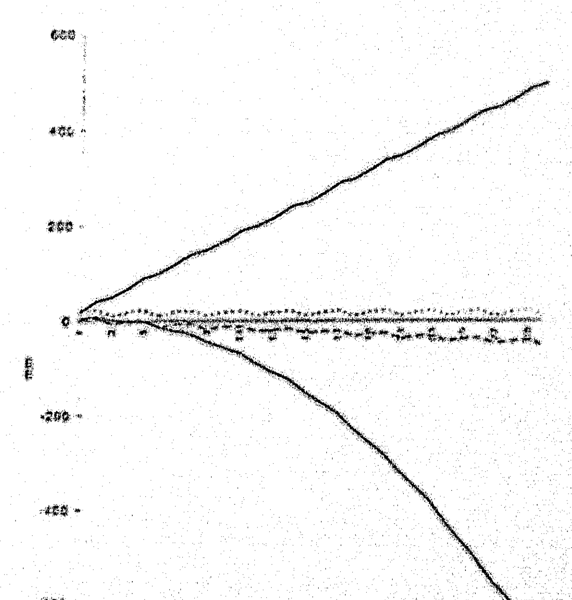


Figure 5 Comparison Of Cash Flows For Existing Cropping Rotation Versus Eucalypt Alleys, Assuming No Watertable Effects, And No Yield Benefits; Plains

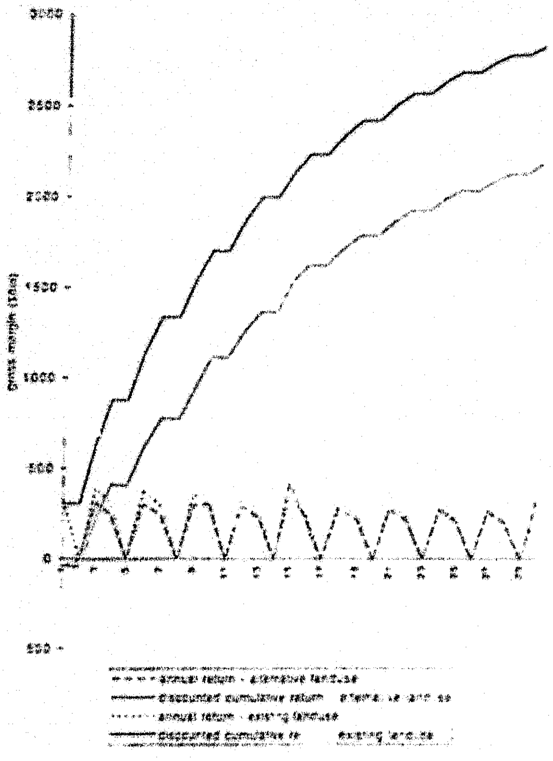


Figure 6 Comparison Of Cash Flows For Existing Cropping Rotation Versus Eucalypt Alleys, Assuming Watertable Effects Where The Initial Watertable Level Was @ 4.3 Metres, And No Yield Benefits; Plains

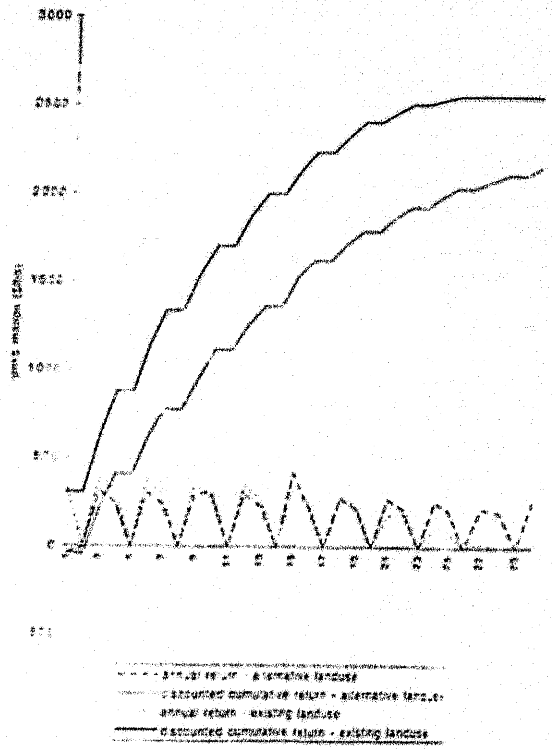


Figure 7 Comparison Of Cash Flows For Existing Cropping Rotation Versus Eucalypt Alleys, Assuming Watertable Effects Where The Initial Watertable Level Was @ 4.3 Metres, And Yield Benefits; Plains

