Distribution and ecological significance of on-farm bushland remnants in the southern wheatbelt region of Western Australia

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DISTRIBUTION AND ECOLOGICAL SIGNIFICANCE
OF ON-FARM BUSHLAND REMNANTS
IN THE SOUTHERN WHEATBELT REGION OF
WESTERN AUSTRALIA

F. Mollemans and G. Beeston

Division of Resource Management
Western Australian Department of Agriculture

Project Funded by the 'Save the Bush' Program

July 1992
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1.0 Introduction
The Southern Wheatbelt Region Remnant Vegetation Survey was funded by the Save the Bush program, and aimed at surveying pieces of on-farm remnant vegetation in the "Great Southern" of Western Australia. At the outset a total of 13 shires were selected for survey, namely: BROOMEHILL, CORRIGIN, DUMBLEYUNG, KATANNING, KENT, KONDININ, KULIN, LAKE GRACE, NARROGIN, TAMBEULLUP, WAGIN, WICKEPIN, WOODANILLING; in this report shire names are capitalised to avoid confusion with place names. However, time constraints meant that subsequently KENT and LAKE GRACE shires (two of the largest) had to be dropped from the survey to allow for proper completion of the remainder. The total area of the remaining shires (Figure 1) is just over 28,000 square kilometres.

These shires were selected as they are within an area where verification of remnant vegetation information has not been carried out to-date. Areas to the north have been studied in some relative detail and, in addition, the Department of Conservation and Land Management, Woodvale, has carried out a separate South Coast Survey in the area from Margaret River to Albany.

Available funding indicated a time frame of 40 weeks for the project to be completed. The first 3 weeks were spent in an orientation phase, in which background literature was reviewed and local farm groups contacted to advertise the survey and elicit support; it was anticipated that farmers would be sufficiently interested in the value of their on-farm remnant bush to enable them to assist in the survey by providing information on their own smaller on-farm bush areas, while detailed surveys were carried out on areas larger than 50 hectares. Weeks 4-23 inclusive were to be spent in the field, and the remainder of the time was to be devoted to plant species identification, final map preparation, collation of other physiographic data collected during field work and final write-up.

Why a survey of remnant vegetation, what's in it for me? This question has been asked a lot during the survey, firstly by Mike Elliott (NSCP Project Officer, Narrogin WADA) as an indication of the likely farmer response to a request to survey their on-farm vegetation, and then by a lot of farmers. Well, ... "We have to know what is there if we are going to manage it properly" (CSIRO officer Dennis Saunders & E. Crossley, pers. comm.; 6/9/91)! Most people know what is on their own properties, but in some paddocks clearance before their time on the farm means that the previous natural vegetation cover in those paddocks is unknown to them (T. Young, Woodanilling LCDC, 5.8.91). For salinity/waterlogging remedial action, information on what remains on other farms may be of considerable assistance in indicating the most appropriate species to plant in areas requiring remedial action. This has been the main aim of this vegetation survey i.e. to document what is left, so that information is available for use by the wider farming community. Associated with this has been the aim to interest more farmers in realising the value of their bush remnants. Other anticipated benefits of the survey were:

1. To provide a source document farmers can utilise to support funding applications for tree planting programmes which also produce wind breaks and fauna corridors which link patches of vegetation (T. Mailing, Katanning WADA, 7.8.91).
2. To provide a seed collecting reference list.
3. To enable the development of an arboretum of the districts plant species.
4. To provide a source document for farm remnant bush management.
5. To increase the information upon which general farm management decision making is based (S. Garrad, Katanning WADA, 7.8.91).

"What do you want the bush to look like in 100 years" (CSIRO officer Dennis Saunders - E. Crossley, pers. comm.; 6/9/91)? That is really the bottom line, if you don't want the bush and wildflowers, birds and other animals around, then do nothing. But if you do want these around, then you are going to have to do something about it. "No one wants to live in a barren landscape" (Saunders, 1991)!

1.1 What is Remnant Vegetation?

Native vegetation has been defined as: "Endemic floral ... communities which have not been planted and which are in place as a result of natural processes" (ACF 1990). Remnant vegetation is that component of the native vegetation as defined above, which still remains in its natural state either completely intact or which has been fragmented into isolated aggregates or scattered individuals by disturbance. Clearing of native vegetation constitutes the major disturbance viz, "... the deliberate destruction of native plant communities in any way and by any means including: the use of machinery, chemicals, over-grazing, repeated burning, drainage or any other manipulation of the plants or their environment" (ACF 1990).

Disturbance may also be by natural means either in the ordinary cause of climatic or other environmental events or by greater susceptibility of plants and their communities when weakened by factors to which they are unaccustomed. Weed spray drift, for example, may weaken a plant species so that it is more susceptible to insect attack. Plant species and communities in their natural state are generally resilient, having evolved as a response to environmental effects and changes in their area of occurrence. But, they are not resistant to changes (disturbances) that have not been an influence during the course of their evolution.

1.2 History and Background

"The fact ... is, we haven't been managing the bush to-date!" (CSIRO officer Dennis Saunders - E. Crossley, pers. comm.; 6/9/91). This begs the question that, if not managing it, what have we been doing to the bush?

One need only pick up historical accounts of life in the bush to know that farming in Western Australia in the past was a question of survival; management of the bush was not even considered an option. A scattering of people came out to settle the land in Western Australia from about 1864 onwards for pastoral and cropping purposes, although the sandalwooders had travelled much of the country by that time. A major influx of people came with the discovery of gold. Many died, many were "dusted" by drilling in
the mines, only a few made their fortune. Many people turned to the land in the late 1800's as a means of making a living after they had failed in their bid to make a fortune in the goldfield's. They selected land and could keep it if they cleared it and managed a small annual rental. Back then it was all bush so clearing their own little piece didn't matter. No one had even heard or thought about salinity and land degradation.

"Many of Australia's pioneering settlers found it very difficult to establish smallholdings in the virgin bush" (Reader's Digest, 1991). "Most ... were married men, and many ... brought their wives and families with them on horseback, in buggies and carts ... In some instances the houses had been built before the family appeared, but mostly only a rough hut, used afterwards as a kitchen, was there to receive them. In a few cases not even the site for the camp had been picked, and when the dray pulled up on a rise and all got down, there was an inspection of the ground, and much discussion and walking about. The woman wanted to be as near as possible to the water, but the man was afraid of floods and preferred the high ground. She was tired, night was coming on, the dray had to be unloaded, supper cooked, tents pitched, and beds made, so he had his way - which accounts for so many selector's huts being a mile away from water.

The first evening on a new selection under such circumstances is not as cheerful as one could wish. It is the beginning of a new life - a hard one, with nothing done and everything to do. There is no house in sight, no sign of life but that of wild birds and animals, and the freed horses feeding out into the wilderness of trees. Boxes, furniture, tools and camp-ware are strewn about the dray, a fire burns under a tree, and a tent or two is erected nearby. This is home. The children enjoy it; it is new and strange and novel, and they race about, climbing trees, gathering wild flowers ... and hunting goannas and possums ... "(Sorenson, E. in Reader's Digest, 1991).

These settlers had only on their minds the battle for livelihood, with the majority interested purely in survival; getting enough water and food to be able to live from day to day, a roof over their head, and enough to pay their dues to the banks and/or the government. They battled rabbits, foxes, drought, and depression, and the wheat quotas during World War II. Life was a struggle, particularly through the depression. There were periods of prosperity, but it was not until after the second world war that real prosperity came to the majority of settlers (Walder in Adams, 1977-8).

Of course this prosperity depended on clearing more country, getting more land in crop and experiencing favourable seasons. The bush was a place to be exploited and we did it well. Even in the 1950's the first job of many migrant settlers in Western Australia was grubbing trees for farmer's clearing their land.

Now the problems associated with this clearing, declining yields due to salinity and waterlogging, and the need to plant trees and shrubs as a remedial measure, are well known. The bush is attaining a value different than it ever had before, as those who chose to retain some bush or were fortunate enough to have acquired a property with remnant bush are in a better position; their yields
have not suffered as much and they don't have to spend as much money on tree and shrub planting as those who have none.

It is "... pointless to blame farmers for land degradation, rather, the challenge ..." is to "... help farmers develop practices to reverse the extensive degradation caused by agricultural practices" (Nulsen, 1992), by changing agricultural practices that are now in use. "Farmers had not set out to destroy the land. We may get some satisfaction by ascribing blame and pointing the finger at those thought to be guilty. But that is history. In some instances farmers had been compelled by government policies to use less than prudent means. Farmers taking up WA land in the 1950's and 1960's were forced to clear a certain percentage of their blocks each year to comply with the conditions of sale" (Nulsen, 1992). The problem of increasing salinity was understood early (e.g. Wood, 1924), but largely ignored until severe deterioration had set in. In some instances, "... No one ... realised the damage they were causing; before the advent of herbicides, repeated tillage was the only way to control weeds and this had destroyed the soil structure" (Nulsen, 1992). Associated with this soil degradation, flora and fauna has deteriorated in a similarly severe manner.

"It was often argued that farmers must be in a sound financial position to carry out soil conservation measures" (Rose, 1992). In the shires which have been the subject of the present study there has been a 6% decline in population from 1981-1988 (Table 1). It is not hard to see farmers avoiding soil conservation measures, when they are faced with the prospect of leaving their farms; the situation then becomes a matter of crisis management, with far different priorities than are evident under more prosperous times. With 10% of Australia's farmers facing the prospect of being forced off their farms during the current year (OUTLOOK CONFERENCE, 1992), crisis management is currently widespread, and so soil and remnant vegetation conservation are far from the minds and financial abilities of many.

Table 1 - Population and dwelling statistics for 11 Shires of the Great Southern of WA (Source: Australian Bureau of Statistics).

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>BROOMEHILL</td>
<td>1,187.47</td>
<td>589</td>
<td>587</td>
</tr>
<tr>
<td>CORRIGIN</td>
<td>2,669.35</td>
<td>1572</td>
<td>1439</td>
</tr>
<tr>
<td>DUMBLEYUNG</td>
<td>2,567.65</td>
<td>969</td>
<td>988</td>
</tr>
<tr>
<td>KATANNING</td>
<td>1,527.74</td>
<td>5042</td>
<td>4846</td>
</tr>
<tr>
<td>KONDININ</td>
<td>7,339.95</td>
<td>1203</td>
<td>1148</td>
</tr>
<tr>
<td>KULIN</td>
<td>4,649.29</td>
<td>1245</td>
<td>1181</td>
</tr>
<tr>
<td>NARROGIN</td>
<td>1,622.38</td>
<td>789</td>
<td>661</td>
</tr>
<tr>
<td>TAMBELLUP</td>
<td>1,407.99</td>
<td>915</td>
<td>820</td>
</tr>
<tr>
<td>WAGIN</td>
<td>1,932.65</td>
<td>2311</td>
<td>2147</td>
</tr>
<tr>
<td>WICKEPIN</td>
<td>2,016.89</td>
<td>984</td>
<td>912</td>
</tr>
<tr>
<td>WOODANILLING</td>
<td>1,115.18</td>
<td>444</td>
<td>430</td>
</tr>
<tr>
<td>TOTAL (km²)</td>
<td>28,036.54</td>
<td>16063</td>
<td>15159</td>
</tr>
</tbody>
</table>

Farm economics is perhaps the most important consideration in management of land degradation. Remedial action planning in one
sub-catchment in the Great Southern has to-date involved several hundred thousand dollars in Aeromagnetic surveys (by Aerodata), to produce a viable hydrological map, including subsurface fault and dyke locations. After this expense tree planting has only just started. "... it cost $3,000 per hectare to do the tilling and associated works involved in tree planting, and planted areas have to be fenced or are useless. There are a few people around on farms who have experience in tree planting and it is generally from these that the others learn. The problem is a massive one and the farmers are doing their best to correct the salt/waterlogging problem" (R. Kerr, pers. comm., 25, November, 1991)

By this example the economic immensity of the problem can be gauged. With the number of affected catchments in the WA wheatbelt numbering over a hundred the reversal of the problem is going to cost tens of millions of dollars.

