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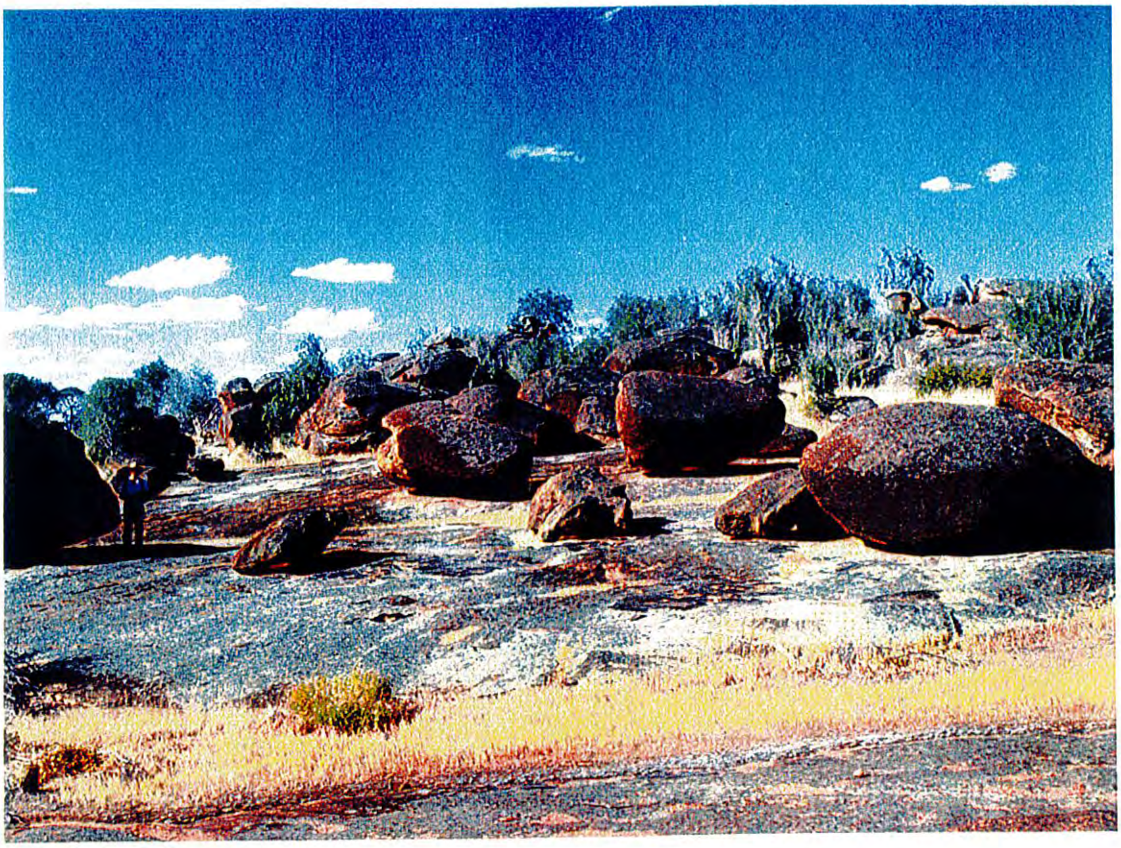
Conservation Values of Small Reserves in the Central Wheatbelt of Western Australia

A Framework for Evaluating the Conservation Values of Small Reserves



Prepared for the Western Australian

Department of Conservation and Land Management

by

Rod Safstrom

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CONSERVATION VALUES OF SMALL RESERVES IN THE CENTRAL WHEATBELT OF WESTERN AUSTRALIA

A FRAMEWORK FOR EVALUATING THE CONSERVATION VALUES OF SMALL RESERVES

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CONTENTS

SUMMARY

The study determined that while there were a number of general principles there were no clear cut criteria for selecting reserves for nature conservation values. The criteria were separated into two types: the intrinsic value or the current value at the time of assessment and factors which affect viability, both natural processes and human induced change. A summary of intrinsic nature conservation values and how they were used in reserve evaluation appears on page 21. A summary of non human, biological and physical influences which affect viability appears on page 26. Reserves with compatible uses and benefits such as shade and shelter, soil stabilisation, water catchment and high landscape value are identified.

The study investigated current methods for ranking reserves for nature conservation values. A summary of the methods and their applicability in the central wheatbelt appears on page 40. The study found that current methods were generally not useful for a subset of reserves or where there were a number of criteria to be considered.

A graphical approach to multi-criteria analysis provided a tool for understanding the range of values for the reserves studied and a data base was used to select reserves which met certain criteria. This methodology, while not providing one clear answer, does allow the input of different decision makers in both selecting the criteria to be considered and in selecting the values within each criteria. The importance of reviewing the criteria and reconsidering the field reports during the decision making process was stressed.

Nine reserves were recommended as high priority for vesting in the National Parks and Nature Conservation Authority (NPNCA). Four other reserves were also recommended either by themselves or with adjacent reserves for consideration as NPNCA reserves. Five other reserves with rare species but lower general nature conservation values should be considered for vesting in NPNCA. The remaining twenty reserves were recommended for consideration for broader land uses including vesting in shires, uses for the establishment of seed orchards, firewood plots etc. The recommendations together with a brief summary of each reserve appears on page 49.

It is felt that the methodology is useful for larger numbers of reserves and is applicable to other areas particularly where a subset of reserves is being considered.

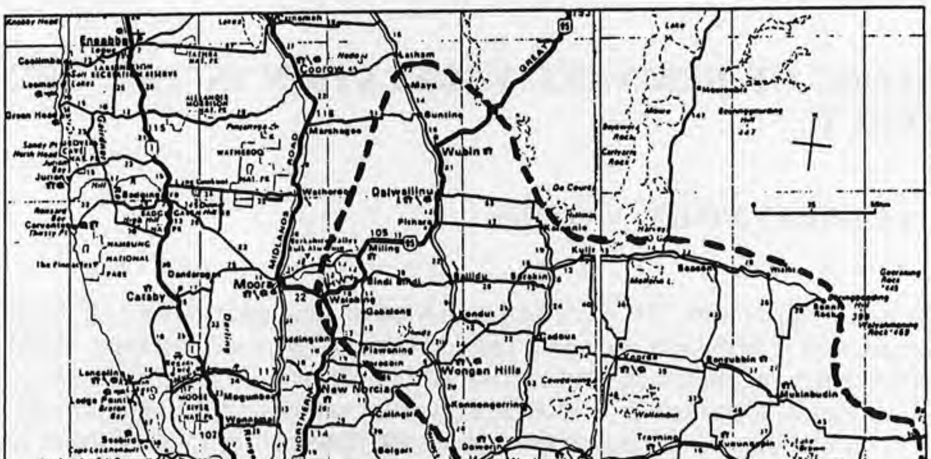

Figure 1. The part of the central wheatbelt of Western Australia covered in this study.

INTRODUCTION

The wheatbelt of Western Australia has been extensively cleared leaving a fragmented landscape with scattered and often isolated areas of the original vegetation surrounded by farming land. Nature reserves occupy less than 7% of the region, the average size being 114 hectares and vegetation types favoured by agriculture are poorly represented (Government of Western Australia 1992). This together with the salinisation of most freshwater streams and lakes has had a significant impact on the regions biota (Government of Western Australia 1992). Additionally the remnants, particularly the smaller ones, are often disturbed and degraded. Soil degradation, including salinity, are serious problems in the surrounding agricultural areas and these issues also affect remnant bushland.

The values of remnants of the original vegetation for the maintenance of biota and diversity are well recognised by the work of Kitchener *et al.* (1980a, 1980b, 1982), Saunders *et al.* (1991, 1993) and Saunders (1989, 1995) and have not been documented in this report. The social and economic benefits of remnant bushland for farmland are less recognised but have been reviewed by Wallace (1994); and require further research. Despite work on remnant values and research aimed at ranking remnants and selecting reserves (see pages 34-40), there are no satisfactory guidelines for managers wanting to determine the relative value of remnants.

This project aimed to:

1. Develop and evaluate a method for assessing the nature conservation values of remnants of native vegetation in the context of other land management and social values. The study focused on part of the central wheatbelt of Western Australia (Figure 1) but it is intended that the results, with some adaptation, will be applicable in other areas.

2. Apply the method to a sample of remnants (currently subject to conflicting land use demands) in the central wheatbelt of WA to test the methodology. This study was restricted to a subset of 38 reserves in part of the central wheatbelt that have the purpose of water and are controlled by the W.A. Water Authority.

The study does not include a detailed review of the literature as there were only sufficient resources to canvass the options and to explore an appropriate methodology.

THE VALUES OF REMNANT VEGETATION IN THE CENTRAL WHEATBELT

NATURE CONSERVATION VALUES

Prior to clearing for agriculture, the wheatbelt consisted of a complex mosaic of vegetation types. The vegetation distribution is closely linked with landform and soil type. Within a catenary sequence the vegetation can range from shrublands and scrub on deep sands and laterites of the uplands, to mallee and woodland types on valley slopes and adjoining salt lake systems in the valley bottoms. Little is known about the dynamics of most of these vegetation types (Hobbs, Saunders, Lobry de Bruyn and Main 1993).

The central wheatbelt lies within the transitional rainfall zone identified by Hopper (1979) as an area having an angiosperm flora remarkably rich in endemic species. This richness is accompanied by a rich fauna. For example, the mammal, reptile and amphibian fauna of the wheatbelt is much richer than the forested areas and their adjoining coastal strips to the west and south (Wallace unpublished data). This is despite the extensive clearing of land for agriculture that has occurred in the wheatbelt.

Therefore, the nature conservation values of the wheatbelt are very high, despite the fragmentation and loss of habitat that has occurred with agricultural development. The remaining natural vegetation generally occurs as small patches that greatly under represent some major vegetation types. Furthermore, many remnants are severely degraded and species are still being lost (Saunders, Hobbs and Arnold 1993).