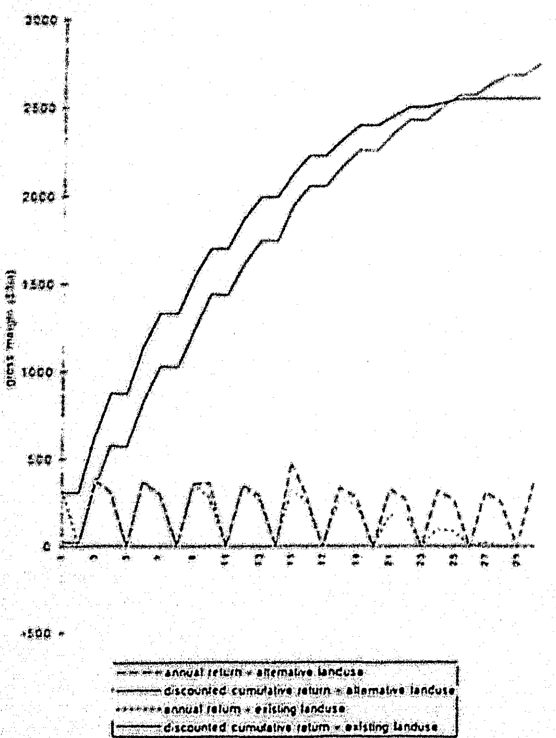


Figure 8 Comparison Of Changes In Watertable Depths For Existing Rotation Versus Plantation (Oils); Plains

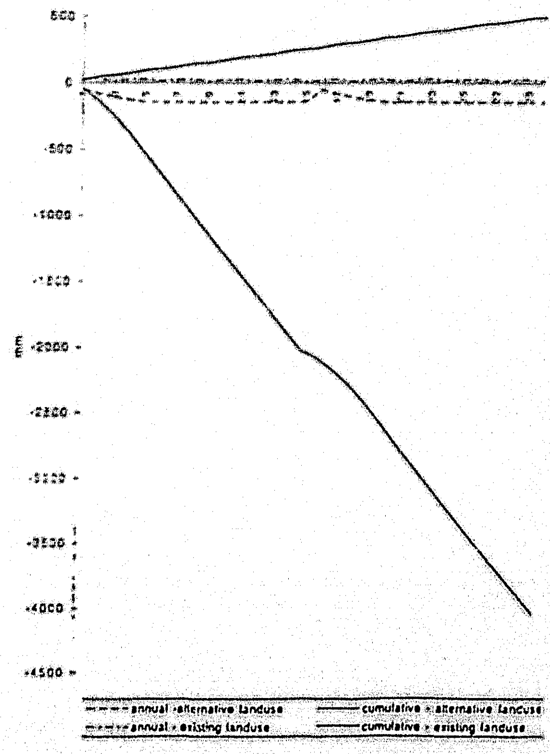


Figure 9 Comparison Of Cash Flows For Existing Cropping Rotation Versus Plantation (Oils), Assuming No Watertable Effects, And No Yield Benefits; Plains

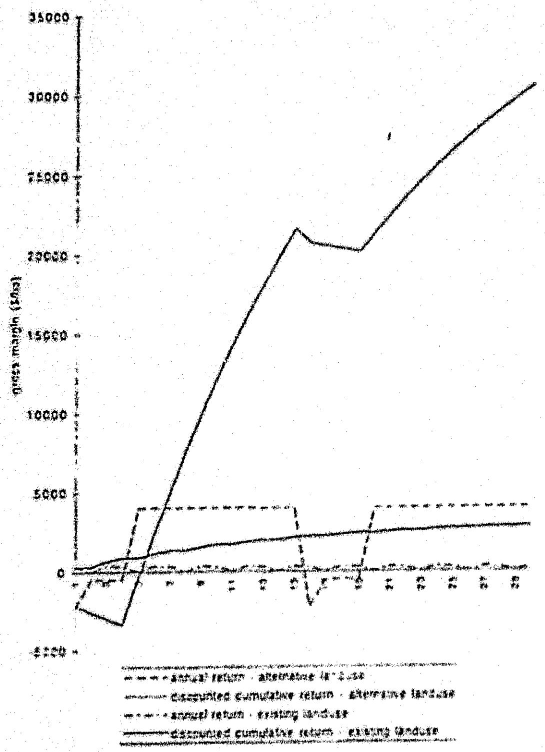


Figure 10 Comparison Of Cash Flows For Existing Cropping Rotation Versus Saltbush Alleys, Assuming No Watertable Effects, And No Yield Benefits; Slopes