1.2 Physiography

The south-western part of the study region is the wettest and progressively, conditions get drier towards the north-east. In the Mt Barker - Albany map area, which contains TAMBEILLUP, the dry season is a little over 4 months long (Beard, 1979). Rainfall in TAMBEILLUP is c. 560 mm in the west of the shire and reduces to 500 mm in the rain shadow of the Stirlings, with a further reduction to 375mm in the NW.

Dumbleyung map sheet, to the north, which includes BROOMEHILL, most of DUMBLEYUNG, KATANNING, part of KONDININ, half of NARROGIN, part of TAMBEILLUP and most of WOODANTILLING, has a rainfall gradient from SW-NE of 625 to 350 mm, and although the local pattern is somewhat enigmatic, most of the area averages 500-375 mm (Beard, 1980c). At Katanning the dry season averages 5.5 months (typical of a Warm Mediterranean Climate), while in CORRIGIN, KONDININ, KULIN, WICKEPIN and the northern half of NARROGIN on the Corrigin map sheet, the dry season (typical of a Dry Warm Mediterranean Climate) averages 6.5 months (Beard, 1980c).

At Hyden and Lake Varley in the east, which give an indication of the general patterns received by KONDININ and KULIN shires, the average rainfall over 40 years was 330 mm, with a dry season averaging 7 months (Beard, 1972). According to Beard (1972) the vermin fence east of Hyden on the Hyden map area approximates the 300 mm rainfall isohyet, and this was the limit of the area studied in this survey, as beyond the vermin fence is crown land. The 300 mm isohyet is the hypothetical limit of agriculture, as cropping failures would be relatively frequent if farms were to be established in areas of lower rainfall (Beard, 1972).

Major rivers in TAMBEILLUP are the Gordon and the Pallinup with salinities to 20,000 mg/l in the north, and part of TAMBEILLUP to the NE of the Stirlings is in the rain shadow of that range (Muhling et. al., 1985). The Pallinup River largely lies east of the study area, but the Gordon (in the west) flows south through TAMBEILLUP and then west to join the Frankland River. Between these two rivers is a gentle plain of saline lakes (e.g. Beard, 1979). Major drainage features in the remainder of the study area include Arthur River and the Buchanan River in the NE, the Coblinine River,
Dongolocking Creek and the Lefroy River in the centre, and the salt lake chains of the Lake Grace and Lake Magenta systems in the east.

1.3 Geology & Soils

According to Muhling et al. (1985), granite and adamellite are the major substrate features of the region, and these are overprinted by Quaternary/Tertiary material. The Yilgarn Block, north of the Stirling Ranges, is the major relevant tectonic feature underlying the study area.

Granite and adamellite exposures are evident throughout the Great Southern, either as bare domal features from which many wheatbelt towns initially derived water or as domed hills which carry limited outcrop and more or less vegetation depending on rainfall. Soils features reflect position in the landscape in relation to these ancient geological domes and to the other major influence, which has been the dissected Tertiary lateritic plateau. Soils patterns are therefore frequently in the form of complex series of mosaics which provide for a pattern of vegetation cover of similar complexity.

Beard (1972, 1979, 1980c) described the soils of the study area as follows. The higher rainfall areas in the west have soils which are predominantly yellow in colour and acidic in reaction. Dissection of the landscape has left no residual sandplains, but a landscape of gently rolling to hilly country with granite exposures, and lateritic plateau remnants. Hard-setting loams with mottled yellow clay subsoil, sometimes with ironstone gravel and of neutral to acid pH is the main soil type.

Soils of the plateau remnants are of hard acid yellow mottled character with moderate to large amounts of ironstone gravel. In the valley bottoms are flat plains with hard alkaline and neutral mottled soils or gently undulating sandplains of neutral to alkaline sand, with mottled yellow clay subsoil.

In the drier country to the east residual, gently undulating sandplains on high ground increase in extent and major valleys contain chains of salt lakes, as remnants of past palaeodrainages. Slopes are of sandy yellow earth with some ironstone gravel, with less sand and a greater gravel component at depths greater than 2m and nearer the parent rock. Lower in the landscape hardsetting loamy soil with mottled yellow clay subsoil occurs, with an alkaline soil reaction in the north-east and neutral in the south, the latter influenced by areas of red soil.

Erosional slope and ridge soils are of ironstone gravel or sand with ironstone gravel, both underlain by hardened mottled-zone material below 30-60cm. In the valley bottoms hard alkaline yellow soils are underlain by acid lateritic clays below 60-120 cm. Claypan and saltlake remnants may also be present in valley bottoms, along with restricted areas of sandplain. Salt-lake systems of the major drainage lines have loam soils with gypsum.

The whole country was at one time capped with ironstone gravel but erosion has left only remnants on hilltops and ridges, and ironstone debris on slopes. Sandy alluvials occur in some drainages e.g. some parts of the Gordon River, but ironstone
gravels and derivatives are common. Soils derived from weathering of granite exposures are loams, while on the plains gentle slopes and slow erosion during a relatively stable geological history has produced more complex soils. During wetter times in the past sand was leached then bleached, to produce pure white infertile sand in upper soil horizons; these are found in the south of the study region in TAMBEULLUP, just north of the Stirling Ranges. Leaching of the upper soil layers concentrates finer (leached) material lower in the profile so a duplex soil is formed. Between the upper sand and the clay, generally mottled, poorly drained subsoil, may be a ferruginous hardpan.

With less sand in the parent rock and lower rainfall less extreme weathering produces loams, which has a hard-setting character as it dries out, overlying mottled yellow clay subsoil. Forest soils tend to be of this type and acid in pH. They are bleached under Jarrah (Eucalyptus marginata), which will also grow on leached sands regardless of the presence of the ferruginous hardpan.

Woodland soils of Jarrah, Marri (Red gum) and/or Wandoo (White gum) are neutral hard-setting loams with yellow mottled clay subsoil, or alkaline under Swamp yate (E. occidentalis). York gum and mallee grow on neutral hard-setting loam with a red clay subsoil. Heath vegetation grows on leached (and usually bleached) sands overlying clay and are acid to neutral in soil reaction.

Due to the stable geological history of the Yilgarn block to the north of the Stirling ranges, soils have had a long time to develop. The character of some such as the sandplains suggests they developed under conditions of higher rainfall.

1.4 Aboriginal Prehistory

The aborigines lived and used the bush for their variety of food and medicinal needs (e.g. Isaacs, 1987; Low, 1990). Consumption of the fruit and seeds of Quandong (Santalum acuminatum) is well known, but not so the edible Apple berries (Billardiera spp.), which when they drop from the vine are sweet and palatable. Berries of the variety of Dodder plants (Cassytha spp.) of the south-west, often seen clothing and appearing to smother other shrubs and mallee (Eucalyptus spp.), are also palatable and were used in season by the south-west aborigines. Even species of the common blackboy (Xanthorrhoea spp.) were used, the spikes soaked in water made a sweet drink and the soft basal parts of leaves was also eaten; this latter source of food gathering resulted in the death of the source plant. For medicinal purposes, a decoction made from the leaves of pale turpentine bush (Beyeria lochenuiltii) was taken for fevers, and there are many other examples (e.g. Low, 1990).

Dense forests of Jarrah (Eucalyptus marginata) with a sclerophyll understorey are reported to have been an inhospitable environment for aborigines, and were thus burnt only at infrequent intervals (Hallam 1975 in Beard 1980c). Reports from the tinfields around Greenbushes suggest that at the time of the early tin explorations (1880's - 1890's), although the overstorey was dense, it was possible to gallop a horse through the open understorey of the Jarrah forests (Eucalyptus marginata), so the aborigines would have been able to pass through this country had they wished. Nowadays
the understorey of the Jarrah areas is thick with sclerophyll scrub, and it would seem that post-European tree-felling resulted in more light getting to the forest floor, thus allowing the sclerophylls to flourish where it was not possible before. The Jarrah country like other dense forest areas is not a refuge for large numbers of wildlife, except perhaps for birds in the upper canopy in nesting and flowering times. It is not hard to believe that the aborigines were not interested in the Jarrah areas, particularly in view of their superstitious nature and the knowledge that the pre-European Jarrah forests were dark and foreboding places.

Hallam (ibid.) did show, in her study of the reports of explorers and pioneer settlers, that large tracts of country were deliberately fired by aborigines at frequent intervals in the early-settled areas of the Swan River Colony, the Avon valley and the Albany district, viz. Scott Nind medical officer Albany at its establishment in 1827, showed that burning was closely meshed into their pattern of life of the Aborigines - they lived upon the products of nature with the small population moving during the year to areas where food was in season; in winter and early spring they were scattered, in summer they congregated, and near Christmas they would burn the country for game by setting fire to low bush and grass with a lighted bundles of dry blackboy leaves; hunters would stand in well used animal paths and spear the animals as they passed resulting in a good harvest; fires lit in this way tended to extend over considerable distances, but were controlled by previously burnt patches (Nind, 1831 in Beard, 1979). Such "controlled burning off" was confirmed by Lieut. Stokes during the voyage of H.M.S. Beagle (Stokes, 1846 in Beard, 1979) who described how the natives set fire to the bush in sections and controlled it by beating the fire out with branches if it threatened to get away. It is suggested that lightly wooded country was burnt in this way more or less annually in summer (Hallam, 1975 in Beard, 1979).

The fires, lit systematically, were intended to bring forth a fresh green pick with the next rains and thereby attract kangaroos. The York gum (Eucalyptus loxophleba) woodlands of the Avon valley responded well and the resultant grassy and lightly wooded country was home to a significant population of aborigines. The diary of explorers Landor and Lefroy gives a similar picture of the country along the north shore of Lake Dumbleyung around 1843, with a similar population of aborigines supported by deliberate burning of the bush (Beard 1980c). This pattern probably extended to the wider hinterland of the study area, with the granite rock water sources supporting variable numbers of aborigines depending on the time of year and the nature of the season. Fire was a widely used tool and the mosaic of vegetation in the wheatbelt suggests a wide pattern of use at different times for hunting and perhaps as a result of accident, mixed with the results of lightning induced fires.

Beard (1979) says that most vegetation in the south-west is highly inflammable in summer, and with lightning prevalent at this time the fire hazard with its resultant effects on the vegetation has been an ever-present phenomenon. A direct consequence has been the evolution of various adaptive traits which enable the vegetation to withstand and recover from fire (Gardner, 1957 in Beard, 1979).
The *Eucalyptus* woodlands of Salmon gum (*E. salmonophloia*) and Gimlet (*E. salubris*) do not carry fire well, due often to an open understorey. This type of vegetation appears not to have suffered significantly from lightning induced fires although trees felled by lightning strike do occur. Heath, scrub and mallee of sandplains and lateritic plateau remnants on the other hand is extremely inflammable, and generally well adapted to regenerate after fire, although some individual species may be fire sensitive and rare as a consequence e.g. *Dryandra shanklandiorum*. Observations of vegetation protected from fire such as on islands in lakes and comparison with the bush around such lakes, indicates the extent to which fire can alter vegetation (Mollemans unpubl. data), and Beard (1979) refers to a study of offshore Bald Island by Storr (1965), which depicts a radically different vegetation from the adjacent mainland.

The arrival of the aborigines in the past 40,000 years has added to this natural phenomenon a human influence of more frequent and systematic burning (Beard, 1979, 1980c). So a further change in the nature of the vegetation has been the result although very recent in a geological context. Nowadays over 90% of fires are started by people (W. A. Bushfires Board, 1992), with Europeans now influencing the vegetation far differently than did the aborigines.

1.5 The European Influence

"Anyone who has flown over Australia cannot help but notice the fragmentation of native vegetation as land continues to be cleared" (Seabrook, 1991). Agricultural development of the landscape has resulted in extensive native vegetation clearance in areas climatically suited to crop production. On some farms reasonable examples of the early vegetation has been left intact, while on others clearance has left little sign of the past vegetation cover. This depends to some degree on local interest in vegetation protection and the perceived fire threat from different types of bush. But, "... we are ..." now "... in danger of losing whole ecosystems over large areas of the country" (Seabrook, 1991)

Use of the land has brought with it signs of poor management practices. Weeds and ornamentals, as escapees from gardens and spread by the movement of vehicles used in the transport of agricultural products and maintenance of transport routes, have become a symptom of land degradation. Decline of vegetation on roadsides adjacent to farm properties has also occurred, generally in a gradual manner and in a gradient from the more settled areas to those more recently cleared. More active roadways tend to be more degraded and become so more rapidly.

