ECONOMIC BENEFITS TO THE FARMER OF MAINTAINING AND PROTECTING REMNANT NATIVE VEGETATION ON FARMS

IN SOUTH-WEST OF WESTERN AUSTRALIA

Report Prepared for the Water Authority of Western Australia

BY

EVONNE RICHMOND

Water Authority of Western Australia

Report No. WS 99
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The photographs accompanying the text are by courtesy of officers from the Water Resources Directorate, in particular, Alan Hill, Neil Pettit, Dr Nick Schofield, Ian Loh and Dr Binh Anson. Bernie Hawkins provided valuable assistance in locating the slides from which the photographs have been produced.

WENDY BODDINGTON
Policy Analyst
Surface Water Branch

PREFACE

Ms Evonne Richmond prepared this report during her vacation employment in the summer of 1991/92 with the Surface Water Branch of the Water Authority of Western Australia. Evonne had just completed her final year undergraduate degree in environmental science at Murdoch University.

This project was designed to be complementary to other biological research on remnant vegetation being carried out by, and for, the Water Authority. However, in this report the emphasis is on the numerous economic benefits directly accruing to the landholder of maintaining native vegetation on the farming property and how to manage it to achieve those benefits. In addition, the report discusses the benefits to the environment and the wider community.

Evonne has canvassed widely throughout Australia to bring together written and oral information in this succint report. The project was supervised by Wendy Boddington, Policy Analyst, Catchment Management Planning and Policy Section with additional expertise and guidance provided by George Kikiros, Supervising Engineer, Catchment Clearing Controls Section and Dr Ray Froend, Research Officer, Hydrology and Land Use Research Section.

Evonne is now undertaking postgraduate studies and we wish to recognise her excellent work by making it available to an interested and wider audience.

D. I. CRAWFORD
Manager
Surface Water Branch

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1. SUMMARY AND INTRODUCTION

In many parts of the world human activities have made great changes to the natural landscape. Where once there was an unbroken expanse of forest, woodland, wetland and heath, there is now a mosaic of farmland, towns, industries, roads and railways, with various sizes and shapes of patches of native vegetation among them.

Western Australia has not escaped the ravages of human impact. When Aboriginals roamed the land, about 37 million hectares of forests and woodlands covered the state. After European settlement, clearing began at an unprecedented rate. It is estimated that 32% of the originally wooded or timbered lands have been cleared or largely modified (Cremer,1990).

Obviously agriculture required the clearance of the eucalypt-wooded landscape. Clearing increased in the south-west of the state in the 1930's when agriculture changed from largely pastoral activity in native vegetation to intensive cereal cropping and pasture improvement (Jarvis,1986). Clearing again increased dramatically due to the availability of the bulldozer in the 1950's and continuing to the 1970's (Collins et al,1981). This process of agricultural development in the south-west has resulted in a fragmented landscape. Only remnant patches of native vegetation now remain. Remnant vegetation is defined here as native woody vegetation left after clearing or after many years of grazing by domestic stock (Patrick Piggot,1991).

The history of conservation in Australia has centred on the creation of large national parks and state forests because of their importance to the community. Large areas are able to include a greater diversity of wildlife and its habitat. However, this concern for size can easily allow us to forget small natural areas such as remnant vegetation on farms. Hopefully there will always be glamour, pride and prestige in places such as Kakadu National Park, but there is no reason why this should lower the value of smaller areas of remnant vegetation (Breckwoldt,1986).

The retention of native vegetation is particularly important on the marginal catchments of rivers affected by salt. These rivers have not been lost as potable water resources and have great potential value to the state in supplying water. If all private land was cleared in these catchments, the water quality would be severely degraded due to rising salinity levels (Public Works Department,1979).

To conserve the water quality of these rivers, legislation to control clearing was introduced on the Wellington catchment in 1976 and on the Kent, Denmark, Mundaring and Warren catchments in 1978 (Steering Committee For Research on Land Use and Water Supply, 1989). Section 3 of this report discusses in more detail the stream salinity hazard-zones, focusing on the four catchments of major concern in the south-west of the state; the Collie, Warren, Denmark and the Kent.

The task of conserving remnants of native vegetation on farms is very difficult due to the economic circumstances that farmers and graziers now find themselves in. Life on the land has never been easy, but it's now becoming impossible for many due to lack of finances. It will be no easy task to encourage landholders to change their way and implement new practices under prevailing economic difficulties (Cremer, 1990).

One possible way in which to encourage the retention of remnant vegetation is to publicise the many benefits that the remnants provide with a particular emphasis on the economic benefits that accrue to the farmer. This report lists and discusses the economic benefits to the farmer in maintaining and protecting remnant native vegetation on farms. The ecological benefits are also discussed because they will eventually return to the farmer. Productivity will ultimately depend on the retention and replacement of trees and shrubs into the agricultural landscape.

Many of the trees left after clearing are now old and dying. Regrowth is lacking due to cultivation and/or grazing. Instead of waiting until revegetation measures are required, it would be significantly less costly and time-consuming if remnants were regenerated naturally. This requires several simple methods which are outlined in section 7.

Once regenerated, the remnant may require continuing management in order to withstand the pressures of agriculture. These management practices are fairly simple, but may be more difficult depending on what the remnant is being used for. The basic principles of managing remnants of vegetation on farms is discussed briefly in section 8.

2. EXISTING REMNANT VEGETATION

Extensive clearing has caused the loss of the complex mechanisms of the natural woodlands and forests, and a replacement with an almost entirely new man-made system (Crane,1985).

There are thousands of private patches of native vegetation throughout Australia on farms and pastoral land that were not cleared, only lightly grazed or fenced off for some reason. Many of these rural trees are in scattered, open patterns in a group or single trees forming open woodlands. They could be part of a windbreak, in ribbons of vegetation along streams and roads or single shade trees. The understorey is often savanna woodland or paddocks of pasture (i.e. grassy) (Crane,1986). Many landholders protect these remnants because they consider them as a unique and valuable property asset, whereas others believe that they decrease the capital value of their land (Breckwoldt,1986).

2.1 Extent and Location

The events that led to land clearing did pass some patches of trees by, but these are in varying degrees of degradation due to lack of regeneration from grazing and/or cultivation. The forests and woodlands which the early settlers believed to be endless, now only occur in small areas throughout the landscape. From Western Australia around to north Queensland, only occasional patches of forests and woodlands remain among the land cleared for rural and urban settlements (Breckwoldt,1986).

If policies and programmes for the protection of remnant vegetation are to be developed, it is essential to know the extent and location of these remnants. The south-west corner of the state, from Geraldton to Esperance, has been mapped for remnant vegetation on the Department of Agriculture's Geographic Information System (G.I.S.).

Data extracted from this system found considerable differences existing in the amount of native vegetation remaining in various areas of the South-West Province. Table 1 presents this data on a shire basis for the wheatbelt and forest and south coastal areas. Compared to the wheatbelt, the area of native vegetation in the forest and south coastal area is considerable, but is predominantly on public land.

In addition, a large proportion of this native vegetation is State Forest and National Parks or nature reserves, though a significant amount on farms still remains uncleared (Remnant Vegetation Steering Committee,1991). This may cause landholders to believe that their remnants of vegetation are not as valuable as they are in areas with little native vegetation, and consequently feel justified in further clearing. However, this is not the case. Every uncleared patch of native vegetation is not only valuable in terms of land degradation control, but also to the farmers themselves.

A better representation of native vegetation remains on the land which was released for agriculture since 1960, particularly on the south coast between Albany and Esperance and on the northern sandplains. A more comprehensive programme of reserve establishment was used in these areas, primarily to protect native wildlife (Remnant Vegetation Steering Committee,1991).

The extent of a patch of remnant vegetation is an important indicator of its value and can determine whether it can be utilised for a specific purpose. The minimum area required will vary depending on the reason why the landholder wishes to retain the remnant. For nature conservation and control of land degradation, the bigger the remnant the better. Smaller areas may well impose additional management costs or require greater skills in many cases (Main In Saunders et al,1986) as they are less likely to be self-sustaining.

TABLE 1. Extent of remnant vegetation in the forest and south coastal and the wheatbelt areas of Western Australia (DAWA Geographic Information System data base)

Regions/ shires	Shire area (ha)	Remnant vegetation area (ha) [% shire]	Remnant vegetation on private land (ha) [% shire]	Remnant vegetation on public land (ha) [% shire]
(a) Forest and south coast[1]				
Albany	445,800	199,272 [44.7]	26,748 [6.0]	172,524 [38.7]
Plantagenet	482,700	174,736 [36.2]	16,411 [3.4]	148,325 [32.8]
Denmark	184,300	140,436 [76.2]	8,293 [4.4]	132,143 [71.7]
Manjimup	689,400	603,241 [87.5]	19,320 [2.8]	583,921 [84.7]
(b) Wheatbelt[2]				
Dumbleyung	255,200	26,578 [10.4]	16,050 [6.3]	10,528 [4.1]
Lake Grace	925,000	282,990 [30.6]	109,132 [11.8]	173,857 [18.8]
Pingelly	123,300	7,026 [13.8]	8,934 [7.2]	8,092 [6.6]
Tammin	108,700	7,642 [7.0]	5,812 [5.3]	1,830 [1.7]

(1) Source: Schofield et al (1989). Vegetation strategies to reduce stream salinities of water resource catchments in south west Western Australia. WAWA, Rep. WS 33, July 1989 p. 61.

(2) Source: Coates, A.M. (1987). Management of native vegetation on farmland in the wheatbelt of Western Australia, Land Resource Policy Council 1987 pp. 58.

Extensive clearing has caused the loss of natural woodlands and forests

Scattered shade trees in rural paddock

Remnants of vegetation can be effective in providing habitat corridors for the conservation of wildlife. Concise information on the use of corridors by wildlife is lacking, as much of the evidence is purely observational and concerns remnant corridors that survived by default rather than by good management (Bennett,1990).

It is known that the width of a corridor is a particularly important factor as it affects most aspects of the corridor function. Therefore, if the remnant is to be used effectively as a corridor for wildlife conservation, the width has to be maximised. This is due to the fact that increasing the width of a corridor incorporates a greater area, providing the opportunity for a greater diversity of wildlife and makes the corridor more suitable for "sensitive species" (Bennett,1990). Studies have shown that there is a clear relationship between the occurrence of species and the area of the remnant patch; a species will only occur in patches larger than a certain minimum area (Lynch 1987; Van Dorp and Opdam, 1987).

How wide should corridors be? A simple answer is not available as there are many factors upon which it depends. The optimum width of a corridor depends upon its objective, the ecology and movements of the target species, and the structure of the landscape (Bennett,1990).

2.2 *Type and Condition*

Enormous changes in the rural environment have occurred since European settlement in Australia. Trees were removed from rural environments all throughout Australia and never replaced. In some cases, the solitary shade trees left in improved pastures are the last remnants of the original ecosystem of which they were a part.

A native understorey of co-existing wattles does not grow under these trees. Instead they now live among the exotic grasses and herbaceous legumes. The animal and insect populations have also changed dramatically, as have the microbes in the soil. The different grass type and abundance is favourable to Christmas beetles and other insects, and successive plagues have defoliated many rural eucalypts (Crane,1986). The ecological balance which once existed needs to be restored so as to stop such widespread tree death.

The large majority of the remnants in the agricultural region, even those in the same district, will vary in many ways. They may differ in composition, size and degree of degradation due to differences in location, climate, soils, extent of human impact and susceptibility to dieback.

Many of these factors should be examined carefully if proper management of the remnant is to occur. This could take the form of a small survey, such as that developed by Hussey (In

Saunders et al,1991) for landholders, or as a more detailed survey undertaken by a biologist.

The main criteria for determining the value of a remnant would include: plant species present, diversity of native species, presence or absence of native vegetation layers and wildlife habitats, proximity to other areas of native vegetation, degree of exotic weed invasion, degree of disturbance by such factors as firebreaks, rabbits and farming, its landscape value and the size of the remnant (Breckwoldt et al,1990). These factors are discussed in detail below.

Remnant vegetation is a resource, and therefore it is important to know what plants are there. For example, the presence of a rare or endangered species in the remnant could be very important and could warrant special management. There is a distinct lack of knowledge about what plants are present in remnants and how they can be conserved through management (Breckwoldt et al,1990).

The following paragraphs outline the major vegetation classifications, as described by Beard's (1981) vegetation survey of Western Australia. The Swan area (covered by sheet 7), includes the Wellington Dam and Denmark River Catchment Areas and the Warren River and Kent River Water Reserves and their boundaries are shown on a section of the vegetation map as Figure 1.