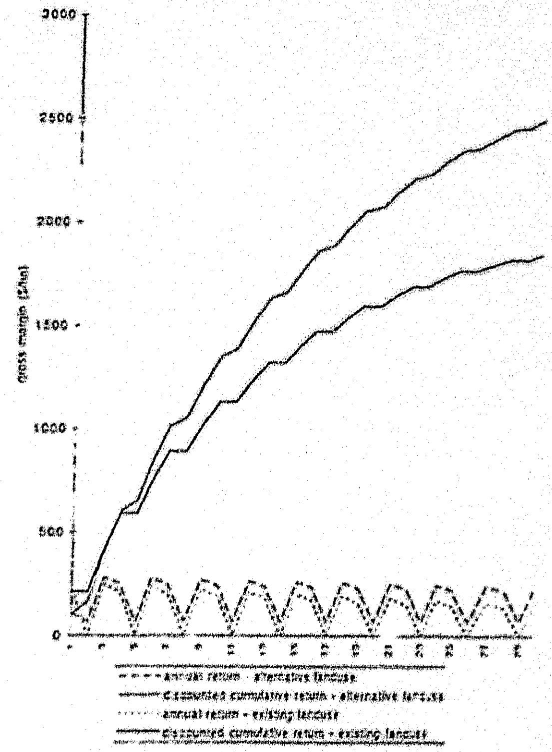


Figure 11 Comparison Of Cash Flows For Existing Cropping Rotation Versus Saltbush Alleys, Assuming Yield Benefits; Slopes

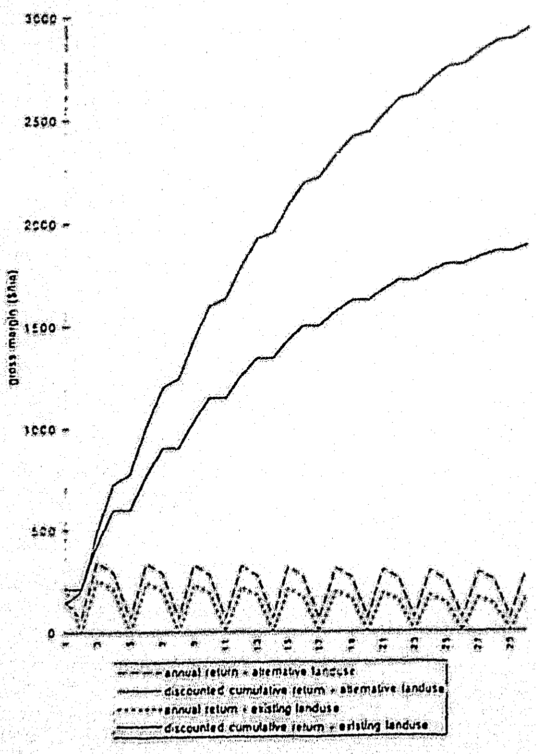


Figure 12 Comparison Of Cash Flows For Existing Cropping Rotation Versus Farm Woodlot; Slopes

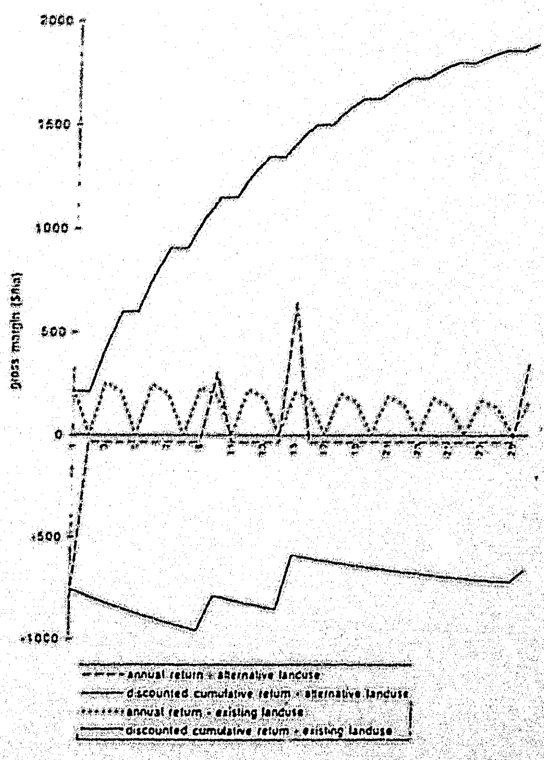


Figure 13 Comparison Of Groundwater Level Effects For Existing Rotation Versus Farm Woodlot; Slopes