Community perceptions of the nature conservation values of the wheatbelt biota have changed, and will continue to change. The history of agricultural development in the wheatbelt is one of pioneering and conquering the land. This led to a view of the bush as an 'enemy', wild lands that needed to be tamed. Slowly these values have changed (Main 1993) to ones that are more positive to the remaining native vegetation. Undoubtedly attitudes will continue to change.

Kirby (1993) recognised in a British context that the value of woods for nature conservation differ depending on the group of people concerned and their objectives for nature conservation. He suggests as a starting point the general objective set by the Nature Conservation Council in 1991 that "wildlife communities characteristic of the various regions.....should remain viable and distributed across their traditional ranges". This general objective is adopted for this project, however, it is recognised that its usefulness will depend to some degree on its community acceptance, and that the cultural context for nature conservation will change.

OTHER VALUES

While this project was aimed primarily at identifying the nature conservation values of remnant vegetation, these values must be evaluated in the context of other remnant values. Some of these values, such as mineral resources, will compete with nature conservation values, others, such as soil conservation, will be compatible. Wallace (1994) has reviewed the values of remnant vegetation from the viewpoint of the farming community. The importance of considering the socio-cultural context of remnants when making decisions concerning their future use or uses is stressed.

Therefore, in arriving at recommendations concerning the future use of reserves, this study also reports on their values for adjacent farmers and local communities. These values include land conservation, shade and shelter, direct production values, water harvesting, effects on hydrology, recreation and landscape values.

This approach also recognises that remnant bushland will not be effectively managed for nature conservation and other uses unless all values are considered together, and a conscious decision is made as to management priorities. Data has been collected and analysed in a way that encourages integration of management goals for a range of land uses. This also reflects the research focus on reintegrating fragmented landscapes (Hobbs, Saunders, Arnold 1993), and is consistent with increasing attempts to integrate land use and management.

ASSESSING REMNANT VALUES - CONSTRAINTS

In selecting assessment criteria and methods, the following constraints have been recognised:

Operational personnel must be able to readily comprehend and implement assessment criteria and methods. There is no point in having an effective method that is too difficult or costly to use.

Criteria should, wherever practicable, use continuous, descriptive parameters rather than 'grouped' data. (For example, area and distance classes have been measured in absolute terms, rather than categorised into a limited number of groups). This enables data collected during survey to be re-interpreted in the light of new information.

No matter how subjectively based, the science behind the selection of all criteria must be clearly stated. This enables people to clearly understand methods and the logic behind them. It also enables ideas and criteria to be more easily reviewed and up-dated in the light of new research.

People will ascribe different priorities and weights to each criterion. Evaluation methods should allow these choices and not cloud important issues or conceal value judgements (Smith and Theberge 1987). Given that this study found no effective mechanism for integrating criteria it was decided that evaluation methods must allow for criteria to be independently and variously ranked and then integrated only if required to ascribe a ranking to specific reserves.

The criteria used in the study are described below. Reasons are given for the selection of each criterion, and criteria that were considered, but rejected, are also described.

CRITERIA USED TO ASSESS NATURE CONSERVATION VALUES

During discussions of criteria for nature conservation values, it became apparent that two types of measures were required. Firstly, a value for each remnant at the time of assessment was essential. This provides a baseline statement of current value, and leads to a range of clear criteria, such as the presence of rare species. This value is termed, in this study, 'intrinsic value'.

Secondly, because intrinsic values may change through time as processes such as species extinction, salinisation, predation by exotic species, commercial use and so on occur, an evaluation of longer term viability is required. Viability will be affected by the future actions of humans, for better, for worse, or through neglect. In this study, these different aspects of viability are separated into 'biophysical viability' (under which the impacts of future human actions are not considered), and social and resource issues where both competing and compatible uses are considered.

Within this section intrinsic values and biophysical viability are considered. Thus a description of current nature conservation values and expected viability with neutral impacts by humans, are described.

INTRINSIC VALUES

Threatened flora and flora of special interest

Some species that were initially widespread have become threatened due to habitat loss and other factors. Other species were probably rare prior to land clearing for agriculture, and have become even rarer with continued loss of habitat. Species at the edge of their ranges and disjunct populations also occur - these are species of special interest. Remnant vegetation containing rare species, or species of special interest, should have a very high priority for protection.

In this study species are included in the Declared Rare Flora (DRF) category according to their State-wide status as recommended by the Endangered Flora Conservation Committee under the Schedule of Endangered Flora under section 23(f) of the Wildlife Conservation Act and approved by the Minister for the Environment. The study also used the Department of Conservation and Land Management's (CALM) Priority Flora list for Western Australia as recommended by CALM's Wildlife Branch. The categories are as follows:

Priority one - poorly known taxa. Taxa which are known from one or a few (generally less than 5) populations which are under threat.

Priority two - poorly known taxa. Taxa which are known from one or a few (generally less than 5) populations, at least some of which are not believed to be under immediate threat.

Priority three - poorly known taxa. Taxa which are known from several populations, at least some of which are not believed to be under immediate threat (ie not currently endangered).

Priority four - rare taxa. Taxa which are considered to have been adequately surveyed and which, whilst being rare (in Australia), are not currently threatened by any identifiable factors. These taxa require monitoring every 5-10 years.

This study adopted the Declared Rare Flora and Priority Flora lists as used by CALM to identify rare and special occurrences of species.

Threatened communities

Within Western Australia, work by CALM and the Australian Nature Conservation Agency (ANCA) is currently aimed at defining and ranking threatened communities. As yet there is no information from this work that may be used in this study. Therefore, for this study it was decided to use the priorities defined in the Remnant Vegetation Protection Scheme. An explanation of these categories and their ranking (see below) and use in the Scheme is given in Wallace (1992). The following summary is largely extracted from that paper.

Vegetation types described as 'Class 1' below are those that are generally of high nature conservation value, and those of 'Class 4' generally of least value. These categories were developed on the subjective judgement of a number of people including botanists. For the most part these rankings reflect how well each habitat is conserved in nature reserves and other conservation areas, but other factors may be involved. For example, granite outcrops are well represented in nature reserves. However, the biota of granite outcrops is so varied and specialised that they are accorded a higher value for nature conservation than might be expected.

Also, it should be noted that some vegetation types given a low priority under the Scheme, such as lateritic heaths, are of very high nature conservation value but they are comparatively well conserved compared with other habitats. Thus rankings reflect how important it is to better protect particular habitats for nature conservation, rather than some absolute value for nature conservation.

When the list of threatened communities for Western Australia has been completed, it will be substituted for the groupings shown below.

CLASS 1 VERY HIGH PRIORITY:
Woodlands or forests, other than those listed below, such as banksia or salmon gum woodland;
Shrublands on sandy soils;
Freshwater wetlands with fringing vegetation greater than 20 metres wide;
Brackish wetlands with fringing vegetation, undegraded vegetation more than 100 metres wide;
Vegetation on greenstone or quartzite outcrops.

CLASS 2 HIGH PRIORITY:
Woodlands of wandoo, powder bark wandoo, silver mallet or blue mallet;
Mallee on fertile soils such as clay or loam;
Shrublands on gravel soils excluding wodjil, tamma or broombush;
Vegetation on granite outcrops.

CLASS 3 MEDIUM PRIORITY:
Woodlands or forests of jarrah, marri, brown mallet and sheoak;
Mallee on poor soils such as sand or gravel;
Shrublands of wodjil, tamma or broombush.

CLASS 4 LOW PRIORITY:
Wetlands consisting of samphire flats;
Wetlands of unvegetated salt pans;
Wetlands consisting of creek lines with fewer than five species of native plants.

This study used the vegetation community priorities defined in the Remnant Vegetation Protection Scheme to prioritise vegetation associations.

Figure 2 indicates the number of reserves with: Class 1 vegetation (may also contain Class 2 and Class 3 vegetation); Class 2 vegetation (no Class 1 and may contain Class 3 vegetation); and Class 3 vegetation types only. It has been plotted with reserve area for interest, showing that smaller reserves are less likely to contain Class 1 vegetation.

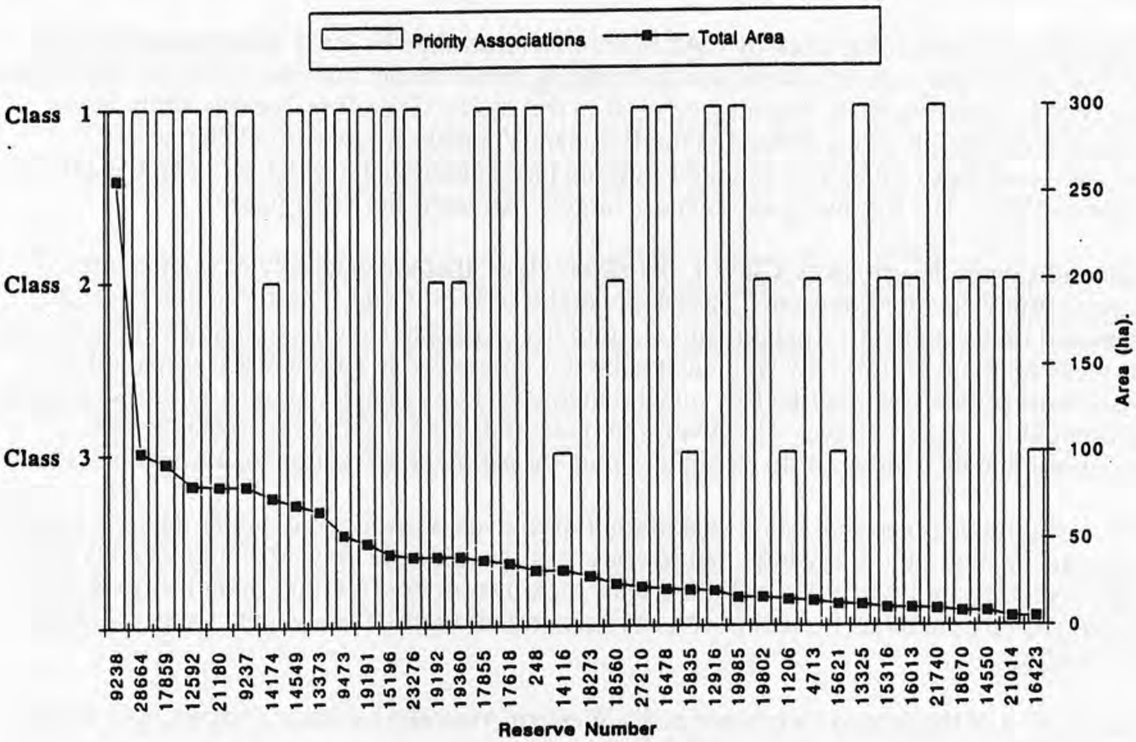

Figure 2. Reserve area / priority vegetation type relationships

Species richness

Comparative measures of species richness are difficult to achieve unless long term exhaustive assessments are conducted or reserves are assessed on an area basis with the same time and search techniques being employed for each one. Neither of these ideals could be achieved in this study.