The Wellington Dam Catchment Area is situated closest to Perth and incorporates the town of Collie. There is little variation in the vegetation types found in this area. Beard (1981) classifies all the vegetation in this catchment as "forest", which he defines as a closed formation of trees of medium height (10-30 metres), normally *Eucalyptus marginata* (jarrah) in mixture with *E. calophylla* (marri). *E. wandoo* (wandoo) also occurs locally (see Figure 1).

The Warren River Water Reserve is located further south and incorporates the towns of Pemberton and Manjimup. Three different vegetation categories are found in this area according to Beard (1981). The major vegetation complex is "forest" as described above. The other dominant vegetation complex appears to be that of "tall forest", which Beard (1981) defines as a closed, medium density canopy of tall trees surpassing 30 metres. *E. diversicolor* (karri) is the principal species found in these regions, either in pure stands or in a mixture with marri and jarrah. The other vegetation complex occupying only small isolated areas of the Warren River Water Reserve is that which Beard (1981) terms "low woodland". This complex is defined as an open low formation under 10 metres, consisting of *Melaleuca rhaphiophylla* and/or other *Melaleuca* species (paperbark and teatree).

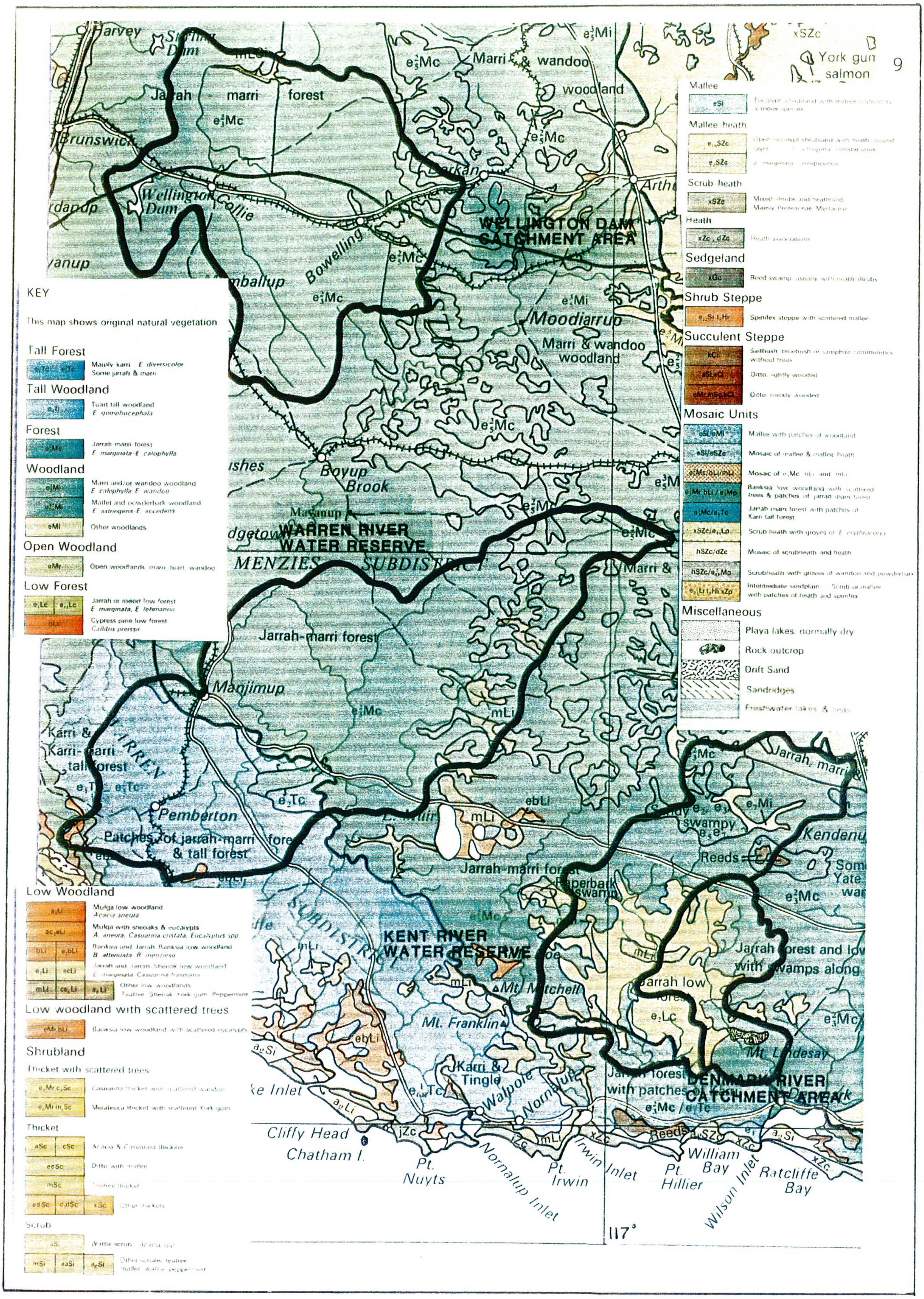


FIGURE 1 Section of Swan Vegetation Survey of Western Australia (Beard 1981) with Clearing Control catchments. 1:1000000 series

The Kent River Water Reserve and the Denmark River Catchment Area are adjoining and situated between the towns of Rocky Gully and Denmark. The Denmark River Catchment Area is the smaller of the two and primarily consists of jarrah/marri forest and low forest with swamp. The Kent River Water Reserve has a wider diversity of vegetation complexes. The "low woodland" has already been described above and again occurs only in small patches, as does the area described as jarrah forest with patches of karri. The other vegetation complexes in this region include "low forest" and "woodland". The "low forest" vegetation complex appears to take up the majority of the catchment. Beard (1981) defines this as a closed formation of low trees under 10 metres, more-or-less dominated solely by jarrah. "Woodland" is defined as an open formation of medium trees, and is formed principally by *E. loxophleba* (York gum), *E. salmonophloia* (salmon gum), *E. salubris* and *E. wandoo*. The remaining few areas mapped are defined as swampy or sandy with various eucalypt species.

The other criteria which are important in determining the value of the remnant is the diversity of species and the presence or absence of native vegetation layers. The more diverse the vegetation in the remnant, the more valuable it will be for nature conservation (Hussey In Saunders et al,1991), and also may widen the options for income diversification. The presence of several layers of native vegetation (grass or other herbs, shrubs and a canopy of trees) will also increase the value of the remnant for nature conservation. Smaller plants are equally important members of the natural community as trees are.

The proximity to other areas of native vegetation is an important aspect because it determines its value as a wildlife corridor. If it links patches of uncleared land, it is very important in the movement of biota (Hussey In Saunders et al, 1991). The availability and reliability of essential resources (food, shelter and nests sites) are critical if it is to be used by wildlife to live in and use as a pathway for movement (Bennett,1990).

The degree of impact on the remnant due to human influence is a major factor in determining its value for nature conservation and its ability to deal with a specific purpose such as wildflower production. Points to be investigated would include: the degree of disturbance by such factors as firebreaks, quarries, access tracks and rabbits, presence of utility services such as power lines, degree of farming pressure and the exotic weed invasion (Breckwoldt et al,1990). Weeds are an important consideration because they compete with the native vegetation, hinder regeneration and decrease the conservation value of the corridor (Hussey In Saunders et al,1991).

A healthy remnant of native woodland would therefore have the following characteristics:

- high degree of diversity in vegetation structure, plant and

animal species present and the age classes of trees and shrubs represented,
- minimal disturbance by man or grazing livestock,
- low to medium pressure on trees due to insects,
- a substantial area of several hectares or more, and
- a majority of trees having normal, full-leaved crowns with very few dead or leafless branches and little obvious epicormic growth (Wylie et al In Saunders et al,1987).

Whereas there is considerable data on the area of native vegetation, there is very little data available on the type and condition of the vegetation in these remnants. Consequently, it was recommended by the Remnant Vegetation Steering Committee (1991) that the completion of surveys defining the types of vegetation represented within remnants was to be treated with high priority, along with the development and regular application of recording their condition and monitoring changes.

3. STREAM SALINITY HAZARD ZONES

By the 1920's the basic mechanism of salinisation had been established by Wood (1924). Following this the subject lay dormant because fresh sources of water were generally plentiful.

The demand for water was rapidly increasing by the 1950's with the growth of agriculture, irrigation areas, mining and other industries and domestic requirements. The deterioration of water resources due to salinity became increasingly apparent through the 1960's and 1970's and led to the government progressively introducing controls on land clearing.

Legislative controls on the release of Crown Land were imposed on the Mundaring catchment early in the century, on the Wellington, Kent and Denmark catchments in 1961 and on parts of the Preston, Capel, Blackwood, Donnelly, Gardner, Shannon, Deep, Frankland and Warren catchments in 1978 (Steering Committee For Research on Land Use and Water Supply,1989).

It was soon realised that this action would not be enough to maintain satisfactory stream salinity levels in the rivers of some marginal catchments. Marginal catchments are those with rivers which are intermediate in their penetration of inland agricultural areas (Public Works Department,1979). Controls on forest clearing were thus introduced in the 1970's on the Mundaring, Wellington, Kent, Warren and Denmark catchments.

The four intermediate rivers of the south-west highlighted in this paper are the Collie (including Harris), Kent, Denmark and Warren. These rivers haven't been totally lost as potable water resources, but if all the private land in their catchments was cleared, their salinity levels would become marginal or unacceptable for public water supply (Steering Committee For Research on Land Use and Water Supply,1989).

Clearing Control Guidelines were developed after it became clear that a process was required to assess clearing applications faster and more consistently. The guidelines were initially developed for the Wellington Dam Catchment Area and were later applied to another four catchments.

Four zones of diminishing stream salinity hazard were established in March of 1979 when the Clearing Control Guidelines were amended (G. Kikiros, pers. comm.). The four zones of diminishing stream salinity hazard, A-D, are indicated on Figure 2 for the Wellington Dam Catchment Area (zones A-D), Warren River Water Reserve (zones A-D), the Denmark River Catchment Area (zones A-C) and the Kent River Water Reserve (zones A-C).

The zones, named A to D, are based on rainfall isohyets with the exception on the Wellington catchment which is modified to include the Collie coal basin. The zones are also adjusted so as not to separate members of the same community. Zone A represents the areas which are highly salt sensitive and have strict controls placed on them regarding clearing. Licences to Clear are generally only granted for farm management reasons. Zones B and C are the intermediate areas, with clearing licences generally being granted for areas less than 10ha and 25ha respectively. An additional 10ha for Zone B and 25ha for Zone C is considered after further assessment. The area with the lowest stream salinity hazard is Zone D. In this zone, clearing can take place up until the statutory requirement of 10% of the holding is left under indigeneous vegetation (G. Kikiros, pers. comm.).

4. THE BENEFITS OF CONSERVING REMNANT VEGETATION

Trees make farms much more beautiful and pleasant places to work and live. However, the reasons for retaining native vegetation on farms goes far beyond merely improving the appearance of the farm. Farm trees are a valuable resource for both the farmer and the community. Respectively, these benefits can be termed on-farm and off-farm.

Pragmatic and economic motives drive many. Farmers in particular, being predominantly small businessmen, often retain remnants of vegetation for pure financial reasons (Burke et al in Saunders et al,1990). Remnants of vegetation have the potential to generate revenue through the production of minor forest products. These products include wildflowers, native tree seed, timber products, honey, essential oils/extracts, native fruit, charcoal and tannins. These commercial uses of remnants are discussed subsequently with emphasis on the south-west of the state.