What vegetation remains after farm development is also under threat. Fertiliser and weed spray drift weakens native vegetation and leads to its replacement by grasses and weeds (Beard, 1979). Grazing can also cause degradation of this vegetation even under low stocking rates (Lal and Stewart 1992). Such degradation is a further sign of the deteriorating condition of land as a resource which in Australia is quite severe. Lal and Stewart (1992) suggest that about 51% of Australia's 5.2 million square kilometre land area is in need of restoration to overcome the effects of land degradation. If non-productive areas are excluded, the percentage of area requiring remedial action climbs dramatically.
Economic considerations play a part, with significant losses of on-farm (and roadside) vegetation (even now) during farm plan implementation, such as in the renewal of old fencelines - complete clearance of bush by farmers speeds up the fencing making it more efficient and cost effective.

"Remnant vegetation of roadsides, however small ..." is " ... vital for the movement of small animals such as honeypossums or honeyeaters across the landscape" (Napier, 1991). Destruction of or damage to "vegetation along narrow road verges apart from removing corridors for fauna movement," ... wastes a valuable and scarce resource" (Napier, 1991). In some instances the only known occurrences of rare Western Australian plant species is on road verges.

Shifting of paddock boundaries to better utilise available soil types often also results in native vegetation clearance. Such clearance invites salinity and waterlogging problems by ignoring the valuable role played by natural vegetation in maintaining a hydrological balance. It is a short-sighted farm management approach which ignores the long term cost of reversing the degradation.

On-farm remnant bush is generally still in good condition, except where disturbed by rubbish dumping, sand and gravel mining, stock grazing, and soil salinity/waterlogging (Beard, 1979; 1980c), although undisturbed examples are nowadays rare in those parts of the wheatbelt that have been farmed for a long time.

1.6 Previous Vegetation Studies in the Study Area

Carnahan (1976) recognised four broad classes of vegetation (vegetation types) in the study area, and stated that the pattern of vegetation was determined largely by rainfall decline along a gradient towards the interior with soil factors greatly complicating the picture. These broad classes are as follows:

1. Woodland with low shrubs (eM2Z) sometimes resembling forest - typically dominated by White gum (Eucalyptus wandoo and E. capillosa) and Salmon gum (E. salmonophloia), the latter in areas of rainfall down to 200 mm. Lower stratum low shrubs comprise sclerophylls, but semi-succulent chenopods characterise alkaline soils. This class of vegetation covers 70% of the region mostly in the west with lesser occurrences in the NE and east i.e. BROOMEHILL, CORRIGIN, half of DUMBLEYUNG, KATANNING, part of KONDININ, NARROGIN, TAMBELLP, WAGIN, WICKEPIN and WOODANILLING

2. Tall shrubs with a lower stratum of low shrubs (cS3Z - >2 m, 30-70% cover) (open-scrub). The tallest stratum is dominated by species of Tamma (Allocasuarina, notably A. acutivalvis and A. corniculata hence the c prefix in the map code of Carnahan as these are in the family Casuarinaceae). Lower stratum of low sclerophyllous shrubs, many heath-like (ericoid), from a number of families, including Myrtaceae and Proteaceae. Annual rainfall range 225-300+ mm; mainly occurring on infertile sands. This class of vegetation covers 5% of the region as small pockets in the north and NE of KONDININ.
3. Tall open shrubs with a lower stratum of low shrubs (es2z - >2 m, 10-30% cover) (tall shrubland). Tallest stratum dominated by Eucalyptus. Annual rainfall 200-450 mm on solonised brown soils, solodized solonetz and some deep sands. Higher rainfall es2z lower strata are usually dense and characteristically sclerophyllous and often heath-like (ericoid); and particularly diverse with Acacia, Proteaceae and Myrtaceae (Melaleuca). Lower rainfall under strata are more open with semi-succulent chenopods or hummock/tussock grasses as dominants, although the latter tend to occur further north and may not be particularly prevalent the study area. This class of vegetation covers about 20% of the region mostly in KONDININ and KULIN.

4. Tall open shrubs with a lower stratum of low shrubs (es2z - >2 m, 10-30% cover) (tall shrubland). Tallest stratum dominated by a range of genera. Infertile (sub-coastal) sandy soils of dunes (and plains) carry this type of vegetation with Banksia, Grevillea and Acacia potential dominants. Annual rainfall 200-450 mm. Dense lower strata consist of +/- heath-like (ericoid) sclerophylls from many families, including Myrtaceae and Proteaceae. This class of vegetation covers about 5% of the region mostly in KONDININ and KULIN.

Beard (1980a), mapped the vegetation of the study region (swrrvs), which lies entirely within the South-West Botanical Province, and identified 8 broad classes - physiognomic vegetation types - within the Southern Wheatbelt Region Remnant Vegetation Survey area. The vegetation was mapped using the system of Beard and Webb (1974).

1. Medium-height trees: Woodland of Jarrah (Eucalyptus marginata), Marri (E. calophylla) and Wandoo (E. wando and E. capillosa) - approximately 5% of the region in the extreme west in BROOMEHILL, KATANNING, NARROGIN, WAGIN, WOODANILLING and to a minor extent in TAMBEULLUP - this distribution appears (for the most part) to be climatically controlled.

2. Medium-height trees: Woodland of York gum (E. loxophleba) and Salmon gum (E. salmonophtoia); tree heights range between 10 and 30 metres, canopy is incomplete and more open than forest (Beard, 1980c) - approximately 30% of the region predominantly in the west in BROOMEHILL, CORRIGIN, KATANNING, NARROGIN, TAMBEULLUP, WAGIN, WOODANILLING and part of DUMBLEYUNG. This vegetation type also cuts through part of KULIN in association with major drainages. There is a significant area of Salmon gum in the NE of the (SWRRVS) region. Woodland often includes patches of mallee, and when tree height falls below 10 m the community becomes low woodland, while more dense patches may attain the status of low forest e.g. Moort (Eucalyptus platypus) as small patches of dense, low trees under 10m in height in the Dumbleung area (Beard, 1980c).

3. Tall Shrubland: Thickets of Acacia-Allocaoursina-Melaleuca alliance - approximately 1% of the region comprising two occurrences in the Worring Lake - Beaufort River area in the SW of WOODANILLING, and two further occurrences in the NE border area of KONDININ. Two types of thicket were recognised in the Dumbleung area by Beard (1980c), viz.
3.1. Thicket with Scattered Trees - dense shrubland of *Melaleuca* spp. 2-3m tall with scattered emergent trees of Wandoow (E. wandoow) and Yate (E. occidentalis).

3.2. Thicket (Kwongan) - Closed shrubland >1m tall: *Melaleuca* thicket, in swampy ground.

4. Tall shrubland: Mallee - eucalypt shrubland of *Eucalyptus eremophila, E. phaenophylla* and *Eucalyptus* spp. - approximately 25% of the region predominantly in KONDININ and KULIN, with further minor occurrences in the eastern parts of BROOMEHILL, CORRIGIN, DUMBLEYUNG, KATANNING and TAMBELUP.

5. Low shrubland: Scrub-heath - heath with scattered taller shrubs; (open kwongan) of mixed composition Proteaceae and Myrtaceae - approximately 15% of the region in the north and east, mostly within KONDININ and KULIN, with more minor occurrences in CORRIGIN and DUMBLEYUNG. Beard (1980c) recognised two types: one Banksia dominated and the other with no consistent dominants. A third, heath, is made up of dense low shrubs <2m tall with *Dryandra* spp. dominant in a rich assemblage (Beard, 1980c).

6. Succulent steppe: Thickly wooded - Saltbush (Atriplex), Bluebush (Maireana) plains on alkaline soils with varying tree and shrub cover of *Acacia, Allocasuarina* and *Melaleuca* - approximately 3% of the region along parts of significant drainages in the central, south and west e.g. Arthur River. Occurrences are predominantly in the west in KATANNING, KULIN, NARROGIN, WAGIN, and WOODANILLING. Succulent steppe also covers semi-succulent low shrub, saltbush and samphire communities occurring in saline areas, either as mixed or single species dominated communities, and as ground-layer only or as the understorey in teatree shrublands and/or eucalypt woodlands (Beard, 1980c).

7. Bare Areas: Salt lakes - approximately 2% of the region in CORRIGIN, DUMBLEYUNG, KONDININ and KULIN.

8. Bare Areas: Freshwater lakes - less than 1% of the region with mapped occurrences (map scale 1: 3,000 000) along the Arthur River (East of Narrogin) in NARROGIN, and NE of Dumbleyung Lake in DUMBLEYUNG.

1.7 Biogeography

The whole of the study area lies in the South-west Botanical Province. Four relevant Botanical Districts, Darling in the west (humid forest areas), Avon in the centre (the wheatbelt), Roe in the east, and Eyre in the south, which are positioned according to rainfall (Gardner & Bennetts, 1956; Beard, 1979c), relate to areas surveyed during 1991.

Each Botanical District is divided into smaller units, Vegetation Systems, of varying size, which are defined as a series of plant communities recurring in a mosaic pattern determined by topography, soils and/or geology (Beard, 1980c). Thirteen vegetation systems are distinguished in the study area. Descriptions below are taken largely from published work by (Beard 1979, 1980b, 1980c) with modifications to account for material which is now out of date.
1.8.4 Beaufort System

The Beaufort System in the Dumbleyung 1:250 000 map area occupies a band about 20 km wide across the SW part of the map sheet bounded in the north by the Beaufort and Carrolup Rivers, in the east by a watershed between Punchmirup and Holly Rivers and in the south the Wadjekannup River. This system extends into the study area in the western parts of WOODANILLIN, BROOMEHILL and TAMBEILLUP, in undulating country where the old land surface persists only as isolated, laterite capped mesas bounded by breakaways (as in the Williams System, above).

On laterite summits woodland of Brown mallet and Wandoo occur, sometimes with Blue mallet, and normally with little or no understorey. Slopes below breakaways and undulating country generally, carry woodlands of Marri and Wandoo singly or in association, sometimes with Flooded gum. Sheoak forms low forest on coarse granite outcrop soils, with Swamp yate woodland in valley bottoms generally on grey alkaline clays soils.

The Beaufort River flats have an open woodland cover of Swamp yate and Wandoo with a dense teatree (Beaforitia micrantha, Kunzea vestita, Melaleuca spp.) understorey, and sandy deposits along the main course of the river carry a variety of plant communities, including York gum - Swamp yate woodland; Flooded gum occurs commonly on both major and minor drainages. Jam, Bull Banksia (Banksia grandis) and Harsh Hakea (Hakea prostrata) are relict components of formerly more widespread Jarrah (Eucalyptus marginata) and Wandoo woodlands (Beard, 1980c), although eastern pockets of Bull Banksia nowadays appear to be in decline.

1.8.5 Jingalup System

The Jingalup System comprises a small component of the study area at the western boundary zone between BROOMEHILL and TAMBEILLUP. Rainfall is higher (below 625 mm) so the country is more deeply dissected than further north and east, and there is more laterite capped country. The dry season extends for over 4 months.

Erosion of the former lateritic land surface has left only remnants on hilltops and ridges, with ironstone gravel summits and less gravelly slopes. On slopes soils are acid and neutral hard-setting loams, and these become alkaline in valleys.

Vegetation comprises (15-20 m) woodlands of Jarrah - Marri - Wandoo on summit ironstone gravels and Marri and Wandoo on the slopes, both with scattered understorey. Brown mallet may occur with Jarrah on breakaways, and Jarrah recurs with Flooded gum on sandy alluvials of the Gordon River. Flooded gum occurs along minor drainages, and major creeks are lined by Flooded gum, Salt-water Paperbark (Melaleuca cuticularis) and Melaleuca vimeina. Flooded gum gives way to Swamp yate on minor drainages, in the south and east.

Marri and Wandoo woodlands reach heights of 15 to 20m. Beneath them are scattered or locally plentiful small trees of Jam and Sheoak with some Bull Banksia and Christmas tree (Nytsia floribunda), and a scattered discontinuous understorey.
1.9 Avon Botanical District

1.9.1 Narrogin System

Named after Narrogin, this system occurs as far east as the Arthur River, and mainly extends immediately to the south, east and north of Narrogin. Moderately well dissected country is characteristic, with substantial laterite remnants.