In practice each reserve was stratified into vegetation formations and associations using aerial photos (where available) and each vegetation association was described. In addition a species list was produced for each reserve. Due to limited time (one visit, average one half day per reserve, average reserve size 41 ha) many ephemeral species were missed and not all areas could be searched. The vegetation lists are therefore far from complete and have been derived with different levels of effort on an area basis. They provide only an indication of species richness.

Furthermore species richness can be a misleading criterion; some sites may be species rich but not as high a priority for protection as species poor associations such as some woodlands that have become rare R. Pressey (pers.comm.).

Species richness has not been used for comparative ranking of wheatbelt reserves.

Biotic diversity - plants

In order to communicate a "picture" of each reserve, it is desirable to provide the most detailed description of the types of vegetation present. A species list provides little idea of the plant communities present. Vegetation formations - for example, woodland or mallee or shrubland (structural descriptors of vegetation) - provide a good general picture of vegetation. However, they may contain different suites of species. Vegetation associations are units of vegetation dominated by one or more species having the life-form characterising the formation to which the association belongs (Muir 1977). In this study vegetation associations greater than a half hectare were mapped and species lists obtained for each vegetation association. Time constraints prevented quadrat data being obtained.

Brooker and Margules (in press) have developed a new procedure that incorporates a measure of alpha diversity (or within habitat diversity) of plant species as well as beta diversity to prioritise remnant patches with respect to plant diversity. This procedure requires vegetation modelling from quadrat data which was not available from this study. Due to resource constraints no attempt was made to calculate formation diversity and patch diversity indices as described by Cale 1994, and plant life form and density classes were not assessed.

Figure 3 shows the number of associations and reserve area for each reserve. There appears to be a general trend of reducing number of plant associations with reducing area, but there are marked divergences as well. Many reserves are quite diverse having four or more plant associations.

The number of naturally occurring plant associations of area greater than a half hectare has been used both to provide a "picture" of the vegetation and a measure of biotic diversity.

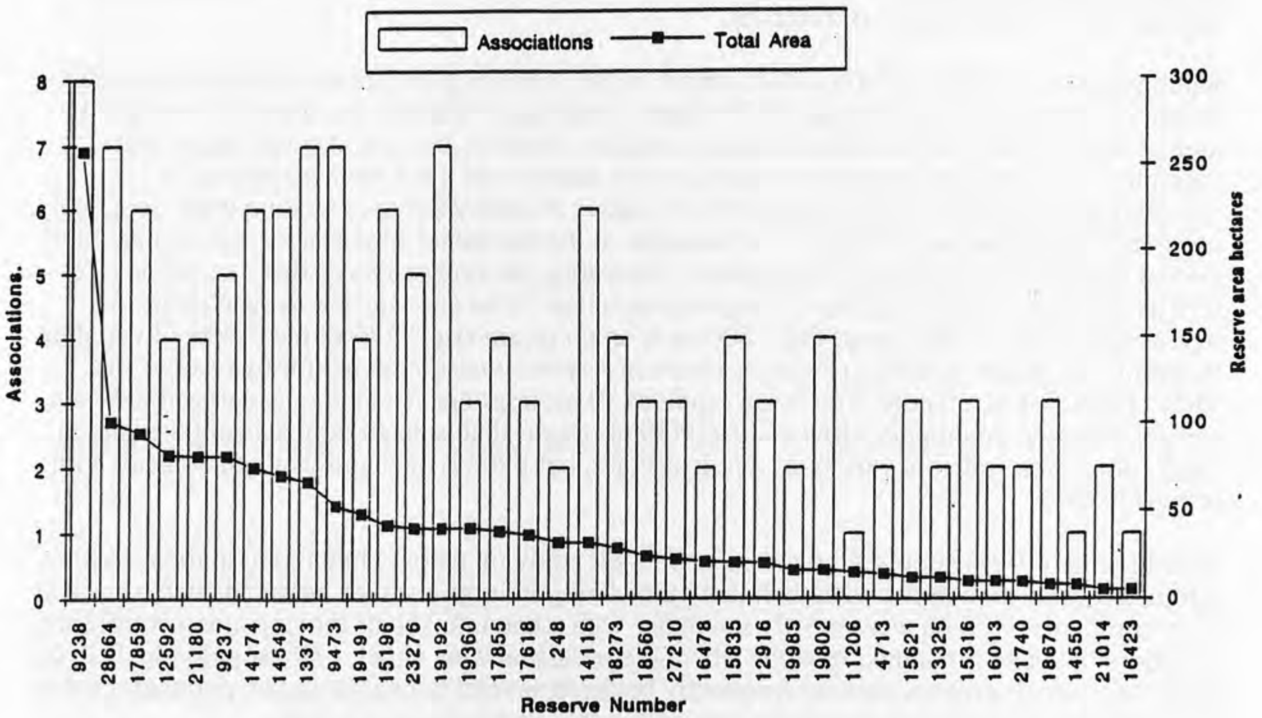

Figure 3. Reserve area / number of vegetation associations relationships

Rare fauna

The presence of rare fauna is difficult to determine without comprehensive surveys. There was only one sighting of rare fauna during the study - a mallee fowl *(Leipoa ocellata).*

Reserves with rare fauna as gazetted under the Wildlife Conservation Act would be a high priority for protection.

Reserve area

Reserve area is related to criteria such as diversity and species richness. However, remnant size can also directly affect some fauna. A minimum adequate area for retaining desired habitat characteristics will vary depending on the purpose of the reserve (Main 1987). A reserve set aside for an assemblage of invertebrate species need not be as large as one required to retain a large mammal (Main and Yadav 1971 reported in Main 1987). Area must, in general, also affect viability. While viability is discussed in a separate section, much of the discussion here is relevant to that section.

Reserve area has been used as a measure of biotic diversity for plants and animals. Saunders *et al* (1991a) reports that larger remnants usually contain greater habitat diversity than smaller ones but a collection of smaller reserves may cover a greater array of habitats than a single large one. Kitchener (1980b) reports that multiple regression analysis on log transformed data showed that 72% of the observed variation in mammal species richness between reserves was accounted for by reserve size. The influences of physical and biogeographic changes are modified by the size, shape, and position in the landscape of the individual remnants, with larger remnants being less affected by the fragmentation process (Saunders *et al.* 1991a).

Nevertheless, reserve area may be a guide in some cases, particularly with respect to particular groups. In the following discussion, faunal aspects only are considered. It is assumed that longer life spans and other life history characteristics make flora less vulnerable in the short term to areal characteristics of reserves.

Kitchener *et al.* (1980a, 1980b, 1982) report on the following species area relationships. Bird species richness in 22 reserves in the Western Australian wheatbelt was shown to be related to area of reserve and certain reserve habitat variables. Reserve area was the most important variable except in some passerine groups, where numbers of plant species, vegetation associations, and plant life form and density classes in each vegetative stratum were, separately, more important than area. 82% of the variation in the number of bird species was explained by area of reserve and number of plant species, indicating the importance of floristics to the total bird assemblage within reserves. Reserves as small as 30 ha are valuable as sanctuaries for lizards although it is suggested that 1500 ha is an optimum size. 72 % of the observed variation in mammal species (non bats) richness between reserves was accounted for by reserve size. They concluded that nature reserves as small as 30 hectares are valuable sanctuaries for certain species of native mammals. How and Dell (1994) report that isolated remnants of bushland in inner urban areas retain a variety of reptile species, but there is no significant relationship with remnant size.

Arnold *et al.* (1993) supported these ideas in their study on euros. They found in their 1680 sq. kilometre study area in the wheatbelt that euros living in large reserves were sedentary, those in large remnants >100 ha were mostly sedentary with some individuals moving along connecting corridors between remnants. In areas where the remnants were small, <30 ha, individuals lived alone or in small groups, moving frequently between several remnants. In two populations with low densities of euros their long term survival in these areas is questionable.

Main (1987) has reported that trapdoor spiders are admirably fitted to persist in small isolated areas because of their low dispersion powers, long life cycle and sedentary life style. As predators the occurrence of trap door spiders also indicates the persistence of other terrestrial invertebrates. She suggests (for *Anidiops villosus)* that a surrounding (appropriately managed) area of at least 25 ha (with additional sub populations) and with a diversity of micro habitats which support prey species is required to buffer and augment the micro habitat of the spiders.

Populations of trapdoor spiders in a reserve may not however be an indicator of a stable population as they may represent a relic population which is not self replacing.

Cale (1994) considered that area and habitat diversity must be considered together when attempting to maximise their effect on species richness. In this study both area and diversity are assessed independently so that the data can be combined or used independently depending on the purpose of the analysis.

So far we have considered minimum areas required for habitats for particular fauna. Small reserves can play other valuable roles even if they do not by themselves support self replacing populations. Main (1987) reported that a minimum adequate area for retaining desired habitat characteristics will vary depending on the purpose of the reserve. A reserve set aside as a "stepping stone" for nomadic birds, retain a vegetation assemblage, a particular plant species, a suite of reptiles, or an assemblage of invertebrate species need not be as large as one required to retain a large mammal.