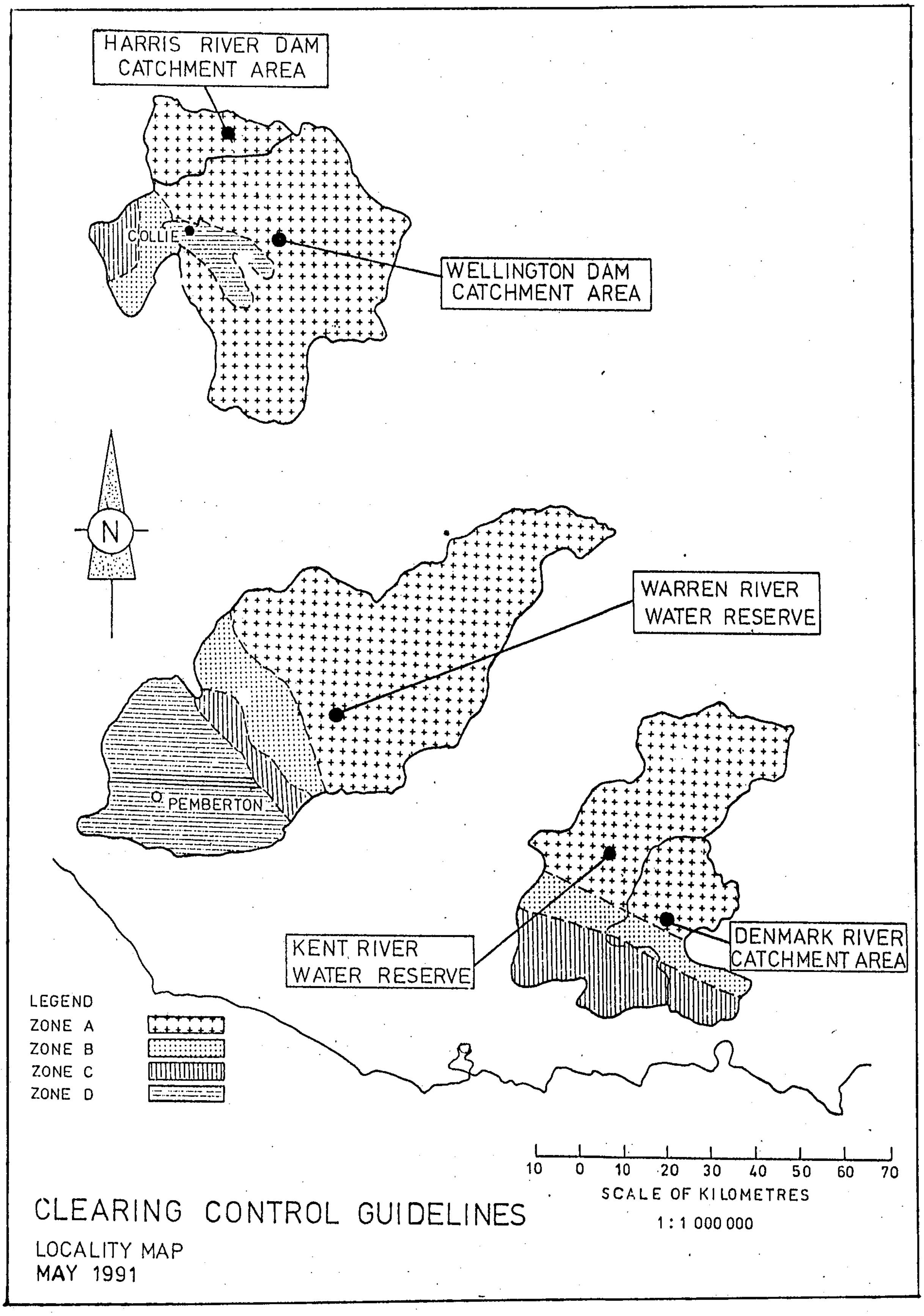

HARRIS RIVER DAM
CATCHMENT AREA
COLLIE
WELLINGTON DAM
CATCHMENT AREA
N
WARREN RIVER
WATER RESERVE
PEMBERTON
KENT RIVER
WATER RESERVE
DENMARK RIVER
CATCHMENT AREA
LEGEND
ZONE A
ZONE B
ZONE C
ZONE D
10 0 10 20 30 40 50 60 70
SCALE OF KILOMETRES
1 : 1 000 000
CLEARING CONTROL GUIDELINES
LOCALITY MAP
MAY 1991

FIGURE 2

By providing shade and shelter for animals, remnant vegetation can improve farm profitability

Wildflower production from remnant vegetation can provide another source of income on farms

Retaining the remnant vegetation provides many other benefits which accrue directly to the farmer. Remnants of native vegetation can improve profitability by increasing animal and plant growth through the provision of shade and shelter. Fodder trees may improve the carrying capacity of grazing properties (Burke et al In Saunders et al,1990) by providing fodder in times of drought.

By providing habitat for those animals which naturally control pests, farmers can decrease crop losses by insect and other pests without resorting to more harmful and expensive methods. The inclusion of trees and shrubs around farm dams can improve the quantity and quality of water provided. Furthermore, property values can be increased by the presence of trees.

Apart from directly benefiting the farmer, remnants of vegetation also benefit the community as a whole. This is not to say that these benefits do not also return to the farmer.

Damage to the environment can be on a local farm scale or on a broader catchment scale. The environmental benefits of stands of vegetation on cleared land include a reduction in salinity, improvement in soil fertility, control and prevention of erosion, control of waterlogging, reduction in catchment eutrophication, possible check of acidification, probable increase in local biodiversity and possible reduction in the Greenhouse Effect (Prinsley,1991a).

In this manner, it is obvious that the benefits of land degradation control accrue back to the farmer as it contributes to the long-term stability and productivity of large areas of agricultural land, without the need for excessive amelioration costs.

Fire can be disastrous in agricultural land. By controlling fire, remnants of vegetation on properties may lessen the damage to crops, stock, farm structures and machinery on both the land it is planted on and the surrounding properties. Research on remnants may contribute to a sustained yield agriculture by supplying information on the soils and vegetation of the area or discovering new resistant crop strains. By contributing to the recreation and tourism industry, remnants of vegetation may generate significant dollars to the surrounding communities.

Non-economic factors certainly affect decision making. Many people are motivated by environmental or quality of life benefits, including landscape improvement and flora and fauna conservation. Concern about the potential global effects of vegetation clearance stimulates further activity (Burke et al In Saunders et al,1990).

A strong argument to retain trees on farms is their contribution to economic returns. In spite of insufficient research or formal trials to quantify many of these benefits, information is becoming available on the real gains which can be made from adequately providing trees on farms (Lindsay et al,1988).

5. ON-FARM BENEFITS

5.1 Commercial uses

Under proper management, there is no better insurance for native vegetation than to have a dollar value associated with its retention (Coates,1987). Minor forest products significant to Australia include: essential oils, honey and pollen production, wildflowers and tree foliage, broombrush, nut and other tree crops, sandalwood, craftwood, seed, trees, drugs, tannins, gums and resins, cane and charcoal (Prinsley,1991a). Those currently and potentially important to the south-west of the state are discussed below.

Many potential industries have not flourished either because of their poor commercial viability or lack of financial and research backing. The distribution and type of research varies greatly with the industry. Some, like the craftwood industry, have little or no research backing at all. On the other hand, others benefit from numerous research programmes (e.g. the Eucalypt Oil industry). Research that is being carried out, is predominantly focused on the technical aspects of the industry or the resource, while little research concerns economics and marketing.

Due to high production costs and highly competitive overseas markets, the opportunities for farmers to enhance their income solely from minor forest products are minimal (Prinsley,1991a). However, additional income could be made by regenerating appropriate species and retaining the remnant of vegetation for multiple purposes. For example, a remnant managed for wildflower production could also increase productivity by providing shade and shelter and controlling land degradation.

5.1.1 Wildflower production

Wildflower production includes flowers, foliage and nuts. They are harvested from natural bush stands, from semi-managed stands (together called bush-picked) or from cultivated plantations. Utilising remnants of vegetation for wildflower production in Western Australia can provide a source of income on farms.

Wildflower production in Western Australia is spread from Esperance to Geraldton along the coastal strip, and includes the agricultural region. Managed stands are located throughout the south-west land division, with an estimated area of 1000ha managed around Albany (DAWA,1988). Albany, Mt Barker and

Manjimup are the centres for bushpicking in the south (Scheltema,1991).

Banksias, Stirlingia, Dryandra, Verticordia, Boronia, waxes (*Chamelaucium*), kangaroo paws and numerous foliage lines such as emu and smoke bush, are the major wildflower species harvested in the state. The major species suitable for semi-managed bush stands include; ti-tree (*Agonis parviceps*), *Banksia* and *Boronia* (Pegrum et al,1990).

Semi-management of bush stands is practised profitably by several farmers in the state. Semi-managed bush stands are those bush areas left on farms that have been left uncleared for flower production and may receive fertilisers, weed and pest control. Wildflower production in this manner has the potential to generate a higher income than that of traditional farming practices. Ti-tree is the most commonly picked export wildflower and in the greatest demand. This species has been recorded as producing an income of $1,000- $2,500/ha., depending on the management practices (DAWA,1988).

Garry and Jan English, tree flower farmers near Esperance, are a prime example of farmers making a significant profit out of their remnant stands of vegetation through wildflower production. The couple harvest *Banksia speciosa* growing naturally on their 50ha sandhill which is too infertile to clear for agriculture. For 1.5 days labour input, the returns to them are around $200/week for 6-8 weeks (Wilson,1992a).

The wildflower industry in Western Australia, although relatively new, accounts for over 50% of Australia's flower and foliage export (Pegrum,1989), with major markets in Japan, USA and Europe. Wildflower exports have grown from $1.3 million in 1980-1981 (Pegrum et al,1990) to $7.7 million in 1988-89 (Pegrum,1989).

Young plantations of wildflowers are still coming into production. It therefore seems likely that the dramatic increases in the state wildflower production will continue. Wildflowers are a likely minor forest product to diversify incomes on farms in the short to medium term in Western Australia.

5.1.2 Native tree seed

Tree seed farming is the use of the native Australian trees and shrubs as "stud farms" to produce "pedigree" seeds (Wilson, 1992b). Seeds from native trees and wildflowers are in demand for use in developing plantations of Australian species, predominantly acacias and eucalypts, in tropical and sub-tropical countries around the world. In addition, they are used for genetically improved material and for use within Australia (Ryan et al,1991).

Native seeds are being used increasingly for propagation purposes as more revegetation is undertaken for the purposes of land and nature conservation. Large quantities of seed are supplied to local and eastern state Shires, mining companies and nurseries for the purpose of replanting and rehabilitating. Seed is also supplied to eastern state companies for domestic consumption and export (Webb,unpublished). Seed collected from remnant vegetation on farms can either be used directly on the farm in revegetation projects, sold locally or to suppliers (Scheltema,1991). The collection of seed occurs throughout the state. Producers of native seed are located in the south-west, from Gingin to Albany (Webb,unpublished).

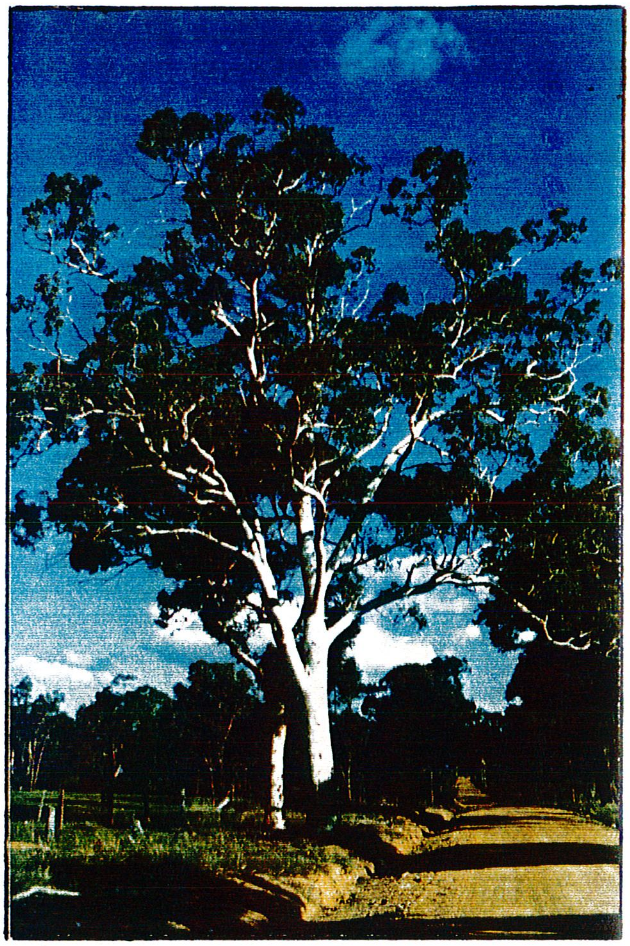
The majority of seed collected from native trees comes from 5 genera. In the period 1980-81, 61% of seed collected (by weight of seed) was from *Acacia, Banksia, Eucalyptus, Helipterum* and *Kennedia* (Wildflower Industry Review Committee,1988).

The wildflower and native tree seed industry in the state consists of several small producers. Most of the operations are basic, relying on one or two people and operating on modest returns and minimal overheads (Webb,unpublished). Seed prices vary with species, but can reach as high as several hundred dollars per kilogram (Scheltema,1991).

Collection and cultivation of seed requires a level of technical competence, and one supplier estimated that it took his collectors on average 5 years to harvest and supply good quality seed. Guidelines for collecting seed from species and provenances has been developed by the CSIRO (Harwood,1990). Good records of species, provenance and location of collection site are needed to supply seed commercially, along with maintaining a number of species over several years.

Tree seed farming can yield gross revenue from $200-$6000/ha (Wilson,1992b). Recent years have seen an increase in the export of wildflower and native tree seed, but is still considered small (Table 2). In the period 1985-86 the value of exports was $43,000, increasing to $213,000 in the first 10 months of 1986-87. According to the industry, this is an underestimate of the value of seed exported from Western Australia and it was closer to $1 million over that time.