Woodlands of Brown mallet and Powderbark Wandoo (Eucalyptus accedens) are dominant with small patches of Kerosene bush (Dryandra spp.) heath. York gum and Wandoo woodlands dominate the dissected country below the breakaways with Wandoo on the upper and York gum the lower slopes. Flooded gum lines major drainage channels.

1.9.2 Wagin System

The Wagin System is situated east of the Darling District in a c. 35 km wide belt from Highbury to Katanning. Its eastern boundary is approximately parallel to and 10 km west of the Great Southern Railway. Undulating, well dissected country with limited laterite capped ridge and mesa remnants and some granite exposures, is characteristic.

Soils derived from laterite are reddish-brown sandy clays. Poorly drained, pallid pinkish grey sandy clay (or clay-loam) soils, containing a moderate percentage of laterite pebbles occur on upper slopes. These are strongly leached and acidic. Red loams occur on lower slopes. Broad valleys contain small, round, permanent salt lakes and marshes.

Woodlands of Brown mallet and Wandoo occupy laterite mesas and breakaways. Brown mallet may be the sole dominant or may occur elsewhere with Wandoo and Blue mallet and sometimes Red morrel. York gum and Wandoo occur on slopes, low woodlands of York gum and Sheoak in association with granites, and woodland, teatree scrub and sapphire mosaics occupy saline valleys. In some valley bottoms on grey clays Wandoo occurs with Swamp yate.

Kerosene bush (Dryandra spp.) dominated heath occurs on some laterites exposures frequently with Drummond's mallee (Eucalyptus drummondii), when skeletal sands are present, and with occasional scattered Wandoo.

Salt flat vegetation is changing, because of increased salinity and waterlogging. Teatree thickets are being replaced by samphires (Halosarcia lepidosperma, Sarcocornia blackiana), which are increasing in areal extent. Scattered (presumably salt tolerant ecotypes of) Wandoo and Salmon gum sometimes with groves of Swamp Oak (Casuarina obesa) are present. Understories, formerly of salt-tolerant shrubs and succulents, are now largely degraded, with only scattered trees, introduced weeds and grasses or just bare salt crust remaining.

In the SW of WAGIN and western WOODANILLING salinity and water logging have not been so severe, with Beard (1980c) reporting the original vegetation to be still intact viz "... teatree thickets with scattered Wandoo and Swamp yate can be seen," but observations
former occurs in the west as a medium-height tree (10-30 m), while Blue mallet occurs further east and is smaller.

Wandoo woodlands, sometimes with Red morrell or York gum, are from 10-20 m in height and 2-70% density, with scattered understorey shrubs and a ground layer, and with a 2-4 m small tree layer of Jam and Sheoak sometimes present. Where present York gums reach only 8-10 m. Salmon gum - Red Morrel woodlands have trees to 14-20 m tall, 30 - 70% canopy cover, and an understorey of scattered shrubs and grasses.

Salt flats and sandplains are affected by increasing salinity and waterlogging and in many instances timbered areas are dead. Samphires (Halosarcia lepidosperma, Sarcocornia blackiana) occur nowadays in open areas surrounded by largely dead tea-trees and patches of York gum and Salmon gum woodland. Another samphire, is found on the channels of the Coblining River. Flooded gum lines river and creek channels if they are fresh but is replaced by Swamp oak if they are salt.

1.9.4 Broomehill System

The Broomehill System includes Katanning, extends east to Bwlyamartup and south to Peringillup, and is comprised of a little dissected, essentially flat to gently undulating plain (formerly plateau) with heavy, winter-wet soils. Now mostly cleared it was originally entirely covered by woodland of varied composition. Blue mallet is predominant along with Wandoo. Brown mallet becomes abundant with Blue mallet on lateritic rises. York gum replaces Blue mallet in more dissected and undulating country. Swamp yate and Red morrel are occasional, and Salmon gum is very rare. Smaller trees of Jam, Acacia microbotrya, Sheoak and Needle Tree (Hakea preissii) occur along with Blackboy (Xanthorrhoea reflexa).

1.9.5 Tambellup System

The Tambellup System adjoins the Broomehill System to the west, south and south-east, and extends into the Mount Barker-Albany 1:250 000 map area to as far south as Cranbrook. It is largely comprised of dissected country of low relief and mostly is confined to the Gordon River catchment.

Rainfall is 450-550mm with a 5 month summer drought. Soils are hard-setting loams with mottled yellow clay subsoil, neutral on slopes, and alkaline in valleys. There is a suite of sand along the Gordon River, from which aeolian sand sheets extend ESE, and east of the River aeolian sands have choked drainages to produced a extensive area of salt lakes north of the Stirling Ranges.

A few laterite-capped hills carry Blue and Brown mallet woodlands, otherwise the vegetation is largely Wandoo - Swamp yate woodland. On valley flats Wandoo may occur alone on sandy soil as seen along the Wadjekannup River SW of Peringillup, with Swamp yate the sole dominant on clay along the Gordon River north and south of Peringillup.

These woodlands have largely been cleared, but comprised trees to 12 m tall over a sparse woody understorey, with occasional larger shrubs and, a ground cover of sedges and rushes. The sandplain at Tambellup consists of Wandoo with scattered patches of heath.
Small outliers of ironstone-capped hills carry Jarrah, while Blue mallet may occur on rises, and York gum lower in the landscape in the lakes country north of the Stirling Ranges. Flooded gum forms woodland with Wandoow and Swamp yate in the west near the Gordon River. In the upper Gordon, drier and saltier conditions result in tea-tree (*Melaleuca viridens*) and samphires (*Halosarcia* spp., *Sarcocornia* spp.) being dominant.

1.10 **Roe Botanical District**

The Roe Botanical District stretches from east of Tambellup north to Narembeen, northeast to the Bremer Range and east to the Nullarbor Plain. It is essentially the mallee region of Western Australia, whose occurrence is explained by annual rainfall being lower in relation to the length of the dry season, than in the Darling and Avon Districts, where woodlands and forests are dominant. Sandplains occupy the highest ground with some woodland on bottomland soils but mallee is the dominant vegetation on the middle slopes.

1.10.1 **Hyden System**

The Hyden System occupies the north-eastern part of the Dumbleyung 1:250 000 map area and extends into the adjacent Corrigin, Hyden and Mount-Barker-Albany areas. Within the study area the Hyden System largely encompasses DUMBLEYUNG, KULIN and KONDININ shires, and the eastern third of TAMBE LLUP, east of a line from Toolbrunup to Lake Balicup.

Its landscape is broadly undulating with very long gentle slopes and an altitudinal range of 150 metres. High ground is capped with residual laterite and sand, but breakaways are rare so boundaries between laterite and sand are often obscure. Granite outcrops are few. Major valleys are comprised of salt lake chains of a few large and numerous smaller lakes and pans.

The Pingaring Hills east of Dumbleyung, formed by the outcrop of banded gneiss with granite intrusions (Chin and Brakel, 1986), carry York gum woodland and Sheoak low woodland. Otherwise the pattern of vegetation is a mosaic of scrub-heath on sandplains, mallee on slopes, a mallee-woodland mosaic in some valleys and continuous woodland in valley bottoms, and, a fringing open woodland with saltbush understorey with some samphire marsh about salt lakes.

Tall Sand mallee (*Eucalyptus eremophila*) is the dominant mallee species with *Eucalyptus foecunda* and *E. transcontinentalis*, and *E. calycogona*, *E. celastroides*, *E. incassata* and *E. loxophleba* (mallee form) less abundant. Understories are dominated by *Melaleuca* spp. Valleys with higher soil clay have *Eucalyptus* spp. woodland patches interspersed with mallies.

Mallet low woodlands dominated by Blue and/or Silver mallet, sometimes by Merrit (*Eucalyptus flocktoniae*), occur on laterite ridges and breakaways. Understories are usually quite open with few other species present, as gum dropped by the trees contributes to the non-wetting character (water repellant) of the soils, thereby increasing run-off and promoting a soil drought zone.
Salt lake country is comprised generally of a few large and many smaller lakes and pans. Smaller lake beds are vegetated with samphires (*Halosarcia* spp.), while larger lakes beds are generally bare. Samphires also occupy east and SE lake margins in association with salt and gypsum lunettes derived by wind from lake beds.

1.10.2 Chidnup System

This system is mostly occurs east of the study area, and is comprised of flat to gently undulating country mostly dominated by mallee, but with Tallerack (*Eucalyptus tetragona*) mallee-heath patches on rises, and eucalypt woodland associated with major valleys and numerous small lakes and pans.

Frog mallee and Hook-leaved mallee (*Eucalyptus uncinata*) are the most commonly encountered mallee species, but Merrit, Blue mallet (*Eucalyptus gardneri*) and Swamp yate are also found; the last three occur elsewhere as trees. Moort (*E. platypus*) and Open-fruited mallee (*E. annulata*), both small trees which regenerate from seed after fire do not possess the mallee habit, occur on heavy winter-wet soil. Mallee communities commonly have a dense Tea-tree (*Melaleuca* spp.) understorey.

Depressions carry patches of Swamp yate woodland with Wandoo in the west, and Paperbarks if swampy. Lakes are mostly saline and intermittent. Continuous woodland occurs in the larger valleys, with Swamp yate and York gum the usual dominants, and some Wandoo and Marri near the Stirling Ranges. Swamp yate tends to dominate the lower ground and York gum the upper slopes.

1.11 Eyre Botanical District

This district comprises an area where prolonged leaching of the soil over millions of years has produced plains of nutrient-poor sands that carry only mallee-heath vegetation (heath with a stunted mallee overstorey), even though the area receives more rain than the better wooded country further inland.

1.11.1 Qualup System

In the Qualup System true mallee is limited to hills and valleys, while woodland (which is almost non-existent) is characteristic of drainages through the plains of sand over clay (with ironstone gravel) north of the Stirling Ranges. On deep sand, scrub-heath of Proteaceae, particularly Chittick (*Lambertia inermis*) replaces mallee.

Mallee-heath dominated by Tallerack is the main vegetation cover in the Qualup System, but is more prevalent east of the study area. It generally has an open, upper layer of tall shrubs of *Eucalyptus* and Proteaceae reaching up to 3.5m, with an understorey of low, dense ericoid shrubs to 50 cm.

The plains are dotted with numerous salt lakes and pans or swampy depressions which contain Redheart Moit (*Eucalyptus decipiens*) mallee if sandy, and Swamp yate woodland if loamy. Redheart Moit may also occur as an understorey species to Swamp yate woodland in these hollows.
Samphires (*Halosarcia* spp., *Sarcocornia* spp.) and tussock sedges (*Galenia* sp.) fringe some salt lakes and occasionally cover lake beds. Scattered fringing Salt-water paperbark trees may also occur.

2.0 Methods

**Orientation Phase**

The project commenced on 15 July, 1991. Initial work at PERTH (head office) involved a broad review of vegetation types and geology recorded in the literature, and project budgeting. Meetings were also arranged with WADA Project Officers to assist in bringing the survey to the attention of local farmer groups within the survey area, and with CALM Officers at Narrogin and Katanning, to determine areas of privately owned remnant vegetation in the region already surveyed by that Department.

Shire remnant vegetation inventory maps were produced from the Geographic Information System (GIS) database, initially at 1:100 000 scale, and these became the basis for communicating the survey to the relevant people in nominated Shires. WADA, NSCP Sponsored, Project officers in each of Lake Grace, Narrogin and Katanning District offices were initially contacted to inform them of the survey, its aims and methods and anticipated outcome. Project Officers also facilitated attendance at Land Conservation District Committee meetings, often providing an initial introduction to the committee. LCDC Meetings at Woodanilling (5/8/91), Broomehill (6/8/91), Katanning (6/8/91), Kulin (7/8/91), Kondinin (7/8/91), Wagin (12/8/91), Wickepin (20/8/91) and Narrogin (21/8/91) and also a meeting of the Wadjekanup Catchment Group (7/8/91) were attended to promote the remnant vegetation survey and gain support from local farmers. Where it was not possible to attend LCDC meetings, letters were sent with the same aim as above (to Corrigin, Dumbleyung and Tambellup). Department of Conservation and Land Management (CALM) offices in both Narrogin and Katanning were also visited to determine which areas of remnant vegetation on private land had already been surveyed by CALM.