Cale (1994) found that, for birds, a number of interconnected small remnants can be of high conservation value if the concept of metapopulations appropriately describes the population dynamics of species. These findings are supported by the work of A Sanders (pers. comm.) who has suggested that small remnants, less than 50 hectares, within close proximity, may support a metapopulation.

However, the importance of connectivity and proximity must be stressed. Saunders and Curry (1990) reviewed the impact of agricultural and pastoral activity on birds. They summarise changes that have occurred in the wheatbelt as a result of clearing of native vegetation including continual loss of species through time. Obviously, for some species remnants in the study area were not sufficient to support metapopulations of some species. Furthermore Saunders (1989) documented the disappearance of three passerine species from an 81 ha reserve over a ten year period. Clearly, the stability of a metapopulation cannot be assumed for any particular species in a specific locality without evidence that remnants involved are adequately connected.

There appears to be little agreement on the minimum size of remnants for conservation purposes. In his description of WA's Remnant Vegetation Protection Scheme, Wallace (1992) suggested that 30 ha is one reasonable cut-off point based on the work of Kitchener et al. (1980b) on mammals. Selecting an area below which remnants are too small is difficult to quantify. However, under the Remnant Vegetation Protection Scheme fencing assistance may be provided for areas down to 5 ha.

Note also that, for any specified shape, the perimeter to area ratio increases with decreasing area. Thus the proportion of reserve core area to total reserve area decreases with decreasing reserve size. Therefore on this basis, too, larger areas are likely to be of greater value for nature conservation.

Reserves vary greatly in composition and quality and there appears to be no readily quantifiable relationship between a reserve's area and its value for nature conservation save that larger reserves are generally more desirable.

In this study it has been assumed that larger reserves have higher conservation values than small reserves but that small reserves may play a valuable role in supporting metapopulations and in providing corridors or stepping stones for species movements.

Intact area

So far only the total area of a reserve has been considered. Many reserves are, however, seriously degraded and may not support fauna populations to the extent expected by their area. Kitchener (1982) looked at reserve requirements for species recorded only in natural undisturbed vegetation (U species) and species which also occur in disturbed situations (D species). For U species richness tended to be principally influenced by variables of reserve area and extent of associated uncleared land; for D species by vegetation floristic and structure variables. Generally, U species have a more vulnerable conservation status than D species.

Cale (1994) suggests that the number of remnant-dependent species occurring on a remnant is influenced by the remnant's area, vegetation diversity, the level of degradation of the vegetation and the spatial relationship between the remnant and its neighbouring remnants.

Scougall *et al.* (1993) studied edge effects and the effect of grazing in WA wheatbelt remnants. They conclude that for the majority of habitat variables measured, major differences exist between fenced and non fenced remnants of vegetation. Livestock are therefore considered to be the principal cause in the decline in environmental quality of non fenced remnants. Interestingly the effects of disturbances tended to decrease away from the edge of a remnant and for this reason interior areas of unfenced remnants were studied carefully to determine if relatively undisturbed areas occurred. The issue of exotic animals and problem fauna is considered below within the section on viability.

This study has recognised that reserves have different levels of quality or intactness and the methodology for assessing this is considered later in the report. The assumption has been made that the intact area of a reserve could be an important criterion for fauna. Therefore both total area and intact area are recorded and the reserves mapped into intactness classes based on the level of weed invasion so that a picture of the level of degradation can be seen.

Figure 4 shows the relationship between reserve area and intact area for the reserves studied. While larger reserves tend to have larger intact areas there are many larger reserves with small intact areas showing the importance of not just considering total reserve area.

In this study the level of degradation of a reserve has been assumed to affect the value of a reserve for wildlife. Reserves with large intact areas are likely to be better prospects for vesting as NPNCA reserves than reserves with smaller intact areas.

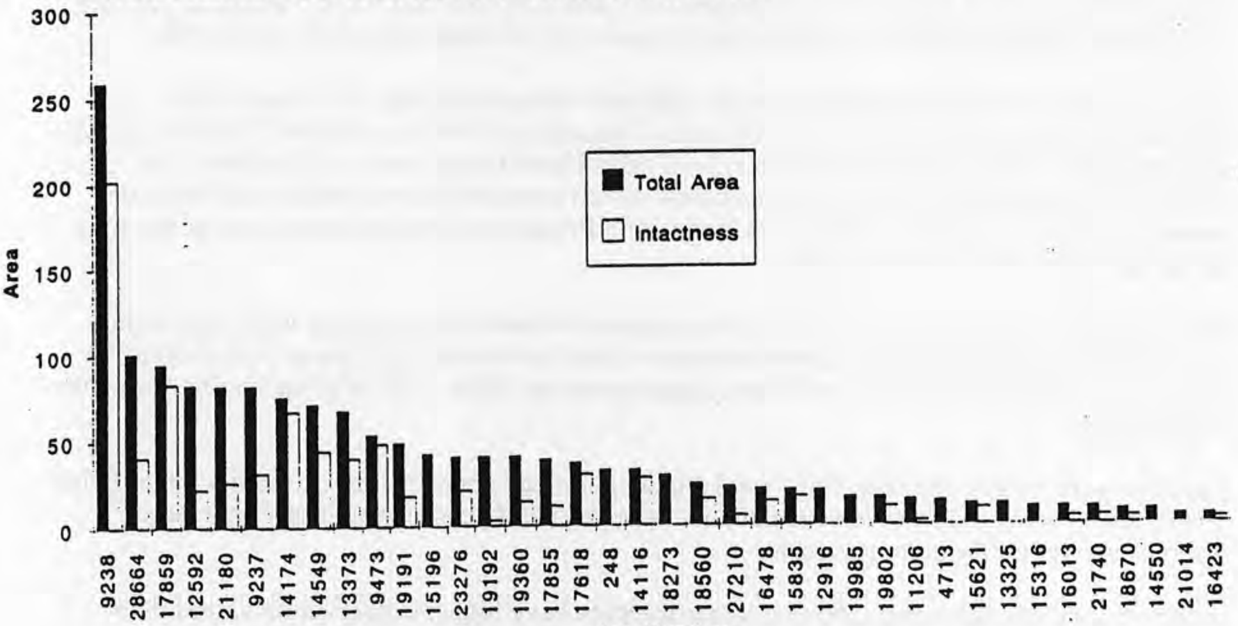

Figure 4. Reserve area / intact area relationships

Plant diversity as a measure of fauna diversity

A diversity of plant communities within a remnant has been thought to be an indicator of faunal richness. Kitchener *et al.* (1980a, 1980b, 1982) found that significant correlations existed with most variables for mammals but for birds plant diversity was only important for some passerine birds. For lizards the number of vegetation associations did explain 75% of the variation observed in species richness. Friend (1995) reports that invertebrate abundance and composition do not correlate well with floristics or vegetation structure. Patterns which may exist are at a fine level of taxonomic resolution.

Cale (1994) studied the interpretation of habitat diversity and scale and considered that the effect of different scales can only be addressed by studies that identify the components of the ecosystem that affect particular species and the scale at which these interactions occur. Cale (pers. comm.) also suggested that there is no evidence that more complex measures of diversity than number of associations demonstrate any better correlation with faunal richness.

Some vegetation formations may be more important than others. Kitchener (1982) reported that some vegetation formations within reserves were more important to birds than others; woodlands were most important both to resident and transient species and most species do not appear to distinguish between shrublands and heaths as major habitats.

It is recognised that diversity is not always positive - for a given area increasing diversity may equate with decreasing population sizes which leads to increasing extinction possibilities (R. Lambeck pers. comm.). Therefore increasing diversity can be a positive or negative trend depending on the area, types of associations and the species being considered.

As more complex measures of diversity do not appear to be justified the measure of biotic diversity used in this study was the number of vegetation associations (greater than one half hectare) within a remnant. The number of vegetation associations has been recorded together with the area of each association so that the value of a reserve for a particular species can be determined if habitat requirements are known.

Increasing plant diversity is not necessarily a good indicator of increasing value of a reserve for fauna. Values are species and scale specific and can only be determined when species or groups of species with similar life histories are considered.

In this study the number of plant associations has been used as a measure of increasing biotic diversity but with caution in relation to fauna.

Remnant shape and edge effects

Perimeter to area ratios for reserves may be used as a criterion for assessing remnants given that reserves with a small edge to area ratio, say square reserves, will have a larger core area than rectangular reserves with a larger edge to area ratio. Lynch and Saunders (1991) considered that most bird species dependent on remnant vegetation were more common in reserve interiors than remnant edges. However Cale (1994) reports that edge effects had no significant impact on bird species present in a reserve and suggested that the difference could be the time scale of the sampling due to temporal changes in their use of edge and interior habitats.
Cale (1994) suggests that in line with other studies (Saunders, Hobbs and Margules 1991) the shape of a reserve is only likely to be important in small areas and in these cases their shape becomes irrelevant because they only constitute edge habitat. However, this conclusion does not consider factors such as:

- the greater costs (for example, fencing) of managing irregularly shaped reserves
- that, from a hydrological viewpoint, compact reserves are likely to be better protected
- the apparent (but not quantified) tendency for some exotic species, for example rabbits, to favour edge habitat.

Therefore it may be concluded that reserves with small edge to area ratios will be better for nature conservation than reserves with large edge to area ratios, but this has not been confirmed in Western Australian wheatbelt studies.

The amount of edge habitat will depend on species requirements, past impacts and the vegetation association. Various studies reported on by Cale (1994) refer to edge effects over distances of between 10m and 50m depending on the factor being evaluated. This study found that edges are degraded more than interiors and the condition, intactness, of edge habitat has been mapped for each reserve.