Collection of native tree and wildflower seed is one of the most likely minor forest products likely to diversify farm income in the short to medium term in Western Australia. Revegetation for the purposes of land and nature conservation is increasing, and is likely to continue to do so. Therefore, the demand for seed of native species and of local provenances will also continue to increase (Scheltema,1991). However, careful planning is required before beginning. The guidelines for collecting from species and provenances developed by the CSIRO should be studied, and the market place should be thoroughly evaluated.



Fence posts and rails can be produced from *Eucalyptus Wandoo*

Plant growth can be increased when sheltered by windbreaks

TABLE 2 Australian Exports of Wildflower and Native Tree Seed 1981-87

	Tonnes	$000's	W.A. as % of Aust. exports
1981-2	423	879	1.8
1985-6	264	2948	1.4
1986-7*	145	3472	6.1

* for first ten months only
Source: Webb (unpublished)

5.1.3 Timber products

Trees provide a means of diversifying farming income where there is a market for timber products. Timber products which can be produced from remnant forests on farms include firewood, pulpwood, posts and rails, sawlogs and poles. Sandalwood and craftwood are also important as minor forest products.

A wide range of species have been trial planted on farms during the past two decades, and have indicated the species that grow well. Moore (1991) lists some of the species suitable for firewood, pulpwood, posts and rails, sawlogs and poles. Table 3 details this information, but includes only the Australian species in Moore's list.

A third of all households in Perth rely on wood as their main source of heating (Slavin,1989). With population on the increase, the ability of our forests to satisfy demand for firewood without jeopardising their survival and beauty, is being strained.

The damaging dieback disease is most active after rain, which is the time that many people begin collecting firewood. With dieback becoming an increasing problem in our forests, more stringent regulations are being put on indiscriminate collection of firewood.

This has led to an increase in demand for firewood from private remnants of vegetation. This has meant that although the majority of firewood is used on-farm, there is also the potential to commercially supply firewood to markets existing close to regional population centres and Perth.

The yield of firewood can range from 2-15 tonnes/ha/annum over 10 years. Prices paid for dry firewood delivered to Perth range from $60 to $100 gross per tonne (Moore,1991). If landholders do not wish to deliver the wood themselves, allowing people to collect firewood on their land may be an option. A fee could be charged for being allowed in, or for a certain quantity of firewood (e.g a trailer load).

TABLE 3 Some suitable species for various timber products[1]

PRODUCT	SUITABLE SPECIES	COMMENTS
Firewood	Examples include: *E. cladocalyx* *E. camaldulensis* *E. astringens** *Casuarina obesa**	many species OK.
Pulpwood	*E. globulus*	others being evaluated include: *E. botryoides* *E. viminalis* *E. grandis* *E. saligna*
Posts and rails	*E. cladocalyx* *E. astringens* *E. wandoo** *Acacia acuminata**	
Sawlogs (hardwood)	*E. diversicolor** *E. saligna* *E. globulus* *E. maculata* *E. muellerana* *E. microcorys* *E. grandis*	These species are for wet temperate zone (>600mm/yr)
Poles	*E. meullerana* *E. diversicolor**	used by SECWA

(1) obtained from trial plantings of a wide range of species established on farmland during the past 2 decades.
* native to south-west W.A.
Source: Moore,1991.

Fencing materials are predominantly for on-farm use. However, there is a potential for supplying treatment works with posts and for developing markets within local farming regions. A 25 year old *E. cladocalyx* windbreak near Esperance produced strainer posts at more than one per tree on average. With on-farm treatment (cold creosote) the farmer's estimate of their worth was at least $10 net per post, which comes to $2000/kilometre for one row of trees (Moore,1991).

Production of saw logs from farms is restricted to areas with greater than 450mm rain annually. Yield data for farm grown hardwood species is limited because many of the plantings by farmers have not yet reached a millable size. The stumpage for young hardwood sawlogs ranges from $14/cubic metre to $34/cubic metre depending on the size and grade of the logs (Moore,1991).

There is a greater potential for producing hardwood saw logs on remnant stands of native vegetation on farms since the introduction of the VALWOOD process for young saw logs. The name VALWOOD has been registered by CALM in Western Australia as the trade mark for a sequence of timber conversion processing steps in which low-value small eucalypt logs are converted into high value products for furniture manufacture (CALM,undated).

A lot of timber is left wasted on the forest floor, particularly in regrowth jarrah and marri forests in which thinning of the crowded young stands occurs in order to promote the growth of healthier trees. Before the development of VALWOOD, these thinnings were considered too small for saw mills. They were used for low value products or left to rot.

The VALWOOD process puts these small eucalypt thinnings, with little or no commercial value to ingenious use. The 10mm thick boards are laminated edge to edge and face to face and turned into economical blanks (the panels from which furniture is made). The result is an economical, strong, practical timber of high value to sawmillers and furniture makers (CALM,undated).

The VALWOOD process has increased the market for small-sized timber. In addition, there are contractors with portable mills that can be hired at relatively low prices (J. Bartle, pers. comm.). This has meant that the production of timber from remnant vegetation on farms has become more commercially viable.

There is likely to be a strong demand for poles by the State Electricity Commission of Western Australia. Producing poles could mean a significant economic gain to farmers located within 120km of the market. This is calculated on the stumpage value of $74.90/cubic metre (Moore,1991).

Sandalwood (*Santalum spicatum*) is harvested as either green barked logwood or dead wood. Trees that are either dead or alive are pulled or pushed from the ground to gain access to the roots. The roots, along with the butts, branches and stems, are a valuable source of heartwood (Scheltema,1991).

Sandalwood production was once widespread throughout the agricultural area. Presently it is now predominantly found on pastoral properties and vacant crown land in the eastern Goldfields, Murchison, Gascoyne, northeastern Goldfields and Central Desert of the state (Keally,1989). Thus Sandalwood production is not viable in the south-west of our state.

Craftwood is selected from the floor of the forest, and purchased from the retailers (either green or fresh). Timbers used for craftwood are selected for their unusual grain, colour and texture. The main products of craftwood are furniture (47%), sculpture (22%) and woodturning (23%) (Keally,1989).

The species used for the production of craftwood are similar to those used in the honey industry; jarrah, sheoak, blackbutt, banksia, marri and yate. The industry is centred in the high rainfall area to the west of the agricultural zone (Margaret River - Manjimup - Albany) (Scheltema,1991).

The majority of woodturners in the craftwood industry are hobbyists or part-time workers. The industry is cottage-based with products being predominantly sold through galleries and craftshops (40%) or privately (35%). An estimated 1700-2300 cubic metres of timber are used by the industry each year (Scheltema,1991).

There are currently many social, economic and technical constraints to timber production on farms (Prinsley,1991b). With environmentally sensitive management, remnant stands of vegetation can provide timber in a sustainable manner. In addition, they can provide other benefits such as land degradation and control.

5.1.4 Honey

Apiculture is the raising and care of bees for production of their honey. Native shrubs and trees are the backbone of the honey industry. The European honeybee was introduced in 1846 and commercial beekeeping commenced in Western Australia in the 1880's when stands of local jarrah, marri and wandoo were relied upon for production (Wills <u>et al</u> In Saunders <u>et al</u>, 1990).

The majority of hives in the state are found in the South West Province to the south-west of the 300mm rainfall line between Shark Bay and Israelite Bay (Scheltema,1991). This is shown in Figure 3. As shown from this map, the major centres of honey production are situated outside of the agricultural area.

Around 66% of the honey produced originates from eucalypt species, while that remaining originates from the coastal heathlands and banksia woodlands. The dominant eucalypt species is marri which occurs in the high rainfall zone inside and outside of the agricultural area. Jarrah, wandoo, blackbutt, powder bark wandoo, york gum, karri, tuart and brown and blue mallets are the other eucalypts of importance. Mallees are also important trees for honey production, especially when the forest trees fail to bloom in years of drought. However they can cause the costs of production to rise, making returns marginal (Scheltema,1991).

The majority of commercial apiarists currently practice migratory beekeeping. They are dependent on native plant communities as the major source of pollen and nectar. Each season the apiaries are moved to enable the bees to utilise the peak flowering of *Eucalyptus* species in the south-west forests, and relocated in the kwongan (native shrubland) of the northern sandplain for the winter flowering (Wills et al In Saunders et al,1990).

This method of traditional honey production may not be available to migratory beekeepers in the future due to the claims of conservationists that introduced bees take nectar and pollen from trees and shrubs in native forests and scrublands, without necessarily triggering the pollination process (Wilson,1992b).

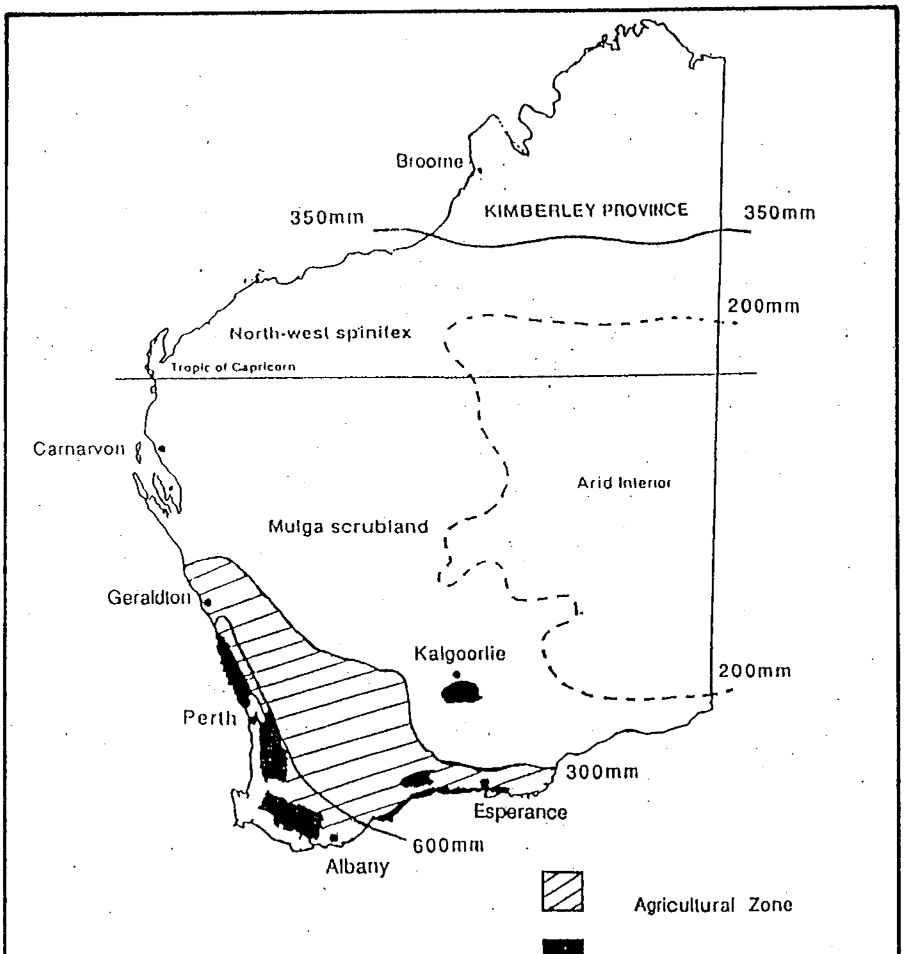
If migratory beekeeping was disallowed, the viability of honey farming would be greatly improved for farmers. Honey farming is a method of honey production in which farmers, perhaps on a catchment basis, could provide a significant resource in nectar and pollen producing trees and shrubs, while beekeepers provide the harvesting and market expertise. The beekeepers would be required to pay the collaborating catchment groups a fee for the provision of "bee pasture".

On the upper scale, honey farming could yield produce worth $100 to $400/ha compared to sheep that gross $125/ha and wheat which grosses $200/ha on the same kind of land. The lower scale is estimated between $10-$15/ha by beekeepers (Wilson, 1992b). The practical range will probably lie somewhere in between these estimates.

Ten percent of Australia's annual honey and beeswax production comes from Western Australia (Allan et al,1989). Table 4 outlines production in tonnes and value of honey products. Production in other states is more lucrative with case studies in Tasmania currently yielding honey worth $400 to $1200 per hectare (Castley,1991).

Honey can be produced from remnant vegetation on farms in Western Australia as long as the appropriate species are chosen. In the short to medium term and under existing arrangements, returns would be marginal (Scheltema,1991). As discussed above, a new approach to honey farming has the potential to significantly improve returns to farmers as a means of diversifying their farm income.