**Field Work Phase**

The major part of the project was to survey as many patches of bushland as possible on private land in the available time. This comprised two parts:

1. Detailed surveys of remnants greater than 50 Ha in area, augmented by opportunistic field observations by a botanist,
2. Farmer assisted component where farmers provided information on remnants of 10-50 Ha on their own properties.

With the assistance of local WADA offices, articles were included in local Ag Memos to further communicate the survey to the wider farmer community. Simplified remnant vegetation survey sheets were distributed via Ag Memos, WADA Offices, and LCDC's. A steady flow of these came back during the period up to December.

Remnant vegetation maps from the GIS database were then produced at 1:50 000 scale and formed the basemaps for field work. Most remnant vegetation information in the GIS database, was derived by digitising from aerial photographs or from RSAC (Remote Sensing Application Centre) data; all but the 1:100 000 map areas 2330, 2430, 2433 and 2530 have data only from digitised aerial photography. The map product generally comprised plots in green
(remnant vegetation), red (modified remnant vegetation) and blue (scattered trees) -

REMNANT VEGETATION MAPS - Green = remnant vegetation
- Red = modified remnant vegetation
- Blue = scattered trees

areas in blue could be granite, heath or public land - nature reserves and etc depending on the interpretation at the time of digitising. Apart from the larger areas, vegetation promoting connectivity between other remnants were an important consideration for wildlife conservation purposes.

With the 1:50 000 basemaps in hand, surveys were commenced in KULIN, and progressed through KONDININ, CORRIGIN, WICKEPIN, NARROGIN, WAGIN, DUMBLEYUNG, WOODANILLING, KATANNING, BROOMEHILL and TAMBELUP, to, as far as was practicable, take advantage of progressive flowering times and thereby facilitate plant identifications. A survey of the Phillips River drainage (in LAKE GRACE shire) along Muncaster's Road near (east of) Mt Madden and along the Lake King - Ravensthorpe Road was carried out (on 10 to 11.9.91 after a request on 22.8.91) for the WADA Lake Grace WADA (office), to facilitate, by providing a list of appropriate species, a proposed tree and shrub planting program scheduled for the middle of October, 1991.

Farmers were visited to discuss their remnant bush and seek permission to survey areas larger than 50 Ha in detail, after which surveys were conducted. A couple of remnants were visited at the request of owners, and opportunistic notes were made on other remnant vegetation.

Field work comprised vegetation mapping, and soil and plant data collections to indicate species occurrence within patches of bush. Other additional ecological and physiographic observations were made and detailed on a proforma sheet. Time constraints prevented a completely thorough coverage of each remnant. Additional notes on vegetation detail were made on 1:50 000 base maps.

A week was spent from October 7-11 in plant identifications, and subsequently an extended period from late December onwards was also spent in going through the collections made during the survey. Some assistance in plant specimen identification has been required because of the diversity of species encountered during the survey.

Plant and soils data, and vegetation, ecological and physiographic observations recorded on a proforma sheet, along with notes on vegetation detail annotated on 1:50 000 basemap sheets, have been transferred to the WADA GIS database.

3.0 Results

Surveying in KULIN took place from 12.8.91 to 6.9.91 (Remnants 1-13), LAKE GRACE - 10 to 11.9.91 (Sites 14-17), KONDININ - 12 to 19.9.91 (Remnants 18-26), CORRIGIN - 20.9.91 to 3.10.91 (27-30), WICKEPIN - 3 to 18.10.91 (31-37), NARROGIN - 21 to 24.10.91 (38-41), WAGIN - 25.10.91 to 6.11.91 (42-47), DUMBLEYUNG - 6 to 21.11.91 (48-57), WOODANILLING - 21.11.91 to 3.12.91 (58-60), KATANNING 3 to 6.12.91 (61 & 67), BROOMEHILL 9 to 11.12.91 (62-63), and TAMBELUP 11 - 13.12.91 (64-66).
A total of 67 pieces of bush comprising natural vegetation were visited and surveyed in detail (Figure 2; Section 10.2). For other areas that were visited and found to be of the same type of bush as surveyed or in the modified remnant or scattered trees categories, notes were made on the relevant base maps to indicate this.

Over 800 species of plants was recorded during the survey from the main surveyed remnants (Section 10.3). This is not exceptional considering the areas and locations surveyed. With more detailed surveys at different times of the year, the number of species would increase substantially.

Survey sheets forwarded through local Agricultural Memos produced a disappointing return. However, the significant response from farmers in Broomehill shire did occur primarily through the assistance of Gus Woody (LCDC Chairman) providing a covering letter, a follow-up by LCDC members and encouragement provided by Project Officer Steve Garrad.

A total of 899 additional remnants were observed during the survey and notes made on plants species dominants, disturbance, degree of fencing and/or evident waterlogging and salinity effects (Figures 3-13; Section 10.4). These data provide a more general coverage of remnant vegetation information particularly in the 9 western shires viz. BROOMEHILL, CORRIGIN, DUMBLEYUNG, KATANNING, NARROGIN, TAMDELLUP, WAGIN, WICKEPIN and WOODANILLING, and augment the information provided by the more detailed surveys.

Interest has generally been good with several LCDC's supporting the filling in of (simplified) remnant vegetation surveys sheets by local farmers, through the provision of covering letters, feed-back support and follow-ups either in person or by phone. All LCDC's visited in Katanning and Narrogin districts indicated support for the inclusion of survey forms in local Agricultural Memos. The Lake Grace Project Officer indicated that he would personally distribute forms to relevant LCDC's in his district.

The general view of farmers visited was quite supportive, although the tough times appear to have added to farmers fears about Govt activities and how they concern them. Older farmers are much less trusting of this survey than are the younger farmers, although this is not a universal trend. One farmer was very surprised to find an area of bush completely hammered by sheep, had regenerated magnificently after it had been fenced off 4 years ago.

Farmer support was good, with some wishing they had retained more bush, others concerned about the loss of wildlife, particularly nesting birds, during past clearing, and others happy that they have retained sufficient bush to keep waterlogging and salinity effects at bay while they plan remedial action.

Of the bush itself, active fire suppression by farmers has meant that many areas are becoming senescent, with the ground layer bush dieing out and becoming open. Some areas have very high kangaroo numbers, which is causing the ground layer bush to disappear completely. Management of farm bush is therefore required.

Reserves and CALM
Areas of public land (reserves) area of many types. Nature Reserves, Timber Reserves, State Forest, Water Reserves and Stopping Places, are examples of reserve types with CALM interest mainly in the first three, and interest in the others dependent on available funding. Reserves always retain their number and if such a reserve is dropped for any reason the reserve number is not reapplied (but becomes archival). Vacant Crown Land is now limited to those areas beyond the Vermin Fence. Private Property is referred to by either Location Numbers or the owners name(s), with the former more reliable due to the constantly changing land ownership situation, and generally interest by CALM is initiated only by an approach from a landholder.

Searches of CALM files at Narrogin and Katanning found fewer than 20 areas (only 1 in Narrogin!) for which CALM surveys of privately owned bush remnants had been carried out; it appears that if the bush is not acquired for reserve purposes, it either hangs in limbo as a proposed reserve (generally the case due to funding limitations on purchases) or the information rapidly becomes archival. Information available on prior surveys is not readily available even to CALM staff, which could seemingly lead to repeat surveys by CALM with the periodic movement of officers from one region or district to another and the change of ownership of land, so that no one remembers if a survey has been done and where.

Where a proposed reserve has been rejected the information appears to be non-existent, suggesting that surveys are only carried out where a prior "look" has shown that such survey(s) may be viable. Otherwise files may be held under certain species of interest e.g. rare flora survey information. However, no cross referencing of information is apparent so that once the information is filed under a rare flora, for example, it is virtually lost, unless someone finds it by accident. It seems strange that there is no alternative information on private property locations for which surveys have been carried out, particular in Narrogin which is the administrative centre for over 120 000 square kilometres of relatively densely populated wheatbelt.

4.0 Discussion

Farmers today who have on-farm bush are responsible for a very great legacy in the form of these on-farm bushland remnants. Most are now coming to realise the value of their bush and have pride in it. I was told by a farmer's wife in the north of KATANNING that her husband had cleared some on their sons block a while back, and the loss of birds while nesting and other wildlife had disturbed him to the point where he vowed not to clear any more bush.

A second generation farmer in country to the east of Jilakin Lake said about a bit of bush I surveyed, that his father wanted to put a bulldozer through it, but he had convinced him otherwise. Fortunately he did, because it now remains as one of only about half a dozen remnants on private land in the entire Jilakin 1:50 000 map area that is still in its natural state or as near as possible anyway because of the presence of rabbits and foxes. The farmer also mentioned what he would like to do to the pommery b.... that brought foxes to Australia, and I mentioned something similar regarding the one who introduced rabbits, but back to the patch of bush. It seems the local council also got stuck into it as a source of gravel, but again the farmer got on their back and
convinced them otherwise. The council scarred the edges with a large borrow pit and put a rather unsightly bulldozer track into it from the west edge in an effort to find more gravel, however, through strong insistence by the same farmer the borrow pits have been ripped and with the area now fenced, regeneration is occurring.

This particular farmer is quite proud of his bush. He said there was probably 50 acres of arable land in the patch, but clearing it wouldn't be worthwhile. Anyway, he preferred to leave it the way it is and I don't blame him. There was a profusion of orchids, carnivorous plants and trigger plants throughout his bush - everywhere I walked there were donkey orchids, the only place anywhere I have ever seen them in such abundance. Each patch I have found in good condition was like that one, always a fascination because of one or two plants not seen in other areas surveyed.

Section 10.3 shows plant species occurrences in surveyed bush remnants and it will be seen that a lot of species occur at only 1 or 2 localities. These records, however, only give a general indication of the distribution of recorded species, and more thorough surveys would be required to determine whether a species was, for example, rare. One could attempt to apply the criteria used by Mollemans et al. (1984), as follows:

<table>
<thead>
<tr>
<th>VC</th>
<th>very common</th>
<th>occurs at &gt;10 localities</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>common</td>
<td>occurs at 5-10 localities</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(if at 5, must be common at one or more)</td>
</tr>
<tr>
<td>FC</td>
<td>fairly common</td>
<td>at 2-5 localities</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(if at 2, must be common at one or both)</td>
</tr>
<tr>
<td>U</td>
<td>uncommon</td>
<td>at 1-2 localities</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(if at one, it must be reasonably abundant)</td>
</tr>
<tr>
<td>R</td>
<td>rare</td>
<td>at one locality in very low numbers</td>
</tr>
<tr>
<td>E</td>
<td>endangered</td>
<td>under threat in all known populations</td>
</tr>
</tbody>
</table>

as a means of getting an indication of species rarity. But, there are difficulties with applying such a rigorous list in Western Australia, because of the speciation inherent in the south-western flora of this state. The diversity of species present makes it likely that some species which are common in restricted areas, but which aren't particularly rare will be counted in a category of occurrence which is below its actual true status. Certainly some species have a wide occurrence, and examples from the list of plants recorded in the present survey, include Laxmannia squarrosa (Liliaceae) and Ursinia anthemoides (Asteraceae).

Some which are apparently rare by being infrequently encountered include the following. The pink form of Waitzia acuminata - on the basis of this survey it was collected only once (while the common yellow/golden flower form was encountered frequently) - its occurrence in the study area is rare. Gastrolobium stipulare one occurrence - rare. Eucalyptus olivacea one occurrence - rare; this species is distributed in only a few localities where it is not numerous and one would expect that in time it may be gazetted as a threatened flora.

Problems also arise in the survey list because of the absence of some species at later surveyed remnants because they are annuals and their life cycle has been completed. Rather than being an
indication that they are in fact absent from a piece of bush, the lack of a site record may only mean that they are no longer evident. Some perennial species are also not easily picked up when not in flower. The featherflowers (Verticordia spp.), for example are frequently very non-descript when not in flower. Unless remnants are surveyed at several times of the year, plants are going to be missed, although the majority will be picked up in spring, the time the major part of this survey was conducted.