Hobbs (1993a) states that management of external influences is probably more important than management of internal processes within remnant areas. External influences which damage edges and no doubt progressively interiors of reserves, have been recorded for each reserve.

Edge to area ratios are important for assessing the efficiency of fencing subsidies, that is, the smaller the edge to area ratio the greater the efficiency of a fencing subsidy. Length of perimeter will be important if a reserve requires fencing but in most cases reserves had adequate fences where required. However, fences have a finite life, and maintenance and replacement costs may affect the attitudes of adjoining landholders to nature reserves. Twigg (1995) details some of the costs of replacing and maintaining fences around remnant bushland.

A number of reserves in this study were not completely isolated but adjacent to private remnants or other reserves. In these cases the edge to area relationship of the reserve would not be comparable between reserves unless the total area of remnant vegetation was used for measurement.

Finally, it is noted that perimeter to edge ratios are readily quantified and compared with a "perfect square" for ranking purposes. Early schemes in South Australia used this as a ranking criterion. The difficulty is quantifying the results of such calculations in terms of nature conservation values.

In this study edge to area ratios have not been considered as a criterion for ranking reserves but it is recognised that small narrow isolated reserves with significant areas less than 100 meters in width will constitute mainly edge habitat which is likely to be degraded. Such reserves are considered to have low viability.

Time since clearing

Saunders (1989) reports that: (i) time since clearing is important for birds with extinctions occurring in reserves in areas cleared pre 1930's compared to areas cleared in the 1960's. (ii) The avifauna of several reserves examined by Kitchener *et al.* (1982) over 15 years previously, had lost species and this could be an ongoing process. "Species relaxation" is considered an inevitable consequence of area reduction and isolation, but the rate of extinction will vary amongst taxa (Saunders, Hobbs and Margules 1991). Cale (1994) did not find time since clearing a useful indicator in his modelling for bird species richness but local extinctions may have already occurred in his study area.

Time since clearing could be important in deciding priorities between reserves in areas cleared at different times. It will be beneficial to enhance a reserve with corridors and additional edge plantings in a newly cleared area to possibly avoid local extinctions.

Time since clearing has not been used to compare reserves in this study because information was only available for some reserves from anecdotal evidence. However, if such information had been available it would have been used.

Intactness - the current quality of a remnant - bushland health

Methods of determining reserve quality

Some measure of reserve quality, or health, or intactness, is thought to be an important criterion for determining conservation value of remnants. Lyon (1987) in a Victorian context found that small heavily grazed patches (less than 10 ha) supported few forest birds and more farmland birds including noisy miners (*Manorina melaocephala)* which aggressively excluded other species. Observations during this study and by K Wallace (pers. comm.) suggest that the yellow throated miner (*Manorina flavigula*) is a similar indicator of degraded vegetation. Scougall *et al.* (1993) found that major differences exist between fenced and unfenced remnants of York gum and jam woodland. In comparison with fenced remnants, non fenced remnants had less litter, increased numbers of dead trees, moister denser soils, elevated levels of soil nutrients, reduced tree and shrub abundance, and reduced species richness as well as a greater proportion of non native herbs. As well the aggressive dominant ant functional group (*Iridomyrmex* spp, more heat loving, fast moving ants) formed a greater component of the ant community in unfenced remnants whereas the generalised myrmicines (soil and litter ants) were more prevalent in fenced remnants.

There appear to be few studies which demonstrate or study a change in fauna with a reduction in reserve quality such as invasion and swamping of native vegetation by weeds. Personal observations indicate an increase in "weed" and edge bird species in badly degraded reserves.

Even without evidence of a direct relationship between reserve quality and habitat values there have been numerous methods developed to assess reserve quality. This section briefly summarises five methods for assessing reserve quality. The first method is that adopted by the Remnant Vegetation Protection Scheme. The other four methods involve combining a number of criteria for degradation into a score. This study has found that combining a number of criteria into a score is inappropriate for the wheatbelt with its complex of vegetation types. Instead a transparent system has been adopted based on mapping the reserves into weed cover classes and recording and mapping other forms of disturbance.

The Remnant Vegetation Protection Scheme uses criteria which have been designed for interpretation by the farming community. This scheme draws attention to remnants with particular problems. Items (1), (3) and (4) in the list below were used to identify areas that had been heavily grazed by livestock.

Does the remnant have:

1 Woodland with less than five native species under the tree canopy?

2 Remnant used as a rubbish dump and/or for gravel mining and/or for sand mining?

3 Shrublands with a canopy cover less than 20%, and a ground cover of native herbs sedges and mosses less than 30%?

4 Granite rock which has been grazed and/or for which there is less than 10% of fringing vegetation?

5 Remnant includes more than 10% of cleared land, or land which has been cleared?

This study provides more comprehensive information than required above including vegetation lists, mapping of disturbances, mapped weed cover classes and cleared areas.

The other four methods are set out below.

Mollemans (1994) developed a key for enabling an assessment of the ecological significance of farm bush remnants. The key combines the intrinsic nature conservation qualities of a reserve with a system of disturbance classes based on the presence of understorey and the percentage of area affected by factors such as feral animals, grazing rabbits etc. The key is not considered useful because there is no differentiation between the types of disturbances and the severity of disturbance is not considered, only percentage of area disturbed.

Orsini and Lewis (1991) devised a rating system based on area, vegetation structure and dominant species (number of species in a remnant), disturbance level based on visible causes of disturbance and potential for natural regeneration. The study was for a limited geographic area. The scheme is considered inappropriate in a broader context because:

1. the number of species in a remnant may not be an indicator of quality as it does not allow for "simple" ecosystems, for example, some woodlands, which may have very high nature conservation values
2. the disturbance level is an overall score of the more visible causes of disturbance. Measurements using this technique are unlikely to be comparable across a wider area using a number of assessors. Furthermore, the causes of disturbance are not included making interpretation of the ratings difficult.
3. the potential for natural regeneration is estimated from the amount of natural regeneration present and an appreciation of the current disturbances. A measure of the potential for natural regeneration could be used to assess whether a disturbed ecosystem is likely to recover. But in some mature, fully stocked ecosystems, for example, mallee, there may be naturally little regeneration.

Cale (1994) used a habitat quality index which is the sum of four subjective measures of disturbance and habitat quality. The features used were grazing disturbance, weed invasion levels, human disturbance such as tracks and vegetation senescence (lack of fires). Each was rated between one and three depending on the severity and the scores summed. The method was not useful in this study because: (1) weed invasion was found to be patchy; this was not allowed for in the model, (2) tracks etc. were a feature of most reserves, (3) most reserves were not grazed and (4) vegetation senescence (due to lack of fire) was not considered relevant for ecosystems where fire may not have been a regular occurrence, for example, salmon gum woodlands.

Goldney (1994) considered a number of characteristics in developing a five stage bushland health rating system suitable for use by landowners. The list is comprehensive in considering factors which affect habitat quality. A simple yes /no mode makes field repeatability possible. The following description of quality bushland provides an indication of the factors considered.

"Quality bushland: Mix of tree ages; old growth with hollows, fully grown but with no hollows, trees, saplings. Grassy or shrubby understorey with wildflowers, free of weeds, with perhaps occasional wattles or shrubs. Fallen logs remain on ground. Little or no tree dieback. Usually free of grazing, evidence of regeneration and absence of weeds."

This model may suit multi-aged woodlands and forests with a similar history and appears to be a valuable extension tool. However, it is not suitable for the wheatbelt as not all factors are appropriate for all formation types. For example, presence of regrowth may not be an appropriate measure for a "healthy" formation in an early seral stage, and hollows do not occur naturally in some important vegetation types.

A measure of intactness for the Western Australian wheatbelt

While there are no studies which demonstrate a relationship between conservation value and quality or intact vegetation, it was considered that reserves which were largely intact were more valuable for nature conservation than degraded reserves.

Multi variable measures of bushland health, quality or intactness are considered inappropriate for the wheatbelt due to the complex of vegetation formations. Shrublands have different characteristics compared with mallee or woodlands. The multi variable measures that have been used combine a number of characteristics such as presence of or potential for natural regeneration or mix of ages, presence of hollows, senescence, but not all the characteristics are relevant to all plant formations at all life stages. For example a fully stocked gimlet woodland would not be expected to have regeneration, a shrubland will not have hollows. Not all formations would exhibit senescence due to lack of fire. And, in any case, is senescence always a problem?

Bushland health or quality are also subjective values that depend on the point of view of the observer or developer of the classification. The difficulty with measures of degradation that combine a number of criteria is that the final result is not transparent, the reasons for the rating are not known. By keeping the criteria separate the condition of the reserve can be checked and alterations over time can be observed.

What is required is a measure of intactness that is not subjective in nature, is repeatable, and preferably allows the data to be reinterpreted at a later date.

The dominant indicator of degradation in the central wheatbelt was found by the study team to be weed invasion which is often the product of disturbance. This study found that in most cases percent weed cover gave a reasonable indication of the intactness, or lack of degradation, of a remnant. Weed cover as used in this study is the percent of the ground which has a cover of weeds.

Weed cover however did not give a reasonable indication of disturbance in scalded or wind eroded areas where the lack of weeds was due to loss of a suitable substrate. Where areas were scalded, eroded or grazed this was noted. The severity of past grazing appeared to be reflected in the weed cover classes.

Weed cover was mapped into four classes: 0-20%, 20-50%, 50-80% and 80%+. In most cases this was straightforward but in some areas there was a complex of weed cover classes which were not mappable. This was noted on the plans and an estimate made of the area of each weed cover class. It was not possible to determine any rate of change in weed cover in a one off survey.

Areas with less than 20% weed cover were assumed to be relatively intact. Zero weed cover was not a class because, while some areas appeared to be completely free of weeds this could not be guaranteed in a brief and one off survey.

It is recognised that the impact of weed invasion will depend on the weed species. Most weeds in this study were grassy weeds but where even small occurrences of highly invasive weeds were observed this was noted and appropriate comments made in management recommendations.