FIGURE 3 Location of honey production in Western Australia



Source: Scheltema, 1991

TABLE 4 Production and Value of Honey Industry in W.A. 1989-90

	Production (tonnes)	Value $ p.a.	No. productive hives
Honey	2182	3,200,000	26,000
Beeswax	39	300,000	
Pollen	26 (est.)	130,000 (est.)	
Queen Bees		70,000-80,000	

Source: Australian Honey Board Annual Report 1989-90

Using a remnant of vegetation for honey production could be viable if the remnant is also being used for some other purpose such as land degradation control or as a shelterbelt. Not only will the landholder gain further income from honey, but the bees will make an enormous contribution to agriculture by pollinating crop and pasture plants (Breckwoldt,1986).

5.1.5 Essential oils/extracts

An extensive range of chemicals can be derived from a wide range of plants throughout Australia. In the past these oils have been used by Aboriginals for medicinal purposes. Essential oils, are defined by Purchom et al (1990) as the concentrated perfume of a plant usually obtained by steam distillation. They are common in myrtaceous species of *Eucalyptus* and *Melaleuca* and can be used for a number of purposes including antiseptic preparation, industrial processes, fragrances, flavourings (Ryan et al,1991) and as a cleaning agent. Research is continuing in alternative uses for eucalyptus oil, including use as an industrial chemical and solvent, as a liquid fuel where ethanol is considered viable.

Eucalyptus and tea tree oil are probably two of the best known oils produced in Australia. The Essential Oil Industry includes the production of essential oils of fennel, peppermint, boronia, parsley, blackcurrant, spearmint, carraway and dill (Castley,1991).

To date in Western Australia, there has been no commercially viable production of eucalyptus or other essential oils. Restrictive and highly competitive markets are the major difficulty in establishing a major and sustainable essential oils industry based on Australian native plants. New flavours and perfumes need to be thoroughly tested and supplies guaranteed. Establishment costs are high and a large capital investment is needed. This has meant that production has not been economically feasible due to the availability of alternative flavours and perfumes (Scheltema,1991).

The production of essential oils in other states of Australia has proved profitable. Scheltema (1991) quoted the market price of high quality pharmaceutical grade eucalyptus oil as $9.00/kg, while the costs of production in N.S.W (excluding the value of land, establishment costs and costs of finance) are estimated at $7.80/kg. The current retail value of eucalyptus oil production in N.S.W amounts to $1.5 to $2 million annually (Hawkins,1991).

There are species native to the state which have the potential to produce oil. Eucalypt species in southern Western Australia have been tested for total oil content and percentage of cineole content. It was found that these species had oil contents equal to or exceeding that of *E. polybractea*, the major eucalypt currently used for this purpose in Australia

(Scheltema 1991). Bulman et al (1991) state that a species native to the south-west of the state, *E. Salmonophloia*, has definite potential.

Further studies may reveal many other common species to be of potential in the future. Nine eucalypt species are being tested for oil production and water usage at the Wongan Hills Research Station by the Department of Agriculture and Murdoch University. After 3 years, cineole yields (kg oil/ha) ranged from 3.5 to 46 kg oil/ha depending on the species, compared with the 70kg oil/ha recommended for commercial production in Australia (DAWA, 1989).

Oil production in Western Australia will only become economically viable if several conditions occur together. These are: species/varieties with high cineole content and yields are used, a "farmer's co-operative" is formed to produce and market the oil, a minimum of 1000ha within a region is in production, production is efficiently mechanised, the majority of the leaf is harvested within a 5km radius of the distillery and the remainder within a 10km radius (Scheltema,1991).

Therefore the production of oil from remnants of vegetation is not economically viable in the state at present. However oil production may be able to be combined with land conservation. This too could prove to be a problem as the location and design of tree planting for the purpose of land conservation are not necessarily the most efficient for oil production (Scheltema, 1991).

5.1.6 Native fruit

Remnant stands of native bushland have the potential to commercially produce native fruits. The Quandong (*Santalum acuminatum*) and the Native Currant (*Acrotiche depressa*) are viable operations in South Australia. Both have been used in pies, jams and jellies since the early days of European settlement in Australia (Bulman et al,1991). Quandongs are used for their flesh and kernels and are now offered as a dessert fruit or a tray service at leading eating establishments. The market could also be extended to Japan and other parts of Asia where quandong fruit is considered a delicacy (East,1992).

The production of quandongs or other native fruit is not a viable option on farms in Western Australia. However, elsewhere in Australia, production has been very profitable. Ben McNamara is an example of a South Australian farmer who has made a successful business out of supplying quandong seedlings and fresh and dried fruit.

Although the quandong is found naturally throughout the agricultural and pastoral regions of the state, its production is not considered commercially viable. This has been attributed to agronomic reasons. Before quandongs can begin producing incomes on farms in Western Australia, considerable work has to be done in plant selection and breeding, agronomic techniques and in market research and promotion (Scheltema,1991).

5.1.7 Charcoal

Charcoal is the carbonaceous residue of substances, especially wood, that have undergone smothered combustion, or burning without sufficient oxygen (Maunsell and Partners,1987). Wood is the usual raw material because of its ease of processing and minimal by-product production, although any organic substance can be used.

Charcoal can be used for smelting, for cooking (char-grilling restaurants), as agricultural charcoal (animal foods, potting mixes and horticulture), in domestic barbecue kettles, in the automotive industry (Bulman et al,1991) and as a source of carbon in industrial processes.

In Picton in the south-west of the state, silicon is produced by Barracks Silicon Pty Ltd. Charcoal is required in the process to reduce silica to silicon. The vegetation of the area, hardwood forests of jarrah, is highly suitable for charcoal production due to its high purity (Maunsell and Partners,1987).

There are also a few smaller manufacturers of charcoal in the south-west of the state, commonly producing backyard barbecue charcoal (J. Bartle, pers. comm.).

At 1991 prices in South Australia, returns to the grower were said to be $5/tonne for access to the timber. Approximately two to two and a half tonnes of wood produces a tonne of charcoal. Upon bagging and delivery to the consumer, the returns were said to be from $500 to $750 per tonne (Bulman et al,1991).

Therefore, harvesting jarrah or other hardwood species from remnants for charcoal production, may prove to be a commercially viable option for landholders wishing to diversify their income. However Bulman et al (1991) believed that in the case of South Australia, one could not expect an economic return on a planting solely for charcoal production, because of highly competitive and restricted markets. Opportunities may be limited to an incidental harvest of remnant vegetation used for other purposes such as fuelwood.

5.1.8 Tannins

Tannins can be extracted in commercial quantities from the wood and bark of some plant species. The tannins are then used for tanning and glue manufacture. The use of natural tanning agents is decreasing because of the increased use of synthetic tannins.

However, attention is now being paid to the use of vegetable tannins as raw material for the manufacture of waterproof wood adhesives, and Australia currently imports tannins for that purpose (Searle,1991).

Tannins can be derived from a number of tree species. The bark of most *Acacia* has a significant tannin content, reaching as high as 45% in some species (Boland et al,1984). Several Eucalypt species are also known to be rich in tannins.

At present there is no commercial production of tannins in Western Australia, although its extraction from wandoo in the south-west of the state was once a medium sized industry.

There is a potential for tannin production in the south-west of the state (J. Bartle, pers. comm.). *E. astringens* (brown mallet) and wandoo are species of particular interest due to their high tannin content (>40%). The brown mallet is found in the drier inland side of the jarrah belt (Boland et al,1984). Wandoo is found extensively throughout the south-west.

E. sargentii (salt river gum) and *E. brockwayi* are two other species of interest, although not to the south-west of the state. Respectively, they are found in the western wheatbelt and in a small region near Norseman (Boland et al,1984).

Total annual imports of tanning extracts from all vegetable origins exceeded 5000 tonnes in 1990-1991. The value of wattle-bark (largely from *A. mearnsii* extensively cultivated in South Africa) was over $4 million (Bulman et al,1991).

There does seem to be some potential for extracting tannins in the south-west of the state for commercial production. However, Bulman et al (1991) warns that the feasibility of re-establishing a tannin industry in Australia must be investigated extensively.

5.2 Shade and Shelter

The agricultural region of the state has a warm to mild Mediterranean climate meaning it has a distinct dry, hot summer and a mild to cool, wet winter. The availability and quality of feed for stock peaks in spring, and reaches its lowest point in autumn. Pastures are generally annual, which germinate with rain about mid-April and senesce in late spring (Bicknell, 1991).

Retention of the native vegetation on farms can provide shelterbelts or shade trees for crops and livestock, or to shelter houses from wind and noise (Johnston et al,1990). The productivity of livestock and crops increases where remnant vegetation acts as a windbreak and provides shade.

The area protected by a windbreak is related to the height of the trees. An effective windbreak can reduce the speed of the wind for a distance up to 30 times the tree height on the downwind side, and 5 times the tree height on the upwind side. Windspeed in the paddock is reduced the greatest in the part of the paddock from 5 to 15 times the tree height away from the windbreak (Wakefield,undated).

There is a greater gain from windbreaks where the probability of loss is greater. For example, Esperance has the potential for large gains from windbreaks due to its highly erodible soils and strong winds. Farmers in the region have recorded net profits from windbreaks within 5 years (Scott,1990).

The cost to the landholder of planting and maintaining new wind-breaks can be costly, yet often landholders have no choice due to overclearing in the past and lack of regeneration. Native trees already existing can achieve the same results if they are incorporated in the farm plan and managed in a correct manner. In this way, remnants of vegetation can increase productivity and save costs of replanting in the future (Breckwoldt,1986).

5.2.1 For stock

Research on the effects of shade and shelter on livestock has been continuing in Australia. It has been found that shade and shelter affects the productivity of sheep and cattle in a positive way by decreasing deaths and feed required, and increasing the quality and quantity of goods produced.

Cold stress occurs when increasing wind speed raises the rate of heat loss from an animal's body. This means that the animal has to eat more food or lose some of its body reserves of fat in order to maintain its body temperature. With more feed being utilised to maintain body temperature, less energy is going into producing milk, wool or meat (Wakefield,undated). Heat stress occurs when less heat is lost by evaporation than is generated by metabolism, leading to a rise in body temperature (Monteith et al,1990).

Cold stress is decreased due to shelter from remnant vegetation. This can be particularly important in decreasing the amount of deaths of newborn lambs. Some researchers believe that approximately 15% of all lambs born in southern Australia die from cold stress. It was found by researchers at Kangaroo Island in South Australia that greater than 70% of lambs died in the first 6 hours after birth when the rainfall and wind speed was above 1.5mm and 18km/hr respectively. When rainfall was zero and the wind was between 0-8km/hr, losses were between 5-10%. Further studies at Armidale in N.S.W. found that protecting lambs from the wind during rain when the temperatures fell below 5C, increased their survival by 27%

(Breckwoldt,1986). Information on lamb death due to cold stress is lacking in Western Australia (Bicknell,1991).

Hot summer winds can increase heat stress in sheep and cattle, a neglected cause of loss on Australian livestock farms (Wilson, 1992c). Greater than 50% of calf losses in north-west Queensland was attributed to heat stress, occurring in particular when the calves were not born under shade (Bird,1984). Watering points also require shade in order to protect lambs from dehydration. Without shade, it is likely that lambs will follow their mothers long distances to water, and suffer heat stress.

The Victorian Farmers and Graziers Association and the Garden State Committee found that in a south Gippsland property, raising fat lambs, vealers and beef cattle under sheltered conditions decreased the amount of winter hay consumed (Lindsay et al,1988). This is due to the fact that the animal does not need as much food to maintain its body temperature.

Furthermore, researchers at Armidale on the New England Tableland of N.S.W found that at high stocking rates, wool production was increased by 31% if the sheep were protected by an efficient wind-break. The sheep on sheltered plots were also an average of 6kg/head heavier than those which had no shelter (Bird et al,1984). Thus, in addition to the extra wool produced, the sheep in sheltered plots would bring in $4/head more than those in unsheltered plot (at August 1984 prices) (Breckwoldt, 1986). Sheltering dairy cattle during cold, wet, windy weather was found to increase milk production (Bird et al,1984).