Species Priority Listed for further survey by CALM (1990) or Gazetted as rare, are indicated in Section 10.3.

5.0 Influences of Land Clearance on Remnant Bushland

5.1 White gum dieback due to insect defoliation?

At a number of remnants surveyed during 1991 (e.g. R61), it was noted that dieback in White gum was evident, and in some case quite severe. The cause was uncertain, as dieback in Eucalyptus caused by fungal attack from Phytophthora spp. tends to be more prevalent in gully situations which remain moist for extended period after rain (Batini 1973; Shea 1977). However, observed occurrences of White gum dieback during the present survey tended to be in elevated situations; R61 is Bellakin Hill (Alt. 400 m) which has a police communications tower on top, and the affected White gums are not far down slope from the tower. Isolated White gums observed in paddocks tended to be far more severely affected than trees grouped as woodland.

This is an significant problem as White gums are an important part of the landscape. After 30 years of bird observing and making nesting records in the Woodanilling Shire, Garstone (1991) suggests that 90% of birds in that area utilize the White gums. The continued decline of White gums may therefore be expected, in the long term, to have a devastating effect on the bird populations. For example, loss of Black Cockatoos from the Mannanning and Kellerberrin areas (Saunders, 1991), is probably due to the gradual decline in the number of suitable nesting trees. So, it is important to find the causes of loss of big trees, such as the White gum and then reverse the process if at all possible. Incidentally, Garstone (1991) also mentioned some of the changes in bird occurrences over his period of observation, including the disappearance of the once prolific Whistling Kite in the 1970's and the reappearance in the last few years of Splendid Wrens, so there is still much to learn about bird dynamics associated with changes in the vegetation cover of the landscape.

Back to the White gums, I could find no answer after looking at the literature on fungal dieback, because of the altitudinal factor, and discussions with people in the bush suggested that the "dieback" effect varied over time. In relation to R61 the landowner said that the White gums on Bellakin Hill exhibited symptoms of severe dieback about 20 years ago, but it has not been so evident in recent times.

Results of a recent study by Lowman and Heatwole (1992) suggest insect attack as being responsible. It appears that a number of species of insect which consume Eucalyptus leaves as adults, have larval stages which develop in grasslands and other low bush.
Adult insects subsequently fly up to the tree canopies and consume the leaves. With far less trees around nowadays due to land clearing for agriculture, there are far more adult insects per tree than was the case before land clearing. Larvae are still produced at the same abundance as was the case prior to land clearance, because suitable larval habitat (pastures, crops etc in place of natural grasslands and other low bush) has not declined in abundance.

The abundant larvae produce abundant adult insects, which in-turn attack the smaller number of White gums still remaining and tend to act like a constant plague. Climatic and other factors (e.g. farm spraying of crop insects) affect the level of insect populations, so from year to year the level of dieback (defoliation) varies. Trees grouped together show less dieback as the insect population for the particular area is spread over more individuals, but isolated trees in paddocks are devastated over successive seasons and gradually weaken and die.

Other eucalypts are also affected, as T. Barritt (pers. comm.) of BROOMEHILL has observed a similar occurrence in Flooded gum (Eucalyptus rudis). But White gum, being more widespread, is seen to be affected more widely. The results of Lowman and Heatwole (1992) suggest that the leaves of some species are far more palatable to insects than others, and White gum may be an example. Being so widespread, far more insects may be dependent on this species, in comparison, for example, to Flooded gum which is more restricted in distribution. Curry and Dickson (1984) discuss some of the insect herbivores of Western Australian native plants, especially eucalypts.

The following comments by Seabrook (1991) may help to further explain the situation.

"Trees are a very important part of vegetation and wherever they are present they probably dominate the ecology; however even trees cannot manage without other components of the vegetation to give shelter to those animals which interact with them and so protect them. Trees all over Australia are being decimated by insects, borers, beetles, leaf eaters and lerp's of many species. The trees can only be protected by the natural predators of the damaging insects which must have an adequate habitat to be present.

A story to illustrate this point concerns a wasp and a beetle. One of the leaf-eating insects which decimates trees is the Spring Beetle. In the spring when the trees are just making their new leaves, this beetle eats the new growth and then proceeds to lay its eggs in the ground beneath the trees. Along comes the wasp which is able to bore into the ground and lay its eggs within the larvae of the beetle and thus only a few of the beetles survive, so their population is controlled. If the wasp is not present, the young beetles will hatch in time to do the same damage the following year and so on. Soon the tree will be irreparably damaged. The catch is the wasp needs nectar to live on and is not a long distance flyer, so if there is not a ready supply of nectar nearby
it cannot be there. Nectar and shelter for such insects is provided by understorey plants.

For a diversity of animals there must be a diversity of vegetation. Plantations of trees by themselves with no supporting understorey do not make a habitat for very many species, in fact an arid situation is created. Food for birds and insects is present only when the trees are in flower, which is mostly only once every year and thus many species would not find resources to complete a life cycle. The rest of the plants which go to make up a plant community, including ground covers and shrubs, must be present to create the habitat for all sorts of creatures which in turn ... develop into an ecosystem.

Now that there is an idea as to the cause, what's the solution to this dieback? Simply growing more trees will greatly enhance the survival prospects of the remaining White gums. In fact growing more eucalypts generally and other species as well to diversify and replicate local natural systems would be better than growing just White gums, but this will require some additional effort. Some people may consider spraying more poison to kill the herbivorous insects a solution, but that would seem a very expensive process as it would have to be repeated annually. The insects would become resistant to one poison and other stronger poisons would have to be found and used. It may also be counter-productive as unwanted side effects may develop, which in-turn require remedial action.

If a variety of trees and other plants of different species are grown, the insects which periodically devastate crops may have an alternative food source, which may result in crops being less severely affected and less often. Farms would then become more like the natural ecosystems which they have replaced.

6.0 Soil Salinity and Water Logging Effects

Some may think by the activities of today that the problem of soil salinity is a recent one, but in fact it has been known for nearly 100 hundred years. W.E. Wood first learnt of the problem in the Northham-Toodyay district in 1897 (Bennett and Macpherson, 1983) and subsequently published a scientific account on the subject (Wood, 1924) appropriately titled "Increase of salt in soils and streams following the destruction of native vegetation."

Early problems were encountered by railway engineers trying to find suitable water for steam engine boilers. A report by the W.A. railways of the late 1800's stated that if catchments were cleared then there would be more water available for the boilers of the steam engines. But, a later associated report by railway engineers recommended that catchment clearing be stopped as the additional salt coming in with the excess moisture was corroding the boilers (see Bennett and Macpherson, 1983). In 1915 the Blackwood River at Bridgetown was too salty for the purpose (Bleazby, 1915; Bennett and Macpherson, 1983).

The very presence of salt country was known in the Swan River Colony as early as 1830 (Dale in Bennett and Macpherson, 1983), but its future effects were at that time not apparent. Many early accounts documented by Bennett and Macpherson (1983), indicated the likely future difficulties, with an important example being an
exceptional flood in 1862 when salt lakes (probably associated with the Mortlock River) overflowed into the Avon River. Counteracting the salt problem by reforestation is not new either as the railways did it in 1915 after the Chidlow Well went salt (ibid.).

But What is the Problem?

Simply stated the problem is that there is too much moisture in the soil. Prior to European settlement the landscape was in an equilibrium situation as regards water coming in via rain and going out via drainage lines and transpiration mechanisms of plants. Removal of the plant cover from large areas to convert the land to agricultural production, meant a significant reduction in the outgoing moisture component. Cropped paddocks only carry plants for some of the time, and generally plants that use less water than species making up the former vegetation cover. Excess moisture is therefore present in soils, soils reach field capacity more quickly and retain water much longer than under former natural equilibrium conditions. Waterlogging is therefore apparent and this leads to soil salinity viz. the water level being higher results in the mobilization of salts from low in the profile and the subsequent crystallization of these salts at higher levels in some situations at or within the near-surface zone; these salts are derived from geologically old marine strata laid down during one or more marine transgressions.

How Do You Solve the Salinity Problem?

To overcome the salt problem the water balance needs be returned to a state of equilibrium i.e. inputs = outputs.

\[
\begin{align*}
\text{INPUTS} & \quad \leftrightarrow \quad \text{OUTPUTS} \\
\text{Rainfall/Runoff} & \quad \leftrightarrow \quad \text{Runoff/Transpiration}
\end{align*}
\]

The land is managed as individual units (farms), but the problem is at the landscape level with the landscape made up of interconnected drainage catchments. It is therefore necessary for the individual units to work together as catchment groups, which is occurring, and the work of the catchments to be coordinated so that the work of one group is not negated by that of another. For example, in trying to facilitate the removal of excess moisture from one catchment all units within that catchment (A) cooperate to produce and link into drainage channels to carry off the excess, but the problem arises, when the next catchment down in the landscape (B) does not want to accept the excess moisture from the first. B is having significant difficulty getting rid of its own excess moisture, because the next catchment down (C) is not prepared to accept its excess. This has happened, and is happening now.

Apart from where the excess moisture is going to go if you can't export it, there are also erosional difficulties associated with poorly planned artificial drainage works, as well as the cost, as discussed below.

Who's Going To Pay For It?

Earthworks to facilitate drainage of excess moisture down the landscape gradient are all very well but they cost a lot of money. To carry a new drainage easement under a bitumen road costs up to
$30,000. Councils are unable to find such funds, unless they
extract it from farmers by way of rates, and farm commodity market
prices are not sufficient at present to even consider this form of
extra revenue gathering for such artificial drainages works. So
rather than carry these artificial drainages down stream as
intended they just come to a halt. This is happening now also. No
one is really coordinating it, although there are NSCP Project
Officers who provide guidance.

If one takes an overview, however, the immense size of the problem
becomes apparent. Some of the artificial channels in the central-
eastern wheatbelt are about 5 m wide. If the coordinated drainage
approach worked, by the time these channels coalesced nearer the
coast they would require a width of perhaps 25 m to carry the
volume of water envisaged by those upstream. But, the artificial
drainages are only holes dug with an excavator or other large
backhoe, and are not stabilised by plants grown at the time of
excavation. The channels tend to be square in cross section, and
the first thing that happens after a significant rainfall event is
that the walls erode and collapse and then the loose silt starts to
move down the channel. Obviously the farmer built a channel of
square cross-section because he doesn't want to lose more of his
productive land than he can help, but with erosion the channel
starts to expand and the $5000 he spent to cut the channel through
his paddock now has to be followed up by an additional $8000 to
repair all the erosional problems which have developed since the
channel was cut. If he is at the lower end of the catchment of has
a road adjacent to his paddock under which the channel is proposed
to pass, he also has to put up with (or remove) silt coming in from
higher in the landscape, and this will enhance his waterlogging and
subsequently his salinity problems.

Then there are the problems with subsurface dykes and other
anomalies such as non-wetting soils, which affect soil hydrology.
Aeromagnetic survey flights cost many thousands of dollars ($70,000
- 100,000 and more) just to get a idea of what happens to water
that enters a catchment, and are needed to properly plan remedial
action. How many catchments are there in the wheatbelt? Perhaps a
100 or more, so just to begin to understand the problem by getting
aeromagnetic surveys, over the entire wheatbelt will cost $7 - 10
million. Then there is the ground surveys to map the salt
locations and areas of waterlogging. It also costs about $3,000
per hectare to do the ground preparation before planting trees (R.
Kerr, pers. comm.), and on it goes!

Possible Solutions

The basic problem is to reduce the net inputs of the water balance
equation i.e. to constrain runoff to the local area of rainfall and
to utilize available moisture to the maximum or to use a reverse
water scheme viz. water is piped to the wheatbelt to bring much
needed drinking water could just as easily be piped to the coast
to remove excess water in winter. Then there are other
possibilities like desalinization of ground water to provide
drinking water and removal of salt by this means; this would reduce
or eliminate the need to pump water long distances. Some of these
schemes in the longer term are going to be far less expensive than
remedial action to overcome the problems caused by excess water and
salt.
7.0 Management of Bushland Remnants to Promote Longevity

7.1 Responsibility of the Land Managers

7.1.1 Role of the Individual Farmer

Farmers may choose to manage their bushland remnants in a number of different ways, for example, by selecting one or more of the following options viz.