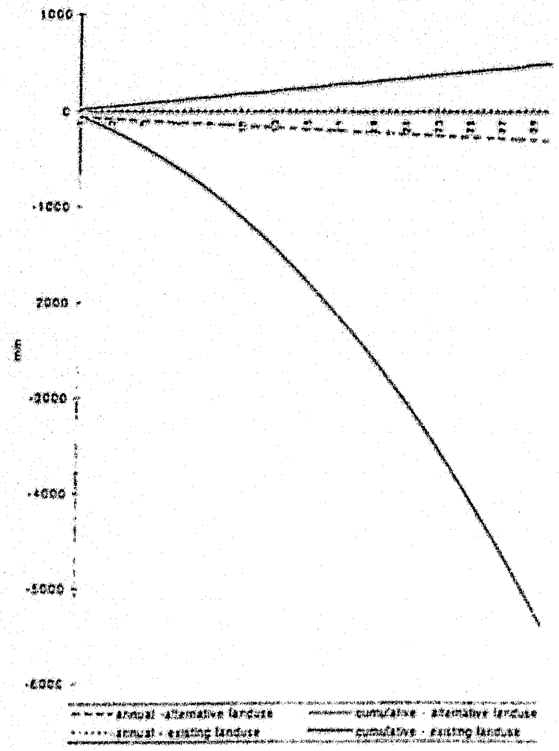


Figure 14 Comparison Of Cash Flows For Native Pasture Versus Native Pasture With Parkland, Assuming No Yield Benefits; Higher Slopes

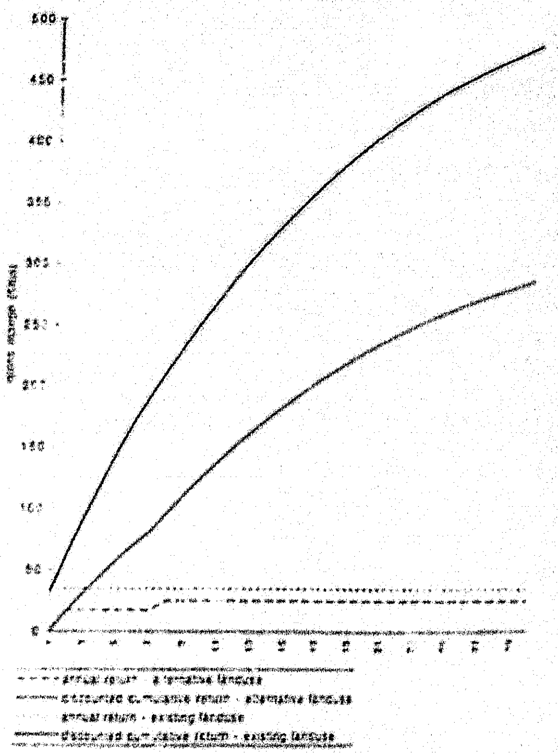


Figure 15 Comparison Of Cash Flows For Native Pasture Versus Native Pasture With Parkland, Assuming Yield Benefits; Higher Slopes

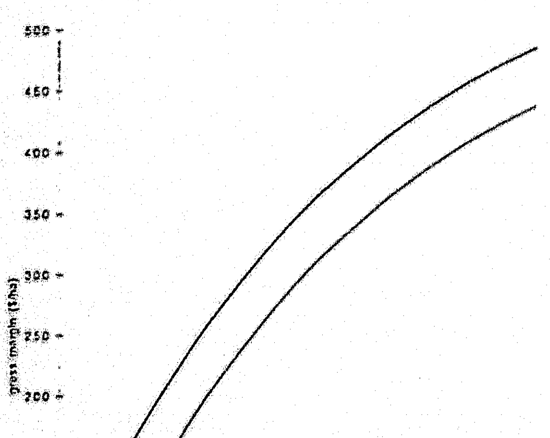
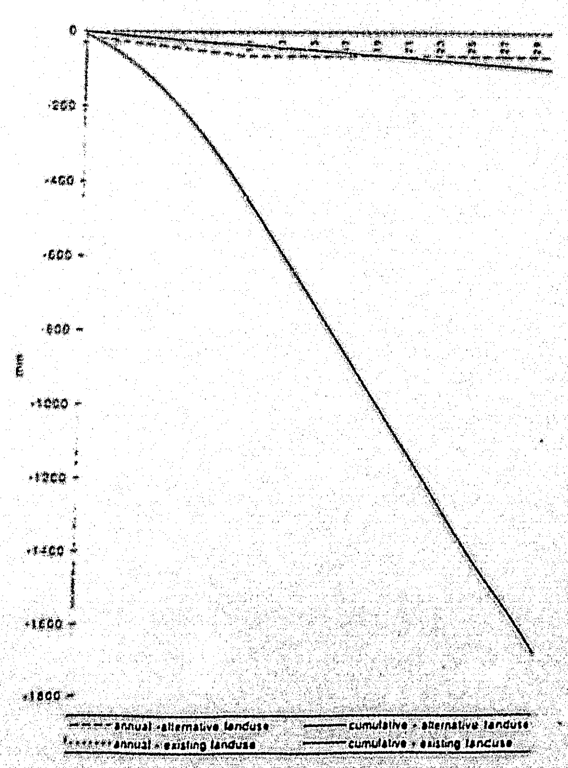


Figure 16 Comparison Of Groundwater Level Effects For Native Pasture Versus Native Pasture With Parkland; Higher Slopes



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