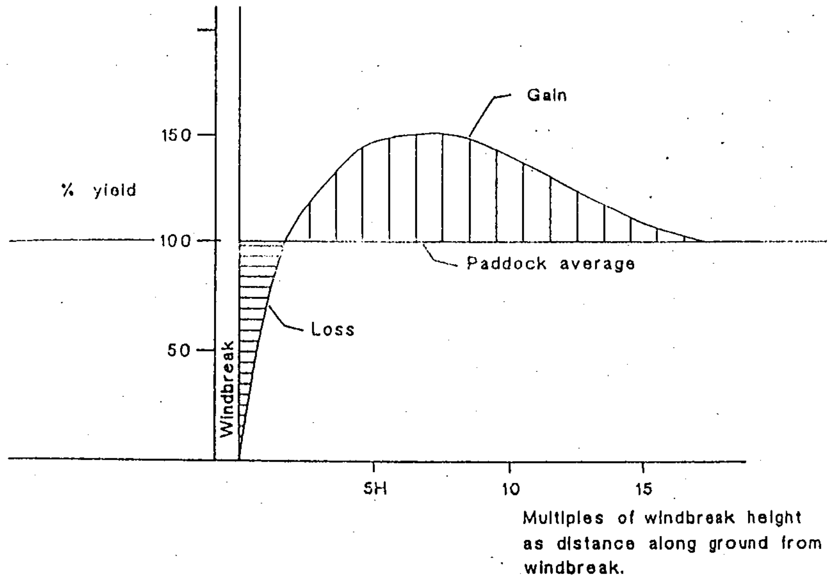
5.2.2 For crops

Remnants of vegetation can also benefit crop production by ameliorating climatic extremes. Pasture and crop yield is increased because direct damage by wind, rain and sun are decreased, but also by water savings in summer.

The roots of the trees in the windbreak compete with pastures and crops for soil moisture. This causes a decrease in growth in the area immediately next to the windbreak. However, what is not so noticeable is the increase in yield in the protected area, which can reach up to 25 times the height of the windbreak (Breckwoldt,1986). Figure 4 shows the effects of tree windbreaks on pasture and crop yield.

P.R. Bird of the Hamilton Research Institute, (Victoria) found that plant growth increased by 10% when sheltered from windbreaks spaced 25 tree heights apart, and by 20% with windbreaks spaced 12.5 tree heights apart (Scott,1990). There is very little accurately recorded data available in Western Australia of the benefits of shelterbelts to crop productivity.

FIGURE 4 Tree windbreak effects on pasture and crop yield



Source: Scott,1990

Most of the material available is purely farmer observation, sometimes with coarse estimates of production changes (Wilson, 1992d).

In Western Australia studies by David Bicknell from the Department of Conservation and Land Management are leading in this area. Research at Gibson, near Esperance in the south-west of the state, have shown significant benefits to crops due to shelterbelts. Although the study did involve a shelterbelt of planted pines, it could just as well be applied to a remnant of vegetation retained in strategic locations.

The measuring program began in 1988 to find the effects on grain and oats yield. The study found that the shelterbelt boosted overall lupin yield by 19-22% when the area of the shelterbelt was included in the net yield/ha, and an increase in yield of 27% on the lupin crop area between the windbreaks.

These increases in yield come about from a reduction in wind velocity on both the upwind and downwind sides. Strong winds can cause mechanical damage to the tips and edges of leaves, reducing plant growth and changing the developmental pattern of crops (Wakefield,undated). A reduction of this physical damage can be achieved through the provision of windbreaks. The huge boosts in lupin crop yield were believed to be due to protection from the cold north westerlies in early winter, and protection from the dry easterlies in spring.

The owner of the farm at Esperance also expected significant increases in wheat yields. He believed that without the trees, the wheat crop would have found difficulty in establishing due to sand blasting of young stems (Wilson,1992d).

Protection from the harsh effects of the wind is particularly important to horticultural crops. Strong winds can cause physical damage to fruit trees and vegetable crops, reducing their productivity (Wakefield,undated).

Wind causes rapid moisture stress on plants, particularly under Australian conditions where the moisture content of soils is typically below their water holding capacity (Bird et al,1984). Plant growth stops altogether when wind speed reaches 40 to 60 km/hr (Wakefield,undated). The researchers at Armidale (N.S.W) found that shelter produced a 12mm water saving over a period of 21 days in early summer (Bird,1984).

It is clear that the retention of native vegetation on farms can be beneficial to the farmer by protecting stock and crops from the harsh effects of the Australian climate. This leads to an increase in productivity which the farmer may see as an rise in income. In addition, there are many other benefits of shelterbelts, including land degradation control. It's therefore imperative that remnant stands of vegetation are retained and managed as carefully as crops, pastures and livestock.

5.3 Fodder

Australia is fortunate in having a number of trees and shrubs that can be used as fodder for stock. Western Australia can be divided into six climatic zones. Native trees and shrubs can be used as fodder in four of these zones: southern semi-arid, monsoonal, dry temperate and wet temperate. Thus, they are important to the south-west of the state as it is classified as wet temperate (Lefroy,1991).

Native trees and shrubs are of a low palatability to stock, and therefore accumulate in good seasons. In this way the quality and quantity of leaf is preserved for use in poor seasons (Wakefield,undated). Thus, remnant forests and woodlands can provide a source of emergency fodder during droughts for the 600,000 beef cattle, 100,000 dairy cattle and the sheep used for wool, that the wet temperate zone supports (Lefroy,1991).

Native trees and shrubs have evolved to withstand long periods without water. Their leaves retain crude protein content even during droughts. However, fodder trees are only equivalent to fair quality hay, and stock become disinterested in it after several months because of its low palatability (Wakefield,undated). Depending on the species used, a leaf diet will maintain stock for up to 9 months. A supplement is

Gully erosion can be the result of extensive clearing of the native vegetation

Salt seep in the Wellington Dam catchment as a result of clearing

required if fodder tree foliage is being fed to young growing stock or pregnant or lactating females (Wakefield,undated).

Regenerating and retaining remnants of native vegetation on farms can therefore provide a valuable resource in the form of emergency fodder in times of drought.

5.4 Natural Pest Control

Agricultural pests can increase to disastrous numbers as a result of tree loss. This is due to the fact that the natural vegetation, and the various animals that require this vegetation as habitat, keep these pests in check. It is thus imperative for farmers to retain their native vegetation for these natural pest controllers to live in. In this way, pests can be kept in check without using other harmful, expensive and time-consuming methods.

5.4.1 Insect pests

Large populations of insects can be disastrous to agriculture because they are able to destroy crops at a rapid rate. Pesticides are no longer thought to be long-term means of pest control due to pest resistance through natural selection, the damage they do to the environment and their toxicity to humans and wildlife.

Conservation of native wildlife however, can be an effective means of controlling insects. Most species of birds feed on insects to a greater or lesser degree, and in doing so may contribute to holding down herbivorous insect populations. For example, magpies are very important in keeping down pasture pests because they eat thousands of scarab larvae per hectare each year, and ibis eat up to 200g of insects per day including caterpillars, grubs, beetles, grasshoppers and moths (Johnston et al,1990). Egrets also consume many insects. Many woodland birds may travel into pasture to forage and may take pasture insects like scarab larvae and grass grubs as adult insects during flight (Ford,undated).

At least half of the insects produced (about 30kg/ha/yr) may be eaten by birds in healthy eucalypt woodlands (Johnston et al, 1990). Therefore it makes good sense for farmers to manage trees to encourage insectivorous birds, in the same way in which they manage their pastures.

Other native animals contribute to controlling populations of insects. Small animals and predatory insects and spiders take a significant proportion of the insects that the birds did not get to (Johnston et al,1990). Many insects benefit farmers by preying on pest species (Denny,undated). For example some native wasp species parasitise scarab larvae. Small ground-dwelling mammals such as marsupial mice, are big feeders and can consume their own body weight in beetles each day (Denny,undated). Tree-dwelling mammals like bats, possums and sugar-gliders also eat insects, as do reptiles and frogs.

5.4.2 Weeds

The native vegetation can also aid in the suppression of the major weed growth problem. This is especially true of native vegetation between roads and adjacent landholders (Brown et al,1989).

5.4.3 Other pests

Some of the larger native animals may help to control pest species by preying on such pests as rats, mice, rabbits and hares. Dingoes may be more important than previously thought in controlling numbers of pigs, emus, wallabies and kangaroos (Johnston et al,1990). It is possible that the control of dingoes has led to these other animals becoming the problem they now are. The dingo also appears to control rabbit numbers during drought and slow down their post-drought recovery (Breckwoldt, 1983).

5.5 *Farm dam improvement*

Farm dams are a long-term investment and proper design and construction will prove beneficial in the long run. The primary use of dams is to provide water for stock, irrigation or domestic use, and often provide greater flexibility in pasture and stock management (Roberts,undated). Secondary uses of importance include: soil erosion control, bushfire protection, wildlife habitats, recreation and aesthetics.

For whatever purpose the farm dam is used for, the inclusion or retention of trees, shrubs, grasses and other ground covers in land and water management plans can provide many benefits. Trees and other vegetation in strategic places can effect the quality and quantity of water in the farm dam.

Every farm dam catchment will be different. Tree cover is more important for those farm dams with small catchments or where rainfall is low, because water yield is usually low. Many farmers believe that trees are detrimental to water yield in farm dams because of the large amounts of water they take up. However, in most cases, a tree cover of 5-10% made up of shelterbelts, small woodlots or scattered trees is unlikely to have any noticeable effect on water yield (Roberts,undated).

At the same time the trees have many other benefits including land degradation control and as a source of fuelwood. By reducing wind speed over the water surface of the dam, it is possible to lower evaporation losses (Scott,1990). Retention or planting of tree blocks or belts on the side from which hot summer winds prevail may increase the water yield.

Poor water quality in farm dams can reduce production. Through proper management of the trees, shrubs and pasture in the dam catchment, the water quality of the water will improve. Water quality problems in farm dams include salinity, algae and soil erosion.

Dryland salinity, a consequence of tree removal in the catchment, can lead to salt and mud being washed into the dam. Retention of native vegetation on farms will lower the ground-water table, and decrease the problem of salinity in farm dams.

Algae populations can reach problem numbers through excessive amounts of nutrients in run-off entering the dam. Problems occur as algae may block pump filters, cause bad taste and odours and may even poison or kill stock. Algae require sunlight to photosynthesise, and therefore trees providing shade over the shallow water at the edge of the dam will reduce the growth of algae (Roberts,undated).

Organic matter pollution of dams is a frequent problem during summer thunderstorms in the East Darling Range "sheep belt" from Boddington to Kojonup (Scott,1990). If the water in a farm dam is muddy, it usually means that soil is being washed in, gradually reducing the dam's capacity. Stock can tolerate muddy drinking water, but it could prove to be unsuitable for irrigation purposes and useless for domestic use. Trees retained in appropriate places in the catchment can assist in the control of soil erosion and improve the quality of the water. Trees, shrubs, grasses and other groundcovers around the dam inlet will act as a filter for a large proportion of the soil and animal dung entering the dam (Roberts,undated).

As a long-term investment, farm dams should be looked after with care. The primary feature in maintaining quantity and quality of water in farm dams is the inclusion of trees, shrubs, grasses and other groundcovers. The least expensive method of achieving this is regenerating and retaining areas of remnant vegetation around farm dams and in other appropriate locations.

5.6 Increased capital value

Natural or planted shrubs and trees, beautify the property landscape and significantly increase its resale value. For a potential buyer, a property with good shelterbelts is preferable to a similar property in the same area that is lacking in trees. This is often reflected in a 10-30% higher price (Lindsay et al, 1988). The higher values of farms with remnants of vegetation simply indicate an appreciation by rural people that trees on farms provide them with many benefits.

6. OFF-FARM BENEFITS

6.1 Land Degradation Control

Some may describe the extensive clearing that occurred in the early days of settlement as "unwise". However, few people were able to foresee the legacy of soil erosion and salinity, as they swung an axe to ringbark a tree or grubbed out a mallee root.

Results from a comprehensive study of land degradation published in 1983 showed that 51% of pastoral and agricultural land in Australia required treatment. The cost of repairing this damage was estimated at $675 million at 1975 prices, while ongoing annual maintenance on required and existing works was as high as $50 million (Woods,1983). The area affected by land degradation, and the cost of repairing the damage, would be considerably higher in a 1992 perspective.

Amelioration is not the only costs of land degradation. There are also huge losses in productivity. Not only is this felt by individual farmers, but ultimately, by the nation as a whole.

Remnant vegetation plays a major role in regulating hydrological processes, nutrient cycling and erosion on surrounding lands. The retention of selected areas of remnant vegetation can help regulate land degradation in newly farmed areas, while selective regeneration and replanting can help control existing degradation processes.

6.1.1 Erosion

Soil erosion occurs through the action of wind and water on unprotected soil. The loss of the finer particles of soil is usually associated with wind erosion, along with drifting and accumulation of the sand fractions. Water movement, over and through the soil can result in sheet, rill, gully and tunnel erosion, as well as landslip (Wakefield,undated).

Trees, in association with the understorey and groundcover layers, play a crucial role in intercepting rainfall and thus reducing the impact of raindrops on the surface of the soil. With the aid of trees, water can soak into the soil and reduce surface runoff. Within the soil, the root system and leaf litter provide structural stability (Wakefield,undated).