Do nothing
Fencing at their own expense
Remnant Vegetation Protection Scheme
Active Destruction of Foxes and Rabbits
Kangaroo Culling to ensure that their farms do not suffer from high numbers
Management of kangaroo numbers to preserve the integrity (wilderness value, floristic diversity, natural state) of the bushland remnant, and ensure the survival of kangaroo populations
Fire Management after appropriate advice
Fire setting without advice (to reduce a perceived fire hazard)
Active weed control: manually
Active weed control: using pesticides without determining the effects on native plants
Active weed control: using pesticides after seeking advice regarding the effects on native plants
Stock grazing
Timber harvesting

Some are less effective than others in ensuring the long term survival of bush remnants.

One area of concern is the uncoordinated development of drainage channels, as discussed above. This potentially is a major erosional hazard and poses a serious threat to some pieces of remnant vegetation, into which such channels have been extended.

What is the solution to the problems of water logging and salinity? Tree and shrub planting, is the simple answer but the choice of appropriate tree and shrub species is more difficult and will be dealt with in the next section.

7.1.1.1 Tree and Shrub Planting

"One of the basic principles of revegetation is to try to use local plants. These plants have evolved to suit local conditions and therefore must be the best plants for those conditions. The local fauna, which has evolved with the plants, will be at home with them and there will be a basis for the many interactions needed to form an ecosystem" (Seabrook, 1991).

A typical tree planting plan by farmers is often scribbled on the back of an envelope or some other handy bit of paper, as, for example, in Table 2.

Table 2 - Tree Planting Plan
Fencing after harvest
Old wire on road fences
Station netting for oak tree planting
6 line on electric fence

Trees
Replacements:
  a) Jam
  b) White gum

Posts and wire
  a) Along Mutters Road
  b) Patch for Lucerne Trees

A more orderly approach could involve some graph-paper, a rough plan (or even one that is drawn to scale as used by T.A. Barritt of BROOMEHILL) of the farm, with an indication of what trees are to be planted where, soil type and the date so that progress can be monitored. White gum and Jam are plentiful and often, in the case of Jam, seeding is not often required as in a lot of cases just fencing an area has resulted in an explosion of this species due to the store of seeds still in the soil, seeds which may survive for many years. A variety of species rather than just the two landscape dominants, will ensure that the tree cover will not become a monoculture which requires constant up-keep, to control insects. A few shrubs in each successive planting program will also provide for a more natural plant cover.

7.1.1.2  Seed Collecting and Germination

Most people are interested in collecting seed from species such as eucalypts, Sheoak (Allocasuarina huegeliana) and Swamp Oak (Casuarina obesa), and for these the collection procedures are quite simple. A fruiting branch is removed from the mallee or tree and placed in newspaper to dry; it is possible to place branches directly in the sun to dry but this risks the seed being shed out in the open when the wind is blowing - eucalypt seed tends to be quite small and Sheoak/Scamnp Oak seeds have winged appendages so both could be lost easily in windy conditions. After one to several weeks in the newspaper the fruits will be seen to open and by shaking the branch over a sheet of paper or sheet of some description, seeds will fall from the fruits to be scooped up and collected. All the material from eucalypt fruits is not seed, as amount of dried floral material from valves and etc is also contained within seed cavities. Sheoak/Scamnp Oak seed (individual seeds are called samaras or winged seeds) is always without additional debris.

Seed for shrub species such as teatrees and other species of Melaleuca, along with the seed of many other species, can be collected in the same way as those of eucalypts and the Sheoaks/Scamnp oaks. Some species such as the members of the family Rutaceae (which also contain citrus fruits) have structures which expel the seed from the fruit, while others have apparatus shaped in such a way so that seeds are carried away by the wind. Some orchids, for example, have an elliptical fruiting body with elongate cavities which allow the wind to penetrate and blow out the very fine seeds, which are then carried off by air currents.

Seeds of rarer species tend also to be rare. The rare species in the large genus of poverty bushes (Eremophila spp.), for example, tend to produce a lot of fruits but very few seed (Mollemans et al., in ed) and this is one probable cause of their rarity. They are not very efficient at reproducing.
The time of year to collect fruits is also important as it is no good if the fruit is still green. In the majority of cases species flower in spring and fruit in summer, but some species flower earlier or later because they have a biological clock which developed under different climatic conditions. Others flower when it rains and may flower 2 times in one year with successive heavy rainfall periods, and then may not flower at all the next year because the rainfall has been too low. For the majority of species the best time to start looking is November - January. There are restrictions in collecting seed from certain species such as those gazetted as rare. However, being rare these species generally have very restricted distributions and are generally not encountered.

Although seed may be collected it also needs to be propagated in particular ways before it can germinate. Everyone knows about the need for some banksia cones to be burnt before the fruits will open. Opening of the fruit enable the release of the seed, but also in a natural situations provides a seed bed of particular pH (acidity) into which the seed will fall. Some wattles have very resistant seed coats which need to be broken into, by sand-papering or scratching, so that moisture can enter and allow for germination; under natural conditions this may occur by long exposure to a hot sun which makes the seed coat brittle enough so that it shrivels and opens with the next significant rain. Some seeds contain salts, such as sodium chloride (common table salt), as an inhibitor to germination and require a particular amount of rainfall (or soaking) before the salt is leached out and the seed is able to germinate. Some seeds are very difficult or even impossible to germinate artificially, because of inhibitory factors which are not as yet understood.

Often nurseries will be able to provide advice on particular seed germination requirements, but sometimes a little experimentation will provide the answer. It is important to remember though that trees or shrubs may produce hundreds, thousands or even millions of seeds (in a very good season), but ultimately only a small proportion of these is naturally destined to produce new trees or shrubs. Having too much seed is therefore probably better than having too little, assuming you can get it! And if you only have a few source trees its a much better idea to approach your local nursery for your supplies.

The following information by Seabrook (1991) provides some additional comments regarding seeds used for re-establishment of native species.

*Seed integrity*

Not only do we need diversity of plants and animals, we also need diversity within species. It is this diversity which enables the species to survive various hardships which may occur, such as fire, drought, cold, or accident. Maintaining this genetic variation is critical to the long term survival of a species. Therefore the seed used must include this diversity. This means collecting seed from several different pockets of the species, because plants growing in close proximity may all be closely related.

It has been established that progeny of most plants are much stronger if outpollinated, rather than
selfpollinated. Some pollinators, such as flies or even midgies, which perform the outpollination are not mobile over any great distance, and some plants are wind pollinated. Seed should therefore be collected locally from robust plants growing near enough to each other to be sure they are outpollinated and not selfpollinated. Never collect all the seed from one plant, even though this may be tempting when the plant carries plenty of seed.

Direct seeding

The understorey that we need consists of many thousands of plants of very many species. It is difficult to envisage any way of providing these plants except by direct seeding. For those of you who are not familiar with the concept, it means any method of distributing seed of the required plants, including trees, onto the ground.

The great problem that arises is where is the seed to come from? Particularly as it has been established that local seed is needed. The rural agricultural areas are, without question, the part of the land in greatest need of revegetation, and the part of the land where seed of the original plants species is becoming scarce. For large scale direct seeding, massive quantities of seed will be required and the only way these seeds can be obtained is to grow them. The ideal would be to have seed production occurring throughout the areas where it is needed. As seed of Australian plants is already a valuable commodity, seed orchards could be a very viable business venture.

If seed is to be grown for use in revegetation every care must be taken to ensure the quality of the seed used to establish the stand. The future viability of areas revegetated with the seed so obtained will be governed by the integrity of the original seed.

Information on collecting seed of understorey species is available from Greening Western Australia."

7.1.1.3 Establishing New Vegetation

Establishing new vegetation is a vastly different concept to planting trees and/or shrubs in rows as a means of overcoming developing salinity or water-logging problems. It is generally quite easy to grow a row or coppice of trees or shrubs for areas of limited areal extent with short-term goals in mind. However, establishing new vegetation engenders with it the aim of providing a permanent or semi-permanent vegetation cover to an area and by its very nature vegetation, whether it be new or existing vegetation, must be of a sufficiently large area to enable it to self-perpetuate and sufficiently complex in terms of species composition so that individual entities within the vegetation support other entities by a mutual interdependence i.e. as an ecosystem. Establishing new vegetation assumes the presence of other wildlife such as insects and birds and other fauna in a progressive manner.
There are obvious problems that need to be considered when starting out with such a concept. Theoretically an area proposed for the establishment of new vegetation will begin as a bare patch perhaps as an area set aside initially under an alternating cycle of pasture/stocking and cropping. In the best case situation it will be a mixture of native and introduced grasses and in the worst case infested with such things as cape weed, dock and thistle; these are relatively hard to get rid of under normal circumstances and at the very minimum a spray with round-up generally precedes all attempts at planting or trees and/or shrubs or vegetation. If the vegetation is planted in rows it will be far more easy to deal with the inevitable cover of weeds and grasses that develop from seeds already in the soil. But, if one wants to be completely weed-free to establish new vegetation in a mosaic pattern more consistent with a natural ecosystem, then a reasonable amount of additional pre-treatment is going to be required. In essence the area intended for vegetation establishment must be isolated from surrounding crop/pasture enterprises, and must be cleared of crop residues, introduced pasture species and weeds in a similar manner to that in which it was cleared of natural vegetation to make way for agriculture. This poses certain risks as it will mean that the ground will have to remain bare for an extended period, so drought conditions may result in soil loss.

The most important thing to attempt to do is to try and associate different soil types with the cover species for the particular soil concerned. Natural systems preserved in nature reserves will be a guide, but the changes brought to the landscape to facilitate cropping/stocking, by the addition of fertilisers, breakdown of soil structure and modifications to surface hydrology will have a profound influence on what type(s) of vegetation communities can be established.

7.1.2 Role of the Catchment Group

Catchments groups ideally are made up of farm representatives from each farm (management unit) within a particular catchment. This allows for a coordinated management approach as each farm is managed according to its abilities within the context of the catchment. Catchment groups are able to plan general salinity and waterlogging mitigation measures such that activities that take place in one part of the catchment do not adversely affect farms in other parts of the catchment. Ideally catchment groups should work together so that management procedures that operate in one are compatible with those occurring in others.

7.1.3 Role of the Land Conservation District Committee

"The role of the Land Conservation District Committee in rural land use planning" (Oma, 1989), is to provide local (farm level) expertise in a (State Planning Commission) coordinated approach to sustaining rural communities, by:

(1) recognising land degradation in a district, e.g. wind erosion, waterlogging, flooding, salinity, degradation of remnant vegetation, rising groundwater levels, farm fragmentation, and to a lesser extent non-wetting soils, which are a natural phenomenon.

(2) determining appropriate remedial strategies, i.e. protection of remnant vegetation, reforestation, alternative land uses, land use
controls, subdivision controls, soil conservation earthworks, improved farming practices.

(3) promote and support these strategies by recommending action to local authorities, groups or individuals.

LCDC's work along with the Department of Agriculture, other Government Agencies, Community groups and the State Planning Commission to provide Local Rural Strategies for Shire (local authority) use as a policy documents for such things as: planning changes in rural land use, promotion of desirable activities, planning for water and power supplies and roads, management of conflicting and competing land uses, assistance in the coordination of land management activities.

7.2 Role of the Government

7.2.1 Advice on Management of Bush Remnants

Advice on management of bush remnants can be obtained from CALM, WADA and nurseries. Management becomes simpler if the remnant is fenced and it is useful to have a buffer strip around the vegetation so that entry of weed seeds and crop spray drift is prevented. Other management options depend on the size of the remnant, the nature of the soil and plant cover, slope and topography, to name a few aspects which need to be considered.

7.2.2 The Remnant Vegetation Protection Scheme

This scheme is covered by the WA Govt Soil and Land Conservation Act. Remnant vegetation application forms (questionaires) are applicable to 4 regions viz. 1. Central Wheatbelt, 2. Northern Sandplains, 3. Southern Sandplains (the questionnaire for 2. and 3. is the same, although differently titled), and 4. Forest. Areas covered by the scheme tend to be relatively small in size due to the cost involved in fencing on a 50:50 basis. The RVPS provides the materials and the farmer the labour.