In this study weed cover has been used as a measure of intactness together with mapping of degrading features. Areas with less than 20% weed were assumed to be relatively intact.

Relationship to government conservation reserves

There are a number of different categories of government owned conservation reserves in Western Australia. The most securely held and those considered in this study are vested in the NPNCA and managed by CALM. The management for conservation of other categories of reserves, for example, those vested in shires, is less secure and they are generally not considered in this study. An exception is where a reserve is adjacent to reserves vested in a shire and the combined value warrants a greater level of protection.

One of the purposes of NPNCA reserves is to conserve representative samples of natural flora and fauna. Part of the purpose of this study was to identify reserves which contain habitat not already conserved or which significantly add to habitat already conserved and which should become NPNCA reserves. The study compared the habitats in the reserves studied with the habitats in the closest NPNCA reserve as reported in previous studies. Vegetation descriptions were not available for all NPNCA reserves.

Reserves which contain habitat not already conserved in the area have a high value for conservation (are significant) compared with reserves which contain more of the same habitats. If a reserve contains larger areas of habitat than the closest NPNCA reserve then it may be more important (significant) for representing this habitat than the NPNCA reserve. Comparing the reserve with the closest NPNCA reserve can be misleading if there is also another NPNCA reserve close by. It would be better (if time allowed and data was available) to take a regional approach and compare the reserves under study with all the NPNCA reserves, and shire reserves in that region.

Reserves which do not meet these criteria may also be important. They may contain subtle but important variations in species and structure, they may provide linkages between reserves or they may be at such a distance that they are important in their own right to represent the vegetation of that area. Burgman (1988) concluded that to conserve the flora of a region, especially rare species, a reserve system should include replicates of the same broad formations and soil types at intervals of less than 15 kilometres.

In summary, those reserves which: contain habitat not already conserved, or significantly add to habitat already conserved, or are further than 15 kilometres from the closest nature reserves should have a high priority for protection as nature reserves.

Replication of habitats is also very important. Hopper (1992) reminds us that simple minded notions that once a species is represented in a conservation reserve, it is safe, deny the overwhelming evidence that individual populations are dynamic and part of an ever changing metapopulation. Most conservation managers are unaware of the great diversity in the genetic architecture, breeding systems and life history strategies of south western plants.

The relationship between connectivity, significance and distance from the closest NPNCA reserve is shown in Figures 5 and 6. Many reserves contained significant plant associations compared with NPNCA reserves and all (for which information is available) were within 15 kilometres of an NPNCA reserve. The likelihood of connectivity decreased with increasing distance as would be expected. Note that information on connectivity, significance or distance was not available for 13 reserves and these have not been included in Figures 5 and 6.

It should be noted that there is a contradiction in valuing reserves for connectivity and isolation. For example, a reserve isolated from other reserves, say by 20 kilometres, will have a high value because it is likely to hold species or genotypes not replicated elsewhere. At the same time, it will 'lose' value given its lack of connectivity with other bushland. In this study all reserves were within 15 kilometeres of the closest NPNCA reserve. Had they been further this would have been noted (refer figure 5) and distance could have been used as a criteria for selecting nature reserves.

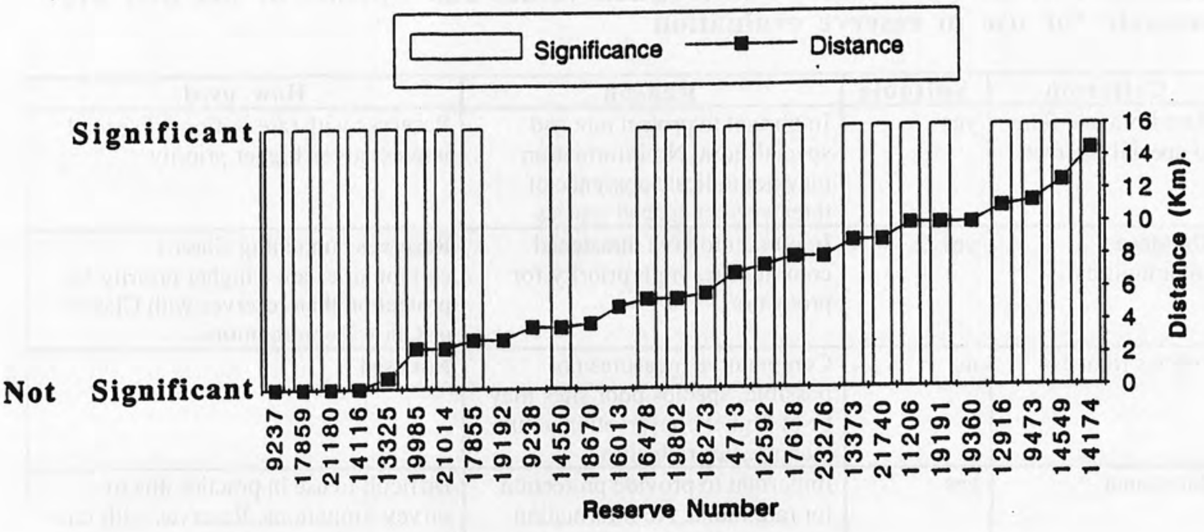

Figure 5. Reserves with significant habitats (contains habitats not already conserved or significantly add to habitats already conserved) **in relation to closest NPNCA reserve and distance from that reserve**

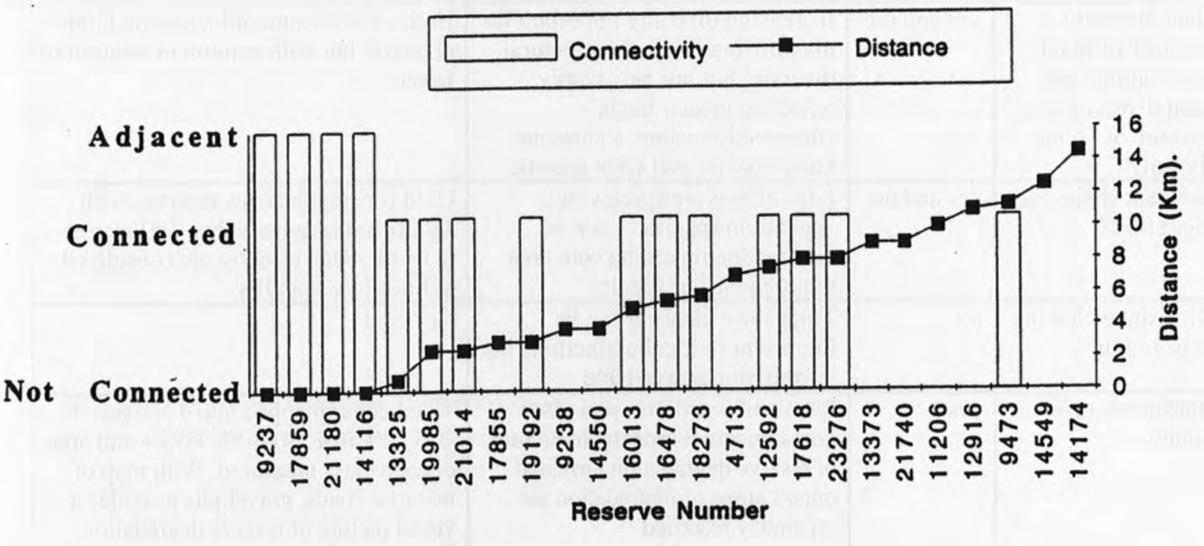

Figure 6. Connectivity of reserve to closest NPNCA reserve and distance from that reserve

Summary of intrinsic nature conservation values and whether or not they are suitable for use in reserve evaluation

Criterion	Suitable	Reason	How used
Rare flora and flora of special interest	yes	Important to protect rare and special flora. No information may not indicate abscence of threatened or special species	Reserves with rare or flora of special interest given higher priority
Threatened communities	yes	Important to give threatened communities high priority for protection	Reserves containing Class 1 communities are a higher priority for protection than reserves with Class 2 or Class 3 communities
Species richness	no	Comparative measures not possible, species poor sites may be of higher conservation value than species rich sites	Not used
Rare fauna	yes	Important to provide protection for rare fauna. No information may not indicate absence of rare fauna	Difficult to use in practice due to survey limitations. Reserves with rare fauna can be given higher priority
Reserve area	yes	General agreement that nature conservation values increase with reserve size	Used as a continuous variable rather than defining area classes, but arbitrary area cut off can be used for specific purposes. Eg NPNCA reserves should be greater than 80 hectares?
Intact area	yes	Little data available on relationship between reserve degradation and nature conservation values. Intact area considered to be a potentially useful indicator	Areas of each weed cover class measured. Intact areas defined as areas with less than 20% weed cover. Used as a continuous variable rather than defining area classes, but arbitrary area cut off can be used for specific purposes
Plant diversity (number of plant associations) and plant diversity as a measure of fauna diversity	yes and no	Increasing diversity important for maximising flora and structural diversity but not necessarily related to greater fauna conservation value. Values are fauna species and scale specific	Used as a measure of increasing biotic diversity but with caution in relation to fauna
Remnant shape and edge effects	yes and no	Edge effects are species and vegetation specific. Lack of information regarding core area requirements of species.	Used for small narrow reserves with significant areas less than 100 metres in width. Such reserves are considered to have low viability
Time since clearing or isolation	no	Time since clearing can be important re local extinctions but information unavailable	Not used
Intactness - reserve quality	yes	Levels of weed invasion gives non subjective repeatable picture of reserve degradation provided other causes of degradation are separately recorded	Weed cover mapped into 4 classes: 0-20%, 20-50%, 50-80%, 80%+ and area of each class measured. With map of features, roads, gravel pits provides a visual picture of reserve degradation. Reserves with large highly degraded areas considered non viable.
Relationship to NPNCA reserves	yes	Reserves may contain habitat not already conserved or significantly add to habitat already conserved or be considerable distance from a reserve	Reserves have a higher priority if they contain habitat not already conserved or significantly add to habitat already conserved or are further than 15 km from a NPNCA reserve

CRITERIA FOR RANKING NON HUMAN, BIOLOGICAL AND PHYSICAL INFLUENCES WHICH AFFECT VIABILITY

So far we have identified characteristics for ranking reserves which can be reasonably measured: the presence of rare species, communities present, distance to other reserves.