Extensive clearing of trees, in association with poor land management, can significantly alter hydrological processes. The consequences of this are increased rainfall run-off, rising water tables and increased surface seepage. This in turn leads to a higher occurrence of flooding, sedimentation and soil erosion (Wakefield,undated).

Windbreaks have been in use for many years in the United States of America for controlling wind erosion, but have not been adopted in Australia on a broadscale basis. Remnants of vegetation are an important infrastructure in the control of wind erosion if all else fails; that is in dry years when crops and pastures produce inadequate groundcover to protect the surface of the soil. Stubble mulching, trash-farming, grazing control and so on, are all considered important practices to prevent wind erosion, but in certain adverse conditions, they can fail (Scott,1990).

The disastrous drought years at Jerramungup and other parts of the south coast and south-west wheatbelt, demonstrated the value of windbreaks in soil erosion. Even low (3m) belts of remnant mallee or scrub were extremely valuable in breaking up the erosion process (Scott 1990).

Steep slopes in high rainfall areas and the arid zone, are not the only areas affected by soil erosion. The problem is widespread and persistent, occurring wherever we use the land. Even the Darling Downs in N.S.W., with its deep, black, self-mulching soils, are affected. Arguably the most fertile soils in Australia, there has been 7 tonnes of soil lost for every tonne of grain produced (Dawson,1984).

Specific sites where trees can play a positive role in soil and water management will vary with each farm. In general, the sites which will benefit the most from the retention of remnants of vegetation include; excessively steep slopes, degraded or eroded areas and lands with soil problems such as severe acidity, fertility imbalance, poor structure, shallowness, stoniness, tunnelling susceptibility and salting (Wakefield,undated).

For many years it has been recognised that clearing of the main waterways and creek banks, results in gully erosion. Trees and mallees not only prevent damage by stock and vehicle or cultivation machinery tracks, but also stabilises the soil through their extensive root system. Retaining or regenerating trees along the sides of gullies, or just upslope of gully heads, can be effective in controlling this type of water erosion (Scott,1990). Again, the shelter and water use provided by the trees are beneficial.

Large areas of remnant vegetation are very scarce on intensive cropping country. It is imperative that those that remain along watercourses are maintained and regenerated so that the most erosion prone areas are stabilised. This can reduce gullying by reducing the rate of stream flow, in turn minimising the loss of soil (Wakefield,undated).

6.1.2 Salinity

Another consequence of vegetation clearance is induced soil salinisation, occurring as either irrigation or dryland salinity. In many parts of Australia, trees kept in suitable parts of the landscape can prevent salting problems by regulating water balances.

The relationship between salinity problems and rising groundwater tables was first noted in Western Australia as early as 1924. Wood (1924) suggested that extensive clearing of trees was allowing more water to percolate to groundwater, which in turn rose to the surface, bringing salts with it. This hypothesis has been clearly established as the principal cause of land and stream salinisation.

Dryland salinity first becomes noticeable in depressions or at changes of slope where the water table comes to the surface. The sun evaporates the water, increasing the salt concentration, killing vegetation and leaving the land bare and open to erosion (Wakefield,undated).

By 1985 only 48% of the total divertible surface run-off of the south-west remained fresh. All the major inland rivers have become saline, and this is the reason why clearing control measures were introduced in the 1970's on five important water resource catchments in the south-west. Despite this, the salinities of four of these catchments have continued to increase at a rapid rate (Scott,1990).

Land salinisation caused by rising saline groundwater tables has also been increasing at a rapid rate. The first survey in 1955 found that 73,000ha (0.5% of land cleared) had become saline in Western Australia. This figure had risen to 443,000ha (2.8% of land cleared) by 1985. Since 1979 the rate of increase of land salinisation has been 17,900ha/year (Scott,1990).

Lothian (1983) reported that as a result of seepage salting, the capital value of land in Australia has decreased by $135 million. In addition, a productivity loss of $16 million was incurred. Salinisation in the south-west of the state has reached a point where it is significantly affecting land and water resources.

Retaining patches of native vegetation can help. Near problem areas, they can use extra water because the perennial trees and shrubs generally use more water than the annual vegetation of current farming systems, particularly close to swamps and sumps, saline areas, drainage lines and seeps (Scott,1990).

6.1.3 Nutrient cycling

Trees play an important role in the nutrient cycle in a number of ways. The retention of remnant patches of vegetation can thus prove beneficial to farmers in the long-term, by maintaining a stable agricultural system.

Trees help keep plant nutrients, elements and moisture in the surface soil. Tree litter and canopy drip retains important plant nutrients in the surface root zone by depositing a significant amount of nutrients on the ground and protecting the soil from erosion. The mulching effect of the litter helps to conserve moisture. In addition, very small amounts of elements derived from the weathering of soil can be transported from the subsoil to the surface soil. This can make an important contribution to the fertility of the soil in the long-term (Breckwoldt,1986).

Nutrients leached from surface soil horizons can be recovered by deep-rooted trees. This is an important process under improved pastures where leaching of legume-fixed nitrogen in the form of nitrate has caused soil acidification and a decrease in pasture productivity (Breckwoldt,1986).

The value of trees in recycling nutrients in agriculture will be most apparent where the original vegetation was only partially cleared, and an adequate amount of trees were left standing as shade and shelter in grassland (Breckwoldt,1986). These trees are now dying due to old age, and provision needs to be made for their replacement. Given the important role that trees play in the nutrient cycle, remnant patches of vegetation should be managed with the same care as pasture, crops and livestock.

6.1.4 Stabilisation of natural communities

The natural vegetation and the many organisms that inhabit it are involved in the breakdown of organic matter, an essential step in recycling nutrients in biological systems. Agriculture utilises these natural systems. Changes in the natural system is compensated for with fertilisers, pesticides and new farming techniques.

The long-term viability of agriculture is increased where natural systems can be maintained to some degree. Working with, rather than fighting against nature, makes the job easier, more successful and maximises returns. It is imperative that natural vegetation is retained, as it can be significant in maintaining sustainable agricultural productivity (Johnston et al,1990).

6.2 Fire Control

Australia has had a long history of bushfires. Before European settlement the Aborigines used fire for hunting, and some fires began naturally through lightning. The frequency and intensity of bushfires increased dramatically after European settlement, and the vegetation has been seriously affected.

Rural landholders are well aware of the dangers of fire and the need for planning of fire control. The eucalypt forest is highly flammable, and this may lead to a suspicion that remnant forests or woodlands pose a fire hazard. This is not the case because most patches of remnant vegetation in rural areas are small and pose little threat. The grasses around them are a much larger threat as they will support a much faster and more dangerous fire (Breckwoldt,1986).

Wind breaks and shelterbelts are now recognised as aids in fire protection (Breckwoldt,1986) because they reduce wind speed and catch burning debris that is rolled along ahead of the main fire front by the strong winds associated with fires. The disastrous fires of February 1977 in the Western district of Victoria and the Ash Wednesday fires of southern Victoria in February 1983 were all associated with high winds (Bird,1984). Therefore, anything that reduces wind speed will also reduce the incidence of spot fires.

6.3 Conservation of Flora and Fauna

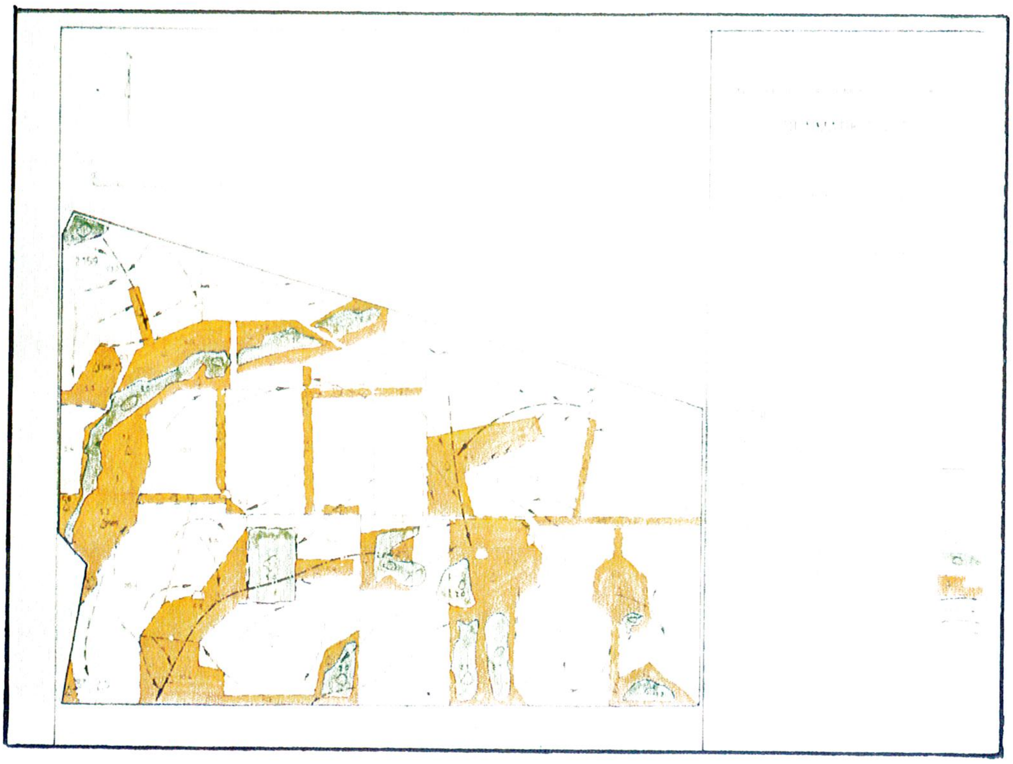
The conservation of native flora and fauna is an important and worthwhile reason for retaining or rehabilitating a natural remnant of vegetation (Scott,1990). Some remnants on farmlands are all we will ever have of certain species or ecosystems.
As a result of widespread clearing, the area left to conserve flora and fauna are generally small, and many species are classified as rare or in danger of extinction. The crested spider orchard (*Caladenia cristata*) and the Mogumber bell (*Darwinia carnea*) are found only in privately owned bushland (Hobbs et al,1991).

Areas of remnant vegetation are required as corridors or stepping-stones of natural habitat between reserves to allow the movement of wildlife. This allows the interchange of breeding stock to take place, therefore increasing the genetic diversity of populations and allowing recolonisation after fire or other dramatic falls in population (Coates,1987).

The genetic diversity contained in remnants of vegetation could also prove to be important in the search for new plant strains, new drugs and other plants of economic and social significance. A research project by the Department of Agriculture involves searching the agricultural and pastoral areas of the state for native shrubs and grasses that could become useful fodder species (Hobbs et al,1991).

6.4 Education and research

Remnants of vegetation also have a great potential for education and research in many areas. Irrespective of size and degree of degradation, a small patch of forest or woodland may fill a gap in our knowledge of the original vegetation. This



The site selected for regeneration should be part of the total farm plan

Regeneration of the understorey after the exclusion of grazing

information can help in making choices of areas worthy of conservation and to replant and rehabilitate reserves that have been disturbed.

The bush is extremely rich in plant species. Many of these are indigenous to Western Australia and many are still undescribed. The south-west of the state contains one of the richest non-tropical floras in the world. For example, the Fitzgerald River National Park contains more plant species than the whole of the British Isles (Hobbs et al,1991). These areas are therefore extremely important to education and research.

Small areas of remnant vegetation are immensely valuable as indicators of how the Australian environment was shaped. Much of the research will benefit agriculture as well as nature conservation. Research on the small remnants that now remain will help provide a better understanding of the soils and vegetation of the area, and contribute to a sustained yield agriculture (Breckwoldt,1986).

6.5 Amenity, Tourism and Recreation

Amenity is defined broadly as attractive and stimulating living and working conditions (Lindsay et al,1988) Trees provide this quality by making a pleasant and psychologically satisfying environment in which to live. The amenity and heritage values of remnant vegetation are very important. These values are linked to the enhancement of the tourism and recreation industry.

Remnant vegetation can have a lifestyle benefit to those living on farms. Stands of native vegetation, usually woodlands, close to buildings can provide shelter from prevailing winds, noise and dust, in addition to summer shade. Other psychological studies suggest the value of trees. For example, people experiencing stress tend to feel more relaxed in natural environments (Lindsay et al,1988).

Aesthetically, the different vegetation types and myriads of different flowers greatly enhance the value and interest of the countryside to both residents and visitors alike. It is difficult to put a dollar price on the aesthetic values of remnants of vegetation.

Another factor in assessing amenity is our responsibility to future generations. We are merely stewards of the environment, and should conserve the unique Australian landscape for those in the future to admire and learn from. There is no doubt that preserving local species of trees and shrubs is the only way to guarantee the survival of those landscapes (Lindsay et al, 1988).