GIS RVPS plots consist of a circled cross with the centre of the cross indicating the location of the piece of remnant bush, plotted from cadastral maps and based on the information supplied in the RVPS application form. In some areas a circled cross is present but no remnant vegetation is mapped, which reflects either the limitations of the mapped remnant data - some of which is based on 1985 photography or the minimum size of mapped areas for capture data e.g. the vegetation may be mapped at greater than 5 Ha while the remnant vegetation area is only 4.6 Ha (C. Hawkins, pers. comm., 2.8.91).

RVPS responses (based on the questionnaire type pro-forma) provide a very basic description of bush remnants nominated for the RVPS, and no additional vegetation or other survey is completed by Land Conservation District officers. The officer confirms the information provided and on the basis of visual (subjective) assessment makes a recommendation as to the fate of the particular bush remnant in the context of RVPS guidelines. Rejected bush remnants may contain rare flora, for example, but unless these are known about they will not be taken into consideration in determining the success or failure of an application. Considering the relatively small number of successful applications in a year
(about 100), a more efficient system would be to have a group of specialist officers assess each remnant that is recommended for the scheme. In this way abuses of the scheme would be avoided and limited funds not wasted; I was informed by one farmer during the survey that the RVPS had been used by a farmer to settle a property border dispute that had been going on for some years, because of the surveying necessary to place the RVPS bush remnant on the land title - apparently the bush that remained in the remnant was of little value, but without adequate scrutiny the application had been successful.

The Remnant Vegetation Protection Scheme has been backed by both the Western Australian Farmers Federation and Australia Conservation through recognition of benefits in enhanced animal survival, crop productivity and pasture protection, while at the same time protecting important native vegetation remnants (Land Conservation District Newsletter, 1991).

7.3 Affects of Herbivores on Remnant Vegetation

Herbivores can have a marked effect on remnant vegetation, whether they be native animals with numbers beyond the normal carrying capacity of the vegetation, introduced species that are utilised by man (sheep, cattle, goats, pigs) or species that have been introduced and have gotten out of control (rabbits). Direct effects of herbivore introduction are foraging and trampling of native plant species. Goats, for example, are capable of eating most types of bush even those with spines and do so with no observed ill effects (Mollemans unpubl. data). General foraging of the vegetation within reach results when paddock feed becomes very low (in cases where remnant bush is not fenced) or when the remnant bush is the only feed available. The latter case may occur where a fenced remnant is used as a shelter paddock during a cold snap after shearing. Otherwise bush may be trampled and opportunistic feeding occur when unfenced remnant bush occurs between the preferred foraging area of a paddock and a watering point.

Indirect effects of herbivore introduction, include the destruction of poisonous plants by farmers to protect their livelihood (stock), and in so doing some species have been pushed to the edge of extinction e.g. Gastrolobium callistachys, a species that frequented the edge of granite rocks and is now quite rare. A number of wheatbelt species have toxic effects on introduced fauna, but do not affect the native species which have built up immunity through long exposure (e.g. Gardner & Bennetts 1956).

7.3.1 Rabbits

The European rabbit (Oryctolagus cuniculus) has a significant effect on remnant bush. Rabbits do not readily colonise heavily timbered country (APB 1982), but often this bush is the only place where they can find sanctuary, while adjacent cleared paddocks are vigilantly patrolled by farmers. Generally rabbits compete with animals of a similar body weight for food, but during drought they frequently strip bark from trees and shrubs leading to soil erosion when the stabilising plant cover is destroyed (APB 1982).

Rabbits grazing differs from sheep grazing because rabbits tend to forage on seedlings and older plants alike, while sheep looking for a more substantial feed tend to concentrate on adult plants (Lange
et al., 1992). For this reason recruitment of native species does not occur or is severely limited in areas of high rabbit numbers (e.g. Lange and Graham, 1983).

Obvious effects of rabbit movement through and within remnants is the introduction of weeds by seed expulsion in their dung. Burrowing activities may lead to plant deaths, and during plagues extensive damage to native vegetation communities may result from wholesale defoliation of the vegetation.

Attempts at eradication of rabbits in remnants by physical destruction of warrens have led to significant unintended damage, and often the effort is wasted as the rabbits then develop a new habitation nearby. Continued destruction of warrens to control rabbit numbers will in the long term have a significant effect on the vegetation. The Agriculture Protection Board considers that warren ripping should be discouraged in native bush (Long et al., 1990). A better method needs to be used, one that destroys the rabbits by non-physical means.

One proposed method, the control of rabbits by aerial dropping of baited oats (Long et al. 1990), has sound benefits in maintaining a check on rabbit numbers while at the same time preserving the remnant vegetation intact. However, this method is only applicable to more extensive areas due to the prohibitive cost involved. Other methods include fumigation of warrens, using carbon monoxide blown into warrens or fumigant capsules laid in burrow entrances. In addition, oats baits can be sprayed into areas using a jet of air but this has limitations as the throw distance is only in the order of 20 metres.

The oats are impregnated with 1080 poison, the same type of poison as occurs naturally in native wheatbelt poisonous plants such as Box poison and York Road poison. This poison (1080) has the benefit in parts of WA of having little effect on the native fauna, which has built up an immunity to the local poisonous species through long exposure; pindone is an alternate poison which can be used with rabbit baits, but it has an significant disadvantage because it also kills many native wildlife species (Long et al., 1990).

Species occurring in areas where 1080-poison carrying plants do not occur naturally are likely to be susceptible. Also ground dwelling species such as native rodents and reptiles may be susceptible, as baits will be dropped into a different zone (ground level) to that at which the edible parts of poison plants tend to occur (20+ cm above the ground); ground level species may have rarely encountered 1080 so probably haven’t developed the same immunity as other wildlife. Active suppression of poisonous species by local farmers since settlement, may also have influenced the ability of native fauna populations in some areas to resist 1080. This suggests a need to determine the susceptibility of local wildlife in areas where extensive baiting is planned.

Baiting will go a long way towards assisting remnant vegetation management by providing a very effective means of non-destructive (to the vegetation) rabbit control, at least in those parts of the wheatbelt where the native species are not susceptible to 1080. Rabbit numbers (as is the case with other fauna) may also be kept in check by foxes in some remnants. However, baiting of foxes
(Vulpes vulpes) which is becoming more widespread, in a concerted effort to reduce the loss of native fauna species may have a similar effect on rabbit numbers.

Observations during 1990 at Split Rocks (north of Mt Holland on the Southern Cross 1:250 000 map area, Mollemans unpubl. data) suggest that explosions in rabbit numbers can occur when 1080-poisoned fox baits are put down without an associated control measure on the rabbits. In the Split Rocks example significant loss of vegetation occurred, and a similar effect is possible in bush remnants in the wheatbelt.

7.3.2 Kangaroos

Kangaroos, because of their mobility, appear to be able to survive where other smaller native animals could not. Foxes are less of a problem to kangaroo populations than, for example, they are to numbats populations. And while Numbats fear the open spaces between bush remnants because of the foraging activities of larger birds such as the Wedge-tailed Eagle, kangaroos are not so constrained and under normal circumstances, the only true danger of which kangaroos has been and still is man. But man has also been a benefactor! With additional watering points introduced into paddocks for stock, a ready supply of feed in the form of cropped pastures and good refuge areas provided by tracts of remnant bush, kangaroos tend to thrive and sustain their populations. If there are a relatively small number of bush remnants in a particular area, however, then the carrying capacity for kangaroos provided by farm paddocks may be significantly greater than refuge areas available in bush remnants. Under these circumstances kangaroos apply to bush remnants a pressure from overgrazing and an added pressure from the site modifications they tend to inflict on bush when settled down to rest. If there are a large number of kangaroos significant destruction occurs, and if left unchecked permanent damage may result. In one bush remnant surveyed during this project ground herbs were rare, as kangaroos had so affected the bush by sustained grazing pressure that normal ground herbs found in other remnants were rare. Flowers were being consumed as soon as they appeared and so many of the ground species were not able to set seed. It can be seen that this does not have occur for too many years before species disappear completely from particular areas.

7.3.3 Kangaroos

It is not known at this stage whether the Emu is of any significance as a threat to remnant vegetation in the study area. Emus tend to be a problem on farms adjacent to large areas of uncleared bush (APB 1983a), so are more likely to be important in remnant bushland management in the eastern parts of KULIN and KONDININ.

7.3.4 Sheep, Goat & Cattle Grazing

Sheep, cattle, goats and pigs are ungulates which means that they all have cloven (or split) hooves. Apart from normal foraging, the combined effects of the trampling activities of a mob of ungulates results in the breakdown of soil structure, surface hydrology, and ground layer floristic cover; permanent disturbance of a remnant may be the result as the bush is unaccustomed to sustaining such
pressures for extended periods. Early signs of such disturbance are a reduced cover of low plants and no evident seedlings. In the longer term, the diversity of the bush declines due to non-replacement of species lost through normal senescence, fire or destruction by natural processes (lightning strike, insect attack) in places where unchecked foraging pressure continues.

7.3.5 Locusts and Grasshoppers

The small plague grasshopper (*Austroicetes cruciata*) and the Australian plague locust (*Chortoicetes terminifera*) are two very destructive, declared vermin of Western Australia (APB 1983b). The former occupies southern WA mostly in the wheatbelt areas with 250-340 mm of annual rainfall, and avoids timber and scrub vegetation (*ibid.*), so would not be a problem in remnant vegetation management. The Australian plague locust, however, generally occurs in small numbers under dry conditions, but successive wet seasons causes a population explosion after which they swarm to provide for an appetite of their own body weight of green food per day; swarms of locusts have reached 50 000 tonnes in weight (APB 1983b). This latter species is the one that affects remnant vegetation, and planted trees and shrubs in areas subject to revegetation.

Many farmers visited during the 1991 field work, reported significant losses of planted natives from the 1990-91 plague. In remnant vegetation locusts tend to attack the soft parts such as flowers, and may totally prevent seed production in the worst affected areas. It is known that near Cunderdin the only known population of a rare Fan-flower was devastated during the 1990-91 plague, as the population of 500 plants in an area of 3 x 5 m was struck during flowering. There is no confirmation that this population survived. Other species which may cause damage to gardens or plantations are the wingless grasshopper, yellow-winged locust, spur throated locust and long-horned grasshoppers (APB 1983b).
8.0 Acknowledgements

The following people assisted with this project and this assistance is acknowledged with thanks. Project Officers Steve Garrad, Justin Hardy (both Katanning), Ned Crossley and Mike Elliott (both Narrogin) and Simon Williamson (Lake Grace) facilitated attendance at LCDC meetings and associated introductions to farmer groups. Ken Wallace and Greg Lehnmann of CALM. Doug Sawkins OIC WADA Narrogin. Ian Mailing OIC, Steve Tunbridge and Justin Hardy of WADA Katanning. The following Remnant Vegetation Survey Sheet respondents are acknowledged with thanks i.e. from BROOMEHILL: T.A. Barritt, K.M. Bignell & Co., R. Dutson (x2), Steve Fleay (x2), A.B. Fletcher, P.A. Heron, Don Rae (x2), R. Schleuten, K.P. & B.E. Taylor, R. & E.J. Webster, A. Woithe; CORRIGIN: J.E. George & Co., K.W. Ling, J.R. Sewoods; DUMBLEYUNG: T.B. & S.R. Angwin & Sons, O.D. & E. Dare; KULIN: J.R. Lloyd & Son (for I.G. Halbert & Co.), T.G. Goedhart; NARROGIN: C.M. & E.B. Hall, W.R. & M.T. Short & Son, W.G. & J.E. Warren (x3); TAMBELUP: J.J. Tilbury; WAGIN: David Walker; WICKEPIN: P.O. & R.J. Spark & Co. and WOODANILLING: Neil Horne. Staff of the GIS group Perth Office particularly Greg Mlodowski for providing the information regarding soil salinity in Western Australia. Alan MacDonagh provided the computer expertise required to produce all the 1:50 000 remnant vegetation basemaps from the GIS database. My wife Nellie provided untiring support as voluntary field assistant throughout the course of the project.
9.0 **References**


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