Viability cannot be easily measured and is necessarily linked to a time scale that will determine if tectonic events or climate change are likely to be of consequence. Cycles which may take hundreds of years are difficult to conceptualise let alone measure and we don't have any real understanding of long-term population viability, let alone relationships between species and viability of the community/ecosystem.

While it is considered to be beyond the scope of this report to consider long term viability it is important to think about the factors involved. Long term viability of a reserve will depend on:

- minimum viable population sizes of wildlife
- periodicity of episodic events critical to regeneration and habitat formation
- sufficient habitat not only to maintain populations, but also to enable dynamic aspects such as successions, space for habitat regeneration, aging of habitat and for habitat regeneration to occur
- maintenance of relevant ecosystem processes, for example, pollinators, nutrient cycles, current and future threats to the reserve, external impacts such as climate change, the difficulty of management, future management resources and goals.

From the above list it will be apparent that many, particularly small, reserves are unlikely to be viable in the long term. But these reserves may still be valuable if only some of the biota survive, if they make a contribution to local, regional or national biodiversity, are available to research resilience of species or ecosystems, or to retain local communities and genotypes for regeneration.

This study has only considered factors that can be identified as having a high likelihood of resulting in serious degradation of a reserve in the next 50 years. Serious degradation is defined as loss of vegetation strata such that the normal ecosystem functions of regeneration and recycling are unlikely to continue operating after 50 years. For example if the understorey was replaced by exotic grasses in a wandoo woodland then it is very unlikely that normal ecosystem functions would be operating and regeneration in the long term is unlikely without active management. It is recognised that a remnant may have several levels of viability. It may be viable for its current complement of species for 50 years, then viable for half of them for a further 50 years. The factors considered when determining if serious degradation is likely to occur are discussed below.

Small areas

It has been suggested that any reserve less than 500,000 hectares will require active management (Hopkins and Saunders 1987). However, the reserves assessed in the current project were (save for one) less than 200 ha and many less than 30 ha. The discussion under Remnant Shape and Edge Effects (on page 15) refers to this issue and suggests that *small reserves with widths of less than 100 metres surrounded by farming land be considered to have low viability. It is also noted that the cost of managing small reserves, say, those less than 5 ha, is comparatively high.*

Vegetation associations

The type of plant association present has an influence on viability. For example shrublands on gravelly soils appear to be more resistant to change than York gum woodlands. In general, shrublands are more resistant to weed invasion than woodlands (Hobbs et al. 1992a). There is also evidence that some native species have an allelopathic affect on weeds (Hobbs and Atkins 1991). Despite this evidence, it was decided that there is insufficient information to quantitatively compare plant associations for inherent resistance to change and *type of plant association has not been used to judge viability.*

Time since clearing

As previously discussed reserves which have been isolated for a long time are more likely to have suffered species extinctions. As this information was not obtained for all reserves *time since clearing has not been used to judge viability.*

Position in landscape - evidence of rising water tables

Rising water tables often affect lower slopes and valley floors first and evidence, such as tree deaths, is usually apparent in the valley floor vegetation. There was anecdotal evidence of rising water tables in more recently cleared areas which had not yet shown as tree deaths or decline. *Where there was evidence of rising water tables which were affecting or likely to affect the reserve this was noted and the reserve or the lower sections of the reserve considered to have low viability.*

Adjacent land uses likely to impact on nature conservation values

The perimeters of the reserves were studied to determine the impact of adjacent land uses on the reserve. In this study farming was the land use most likely to impact on a reserve and in most cases the effects were restricted to the edges. *Where drains for saline water disposal were constructed into a reserve the effects were severe and in such cases the affected parts of the reserve were considered to have low viability.* In other regions where urbanisation and industrialisation are occurring there could be adjacent land uses that impact heavily on a reserve, for example increase in nutrients due to septic tanks.

Exotics and problem native species

Exotic plants and animals can have a devastating effect on nature conservation values. In the wheatbelt grassy weeds and rabbits were the most obvious problems. Weeds appeared to have displaced native understorey in many areas. The rate of spread of weeds could not be determined from one inspection and it appeared that the invasive process was ongoing in the more recently cleared areas. *It was assumed that reserves with no or very low areas of intact vegetation had low viability.* Reserves with a small but potentially very invasive weed would also be labelled as being of low viability if successful control of the weed was unlikely. This situation was not observed in this study.

Foxes, cats, rabbits and other exotic animals present enormous problems for nature conservation (Hobbs et al. 1992a). Rabbits were assessed, using the number and size of warrens, for past and current impacts; only two reserves had severe rabbit infestations. In this study *it is assumed that exotic animals, other than rabbits, present an equivalent level of problem for all reserves, and are therefore not included in the comparative assessment of reserves.* It is recognised that this assumption, with further research, may prove invalid. It is also recognised that some native species - for example, particular species of parrots - currently represent a nature conservation problem. Again, *it is assumed that the threat to viability represented to reserves by problem native species will be broadly equivalent across all reserves.*

Isolation

The remaining native vegetation in the wheatbelt is made up of thousands of remnants of various sizes, shapes and degrees of isolation scattered across the landscape (Saunders 1989). Kitchener *et al.* (1980b) report that species surviving in the wheatbelt are those which have no great problem in coping with the existing environmental patchiness. In the pristine environment they also existed on "islands" of soil and vegetation types in the complex mosaic which characterises natural habitats of the wheatbelt. Wheatbelt reserves larger than about 200 ha have more species of mammals than predicted for pristine modern mammal fauna for similar sized islands and it seems that wheatbelt reserves will lose more species as they become further isolated. Saunders (1989) re-examined birds in areas studied by Kitchener *et al.* (1982) and found that further extinctions have occurred and considers that remnants in the wheatbelt are still in a stage of species relaxation.

A reserve adjacent to or connected to other remnant vegetation is less likely to suffer species extinctions than an isolated reserve. Kitchener *et al.* (1980b) consider that the value of these smaller reserves is likely to be greatly enhanced if they can be closely positioned, or have connecting corridors to allow immigration. The following studies are quoted to confirm the importance of connectivity to the survival of some fauna. Studies showing the effects of connectivity on Western Australian plant species or fauna with restricted home ranges have not been located.

Arnold et al. (1993) supported the importance of connectivity and close proximity of reserves in their study on euros. They found as previously reported that in areas where the remnants were small, <30 ha, individuals lived alone or in small groups, moving frequently between several remnants. The euros appear to be separated into a number of metapopulations with movements between the metapopulations being dependent on the availability of stepping stones and corridors.

Saunders and Ingram (1987) studied the factors affecting the survival of Carnaby's cockatoo. They found that Carnaby's cockatoo can breed successfully in areas which have been extensively cleared providing there are corridors of native vegetation connecting patches of remnant vegetation. Saunders and Rebeira (1991) report that the conservation of the remaining species that rely on native vegetation will depend mainly on their ability to move between vegetation remnants and the quality of the habitat in these remnants.

Cale (1994) reports that models predicting remnant-dependent species richness suggest that isolation is an important factor in determining the number of species (birds) in a remnant. The observed mobility of most of these species, however, suggests that this is not due to an inability of these species to traverse the distances between remnants, but may be the result of differences in probability that a remnant will be visited due to differences in the configuration of remnants in the landscape.

There are two elements to isolation, the configuration of remnants surrounding the study remnant and the connectivity between remnants. These issues will be considered separately.

Configuration

Cale (1994) describes three indices which have been used to model the spatial relationship between a remnant and its neighbours (excluding age since separation and connectivity) and found that the Isolation Index - the mean distance to the ten nearest neighbouring remnants - produced the best model for birds. Unfortunately similar studies for mammals have not been located. The Isolation Index has been used in this study. More complex measures of isolation have not been demonstrated to provide any better model for predicting wildlife movements (P. Cale pers. comm.).

It was not possible in this study to record the variables used for the other indices for possible future use (the area of each remnant within 5 km of the study area, the number of remnants within 5 km). Remnants include road reserves greater than 15 metres in width as used by Cale (1994). Such corridors could be habitat in their own right as reported by Lynch *et al.* (in prep) and were recorded as reserves.

The quality of the neighbouring remnants could play an important role. Proximity to a high quality remnant is likely to be far more valuable as a source for colonisation than proximity to a similar sized degraded remnant. The status or degree of protection of the neighbouring remnant may also be important.

Connectivity

A number of studies have demonstrated the value of corridors between remnants. The value of a corridor will depend on its width, its quality, the nature of any gaps, and the ability of a species to make use of the corridor. Saunders and de Rebeira (1991) report that vegetated links even as narrow as 4 metres allow some species of bird to move along them and suggested that the wider the corridor (provided it is well vegetated) the more species will move along it, and the more breeding habitat will be provided.

Cale (1994) refers to an accessibility index which utilises the number of remnants within a 5 km radius of the study remnant that are connected to the remnant. All road verges and fenceline vegetation were considered corridors if vegetation similar in physiognomy to remnant vegetation occurred along their length and no continuous breaks of greater than 400m existed.

In this study the accessibility index was modified due to resource constraints to count the number of the ten closest remnants which were connected. It is desirable (but was not possible in this study) to record where remnants are connected by quality corridors.

The value of a corridor will depend on the species being considered and the quality of the connectivity. Spread of disease, movement of predators and increased predation are potential disadvantages of corridors which have not been considered in this report. It is considered that remnants close to other remnants and with connectivity have greater viability for many species and offer an opportunity for improvement with revegetation.