Much of the remnant vegetation of greatest importance to the recreation and tourism industry is that owned by the public and managed by local government or state authorities. Privately owned remnants of vegetation also make a contribution by beautifying the landscape.

Indigenous species make a strong contribution to tourism, an important industry to Australia, by maintaining our distinctive landscapes. Travelling through the country roads is much more pleasant if the view includes natural vegetation. "Wildflower tours" are becoming an important part of the tourist industry. The Western Australian Tourism Commission began a heavy promotion of wildflowers in 1987 (Coates,1987).

Co-operation between farmers and government authorities can result in public access to tracks of high recreational value. This is the case in the Megalong Valley in N.S.W where an old pioneering track has been restored. With the permission of farmers, this track was able to go through private farmlands so that users could experience rugged escarpment forest and remnant river woodland on farming country. Recreationists involved in bushwalking have been shown to respect the right of farmers in the majority of cases (Breckwoldt,1986).

7. NATURAL REGENERATION OF REMNANTS

"Natural regeneration" is defined by Cremer (1990) as the reproduction from self-sown seeds or vegetative recovery (sprouting from stumps, lignotubers, rhizomes or roots) after the tops of the plants have been killed (by fire, cutting, browsing, etc.).

Tree planting requires large inputs of labour and capital investment. Many landholders and public authorities are now faced with the high costs of replanting overcleared areas or those that are suffering from tree decline. These costs can be reduced by retaining and protecting existing remnant forests and woodlands. Tree regeneration holds great promise for retaining rural trees and reversing tree decline.

There are many advantages of natural regeneration. Savings in cost is a major aspect. There is no cost and labour involved in propagating and planting, no costs from buying seedlings from nurseries and the cost of fencing is likely to be less because the exclusion of rabbits and hares is not as imperative. In addition native trees are more useful in nature conservation and have a less ordered appearance, blending in more with the landscape (Breckwoldt,1983).

The role of livestock in preventing the regeneration of trees and natural communities is well known to many landholders. Two other major factors in the prevention of regeneration are not so well known and understood. These are the inhibiting role of improved pasture and the higher nutrient levels resulting from manure and fertiliser (Breckwoldt,1983).

Fencing off remnants of vegetation containing seed trees is therefore not adequate in achieving regeneration. Certain techniques are required for effective tree regeneration. Those that are known are discussed below.

7.1 Design

The site selected for regeneration should be fitted into the total farm plan. Strips along fence lines or road frontages, corners or large blocks are more suitable than patches around single trees in paddocks. A minimum of 4-6 seed bearing trees per hectare should cover the site in order to obtain an adequate cover (Lindsay et al,1988).

Investigating land in the vicinity could give information on what types of sites experience natural regeneration and which species are coming up. This will provide an idea of where natural regeneration is likely to occur on the farm.

7.2 Site Preparation

A seed bed can be prepared by removing grasses and weeds. Cultivation, heavy scalping, burning or spraying with an appropriate knockdown herbicide are all acceptable techniques (Lindsay et al,1988).

On severely degraded sites where noxious weed invasion is particularly prevalent, the Bradley method of weed removal could be used. It involves the careful removal of weeds from bushland to minimise soil disturbance (Buchanan,1989). However, with its intensive labour requirements, it is not generally an ecomomic option for a single farmer.

7.3 Timing

Preparation of regeneration needs to take timing into account. Seedbeds should be well prepared before summer when eucalypts and many other species shed their seed. Cultivating should start in autumn and be followed up with a second cultivation before seedfall. If weeds are being eliminated by burning or herbicides, time this to provide a clean seedbed in summer (Lindsay et al,1988).

7.4 Fencing

It is essential to exclude stock from areas being naturally regenerated (Venning,1990; Lindsay et al,1988). Breckwoldt (1983) believes that very light stocking may not cause any damage.

Costs and labour can be further reduced by locating sites in corners or along existing fences. A triangular-shaped enclosure is economical where seed trees are located towards the middle of a paddock. Most seed will usually fall within two tree heights on the lee side close to the tree. Fencing of this area where regeneration is likely to occur, will prove beneficial (Lindsay et al,1988). Therefore, the larger area of the triangle should be placed downwind of the seed tree.

Rabbits and hares may be a problem. They are attracted to young planted seedlings by the freshly disturbed soil around each plant. Cultivating before the seedlings emerge is an insurance against rabbits because there is no fresh turning of soil (Breckwoldt,1983). If rabbits are an extreme problem, a rabbit-proof fence or guards around selected trees will increase their chance of survival (Lindsay et al,1988).

Livestock should be excluded at least up until the trees are large enough to withstand rubbing or browsing. Depending on rainfall and competition, this may take between 3 to 5 years or more (Breckwoldt,1983). Having already outlayed the money for fencing, it may be desirable to exclude stock permanently as trees exposed to grazing livestock are more susceptible to drought, soil compaction and disease. In addition, fencing protects the understorey, allowing it to provide a suitable habitat for many forms of wildlife.

7.5 Regeneration From Coppice

The term coppice refers to sprouts from cut stumps or damaged stems (Cremer,1990). Coppicing can therefore be used in a practical manner for regeneration of trees that are being harvested, or to rejuvenate old trees in advanced stages of decline (Breckwoldt,1983).

Coppicing may cause problems in Australian native forests because the stumps left after cutting may be too few and too old to produce satisfactory coppice. The ability of stumps to sprout after cutting is dependant upon the species, the age of the tree and sometimes also the environment and season of cutting. Additional regeneration from other forms of advanced growth is required in many of our native forests (Cremer,1990).

7.6 Regeneration From Epicormic Buds and Lignotubers

The majority of the south-west of the state is classified as a dry sclerophyll or open forest plant community. Fire has been a common event of dry sclerophyll forest for many thousands of years. The native species of the forest have become adapted, and regenerate well after fire. Thus, fire can be a successful method in regenerating a remnant of native forest, although great care has to be taken in controlling it.

The presence of epicormic buds and lignotubers are significant in regeneration following fire. Epicormic buds are hidden and protected by the bark. If leaves are removed by fire, then energy stored in the roots and the stem of the plant is utilised to produce clusters of shoots (Buchanan,1989).

Most eucalypts can regrow from lignotubers, bulbous swellings that develop on young seedlings near the junction of roots and stem. They store food and carry dormant buds. In the event of fire when the stem or leaf growth is destroyed, the plant will shoot again from one of the dormant buds in the lignotuber.

7.7 *Regenerating the Understorey*

A woodland understorey includes the herbs, shrubs and small trees that occupy the strata below the canopy of the taller trees. The native understorey has long been gone from much of the rural areas in Australia.

A native understorey is hard to regenerate as it is hard to get seed on the ground. If a regeneration site around a large eucalypt with no understorey is chosen, then seeds of the desired shrub will have to be spread over the site, or seedlings planted (Breckwoldt,1983).

Seed could be collected from native stands occurring locally, sown directly into the soil, broadcast and lightly raked in. Success is variable, but is high enough to encourage such a practice (Breckwoldt,1983). If this method of understorey regeneration is to be used, it would be wise to identify the shrub species to be propagated and determine their method of reproduction by consulting a suitable reference.

7.8 *Maintenance*

On occasion too many seedlings will reach germination. Once growth is large enough to indicate general vigour, they should be thinned, retaining the most advanced seedling and removing the rest (Breckwoldt,1983).

Weed control will form a significant part of the after-care of regenerated areas. During the first two years, neighbouring weeds may need to be sprayed. If herbicides are used, care should be taken not to contact seedlings unless it is a safe one for native vegetation. Inspection of regenerated sites for weed invasion should be a regular occurrence (Lindsay et al, 1988).

Once a dense growth of native trees and shrubs is established, weeds will be controlled without any human intervention. However, exotic grasses invade the edge of mature stands and may cause a fire hazard (Lindsay et al,1988). Controlled burning will make the area less prone to fire, and may further encourage the regeneration of native shrubs.

Periodic burning of maturing regenerated bush is usually required and is covered in section 8.2.

8. MANAGEMENT OF REMNANTS

The time and effort put into regenerating remnant represents a substantial investment for many landholders. To ensure that the trees are well cared for in the long term, additional maintenance is usually required. Simple management practices are outlined in the following paragraphs.

8.1 Fencing

Stock will often rub against trees, browse upon their bark, trample the ground around the trees and load the soil under trees with excessive nutrients. Therefore the greatest security that can be given to remnant vegetation is to fence it off from livestock. This will enable regeneration to occur, maintain the shrub layer if one is present, minimise weed invasion (Breckwoldt,1986), reduce drought stress and decrease the occurrence of nutrient toxicity (Lindsay et al,1988).

When Eucalypts are subjected to stress by drought they tend to increase their rate of leaf fall, forming a layer on the ground which acts as a natural mulch. This mulch reduces ground temperatures and conserves moisture. Stock will often eat, trample and scatter this mulch, leaving a bare, unprotected ground surface. The resulting increase in soil temperature, accelerated moisture loss, and the inability of the soil to capture rain all add to the decline of the tree. Again, fencing around the trees will reduce the drought stress (Lindsay et al, 1988).

The Whyte Brothers' method of fencing, using inwards sloping fences, is well known and suitable for single trees and small clumps. Many other imaginative farmers have devised cheap and simple successful methods, a number of which are shown in Caring For Young Trees (1983) published by the ABC (Lindsay et al, 1988).

The Denmark Land Conservation District Committee suggested a very cheap adaption of electric fencing which has been highly effective in the Denmark area. The Denmark LCDC advocates the use of minimal fencing which can be cheap, quick and easy to erect. It can be as simple as a single wire skirting bush areas for cattle, often using the trees themselves as posts. It does not have to be straight and nor does it require the normal strainers because it need only be tensioned to the point where it maintains a sufficient height to deter cattle. Three or even two wire electric fencing has successfully controlled sheep (Conochie,1989).

8.2 Fire

Periodic burning of remnant bushland is often required. Many native shrubs will begin dying only 7 to 12 years after the first burn, and need fire to seed (Lindsay et al,1988). Burning only sections of the area in any one year will allow a quick re-establishment of fauna and maintain a diversity of habitats as regrowth is stimulated in the burnt areas.

8.3 Insect control

Farm trees are under threat from a variety of insects which can end in the premature death and rapid deterioration of young regrowth and mature trees. Native trees seldom, if ever, die from a single attack as they have become adapted, and can withstand losses of about one fifth of their foliage without being significantly damaged. However if the tree repeated loses a large amount of its leaf tissue, its starch reserves are depleted and it may suffer dieback (Lindsay et al,1988).

Widespread chemical control is not economically viable or recommended due to the localised and sporadic nature of insect damage on trees and the large economic and environmental costs associated with the use of insecticides (Campbell,1991). However, Lindsay et al (1988) report that there are few other methods in the control of repeated and heavy insect attacks.

Passive forms of insect control using predators, parasites and diseases should be encouraged. This is the most economical, lasting and safest way to handle this problem, although not the easiest to achieve. Ecological pest control can be achieved by encouraging a diversification of habitats for birds, small animals and predatory insects (Lindsay et al,1988).

The most important aspect to keep in mind in achieving a diversity of habitats is that trees do not occur alone in a natural balanced stand of vegetation. It is trees with shrubs, groundcover, birds, insects and other animals and a wide range of organisms in the soil and litter that provide the conditions for the ecosystem to remain healthy. Managing remnant vegetation to make the most of natural control mechanisms simply requires maintaining and restoring as much of the natural system as practicable (Lindsay et al,1988).

8.4 Fertilizing

Plants need certain elements to grow normally. A lack of an element (nutrient deficiency) causes characteristic growth symptoms, while an excess of some elements (nutrient toxicity) also produces characteristic symptoms. A piece of the plant can be taken to local nurseries or to the garden advisory service in a government department for identification of the disorder (Venning,1990).

There should be no need to fertilize local species, especially those native to the south-west of the state. Some species, including *Banksia, Grevillea, Isopogon* and *Hakea* are sensitive to phosphorus and readily display phosphorus toxicity. However the addition of fertiliser may be necessary if soil reserves have become depleted through regular cropping or leaching. Soil sample analysis could reveal any elements that are low or lacking (Venning,1990).

8.5 Reducing stress from too much water

Agriculture has caused great changes to the natural hydrological balance. Irrigation, rising water tables, changes to the natural drainage system and soil compaction are all factors which contribute to waterlogging. Unless adapted to swampy conditions, plants cannot tolerate more than very short periods of waterlogging because their roots are deprived of oxygen and they cannot take up nutrients. In addition they are more susceptible to fungal and bacterial diseases (Lindsay et al,1988).

Solving the waterlogging problem is a difficult task because the problem is often caused by poor land management practices well away from the affected area. However, deep ripping away from trees and improving the drainage system can help (Lindsay et al, 1988).

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