Configuration and connectivity in practice

There were practical problems in determining configuration and connectivity in this study. For some reserves aerial photos were unavailable making estimation impossible. Aerial photos were 10 years old and there have been many changes in the landscape in that time. There was insufficient time to field check each remnant for connectivity and condition. There was also difficulty in determining consistently from the aerial photos (at 1: 50 000 and 1: 80 000 scale) acceptable corridors and acceptable remnants to count.

Due to the limitations described above the data on configuration and connectivity for each reserve should be treated with caution. This data was collected and is reported for each reserve and should only be used as a guide to rank reserves in the study.

In this study it is considered that remnants close to other remnants and with connectivity have greater viability for many species but due to lack of consistent data and the species specific nature of the benefits of connectivity measures of isolation have not been used to judge reserve viability.

Summary of non human, biological and physical influences which affect viability.

Influence	Suitable	Reason	How used
Shape and size	yes	Small narrow reserves are subject to external influences and degradation over much of their area.	Small narrow reserves with significant areas less than 100 metres wide are considered to have low viability
Vegetation associations	no	The resilience of different plant associations to change is largely unknown	Not used
Time since clearing	no	Lack of information on isolation of each reserve. Could be a valuable criteria re extinctions if information available	Not used
Position in landscape - rising water tables	yes	Rising water tables and salinity can alter, degrade and kill existing vegetation	Where there is evidence of rising water tables affecting or likely to affect a reserve then that part of the reserve affected is considered to have low viability
Adjacent land uses	yes	In the wheatbelt adjacent landuses appear to have a low to moderate effect on reserves save where saline water is drained into reserves when the impact is high	The parts of reserves affected by drainage of saline water from adjacent land are considered to have low viability
Exotics - intactness	yes	Exotic plants and animals can cause serious damage. Weed invasion can be measured (refer intactness)	Reserves with no or very small areas of intact vegetation are considered to have low viability. Small occurrences of highly invasive weeds have potential to influence viability
Isolation - configuration and connectivity	no	Value of measures of configuration and connectivity is species dependent. Consistent data could not be collected	Measures of configuration and connectivity in this study should be used only as a guide due to inconsistent data. Generally it is considered that proximity of quality adjacent remnant vegetation and greater connectivity improve viability

CRITERIA FOR RANKING SOCIAL AND RESOURCE ISSUES - COMPETING LAND USES

For many reserves there were significant competing land uses. The types of competition are summarised below.

Extractive materials

Evidence of extractive material removal (gravel, sand, gypsum) on each reserve was recorded and mapped as well as an estimate, gained from soil profile analysis and vegetation mapping, of the remaining resource in the reserve.

Recreation/amenity

The current use of a reserve for recreation was recorded together with suitability and impact of the use. Special features of the site likely to be attractive to people were recorded together with notes on access type and condition.

Grazing

A method of assessing sheep grazing intensity with consistency by counting the number of sheep pellets in a number of .25 square metre plots set out in a grid within each vegetation association has been developed by G. Smith and M. Traum of CSIRO (pers. comm.). The mean number of pellets per hectare is used as a measure of grazing intensity. This method could not be used in this study because considerable time is required to establish grids to provide consistent results. An attempt at random placing of quadrats did not produce repeatable results as sheep droppings tended to be concentrated in zones and along tracks. When grazing has not occurred for some time due to cropping of adjacent land number of pellets did not appear to reflect grazing intensity as many sheep droppings are lost or concentrated by water wash.

There were insufficient resources to establish grids in this study and as few reserves were subject to recent grazing it was decided to rank reserves as subject to severe, moderate or light grazing from observations of droppings, weeds and understorey vegetation damage.

Direct production

Wallace (1994) reports that in the central wheatbelt many people use their remnants for direct production, for example as a source of fencing material, struts, honey, firewood, and so on and that more recently, the development of farmstays and other forms of tourism and recreation have begun to use remnant vegetation as an important attraction.

Many of the reserves studied have been heavily cut over for timber. The current resource is mainly small, often coppice growth, of doubtful quality and in many areas regeneration of the woodlands has been poor. There was little evidence of recent timber cutting. Records of timber cutting including estimated time and intensity of cutting were recorded together with notes on the timber resource currently available.

Evidence of wildflower harvesting was not found but no doubt occurs, its value is not known.

Figure 7 provides a "picture" of the types and number of reserves affected by competing land uses.

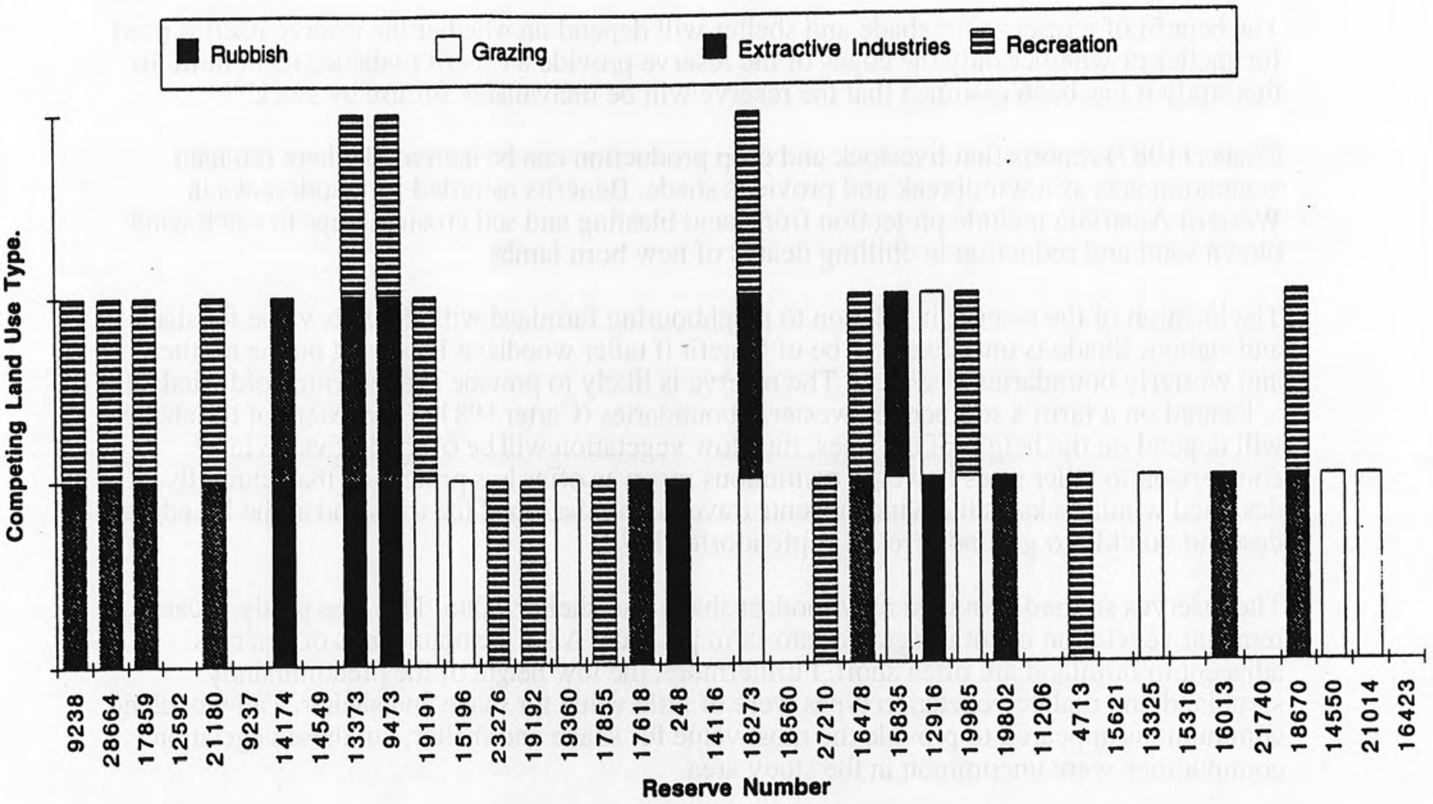

Figure 7. Competing land uses

CRITERIA FOR RANKING SOCIAL AND RESOURCE ISSUES - COMPATIBLE USES/BENEFITS

Shade and shelter

The benefit of a reserve for shade and shelter will depend on whether the reserve itself is used for shelter or whether only the edges of the reserve provide a benefit to the adjacent farm. In this study it has been assumed that the reserve will be unavailable for use by stock.

Coates (1987) reports that livestock and crop production can be increased where remnant vegetation acts as a windbreak and provides shade. Benefits recorded for windbreaks in Western Australia include protection from sand blasting and soil erosion, traps to catch wind blown sand and reduction in chilling deaths of new born lambs.

The location of the reserve in relation to neighbouring farmland will affect its value for shade and shelter. Shade is only likely to be of benefit if taller woodland is present on the northern and westerly boundaries of a farm. The reserve is likely to provide shelter from cold winds if it is located on a farm's southern or westerly boundaries (Carter 1981). The extent of the shelter will depend on the height of the trees, thus low vegetation will be of modest value in comparison to taller trees however continuous reserves offer less protection than carefully designed windbreaks as the wind currents travel along the top of the trees and at the lee edge descend quickly to ground level (Simpfendorfer 1975).

The reserves studied provided only modest shade and shelter value. This was partly because remnant vegetation is not integrated into farm practice. Also, the boundaries of reserves adjacent to farmland are often short. Furthermore, the low height of the predominantly shrubland and mallee vegetation types were of little value for shade and shelter. Tall woodland communities appeared to provide the most value for shade and shelter, but these vegetation communities were uncommon in the study area.

The position of a reserve in relation to farmland was recorded and an assessment made of the value of the remnant for shade and shelter based on the vegetation formations present. Reserves were ranked as valuable for shade and shelter only if they shared a significant boundary with farmland on an aspect which provided shade or shelter from cold winds.

Land degradation

Experience has shown that many soils in the wheatbelt are fragile and suffer from waterlogging, wind and water erosion when cleared of native vegetation. Reserves with soils rated as at high risk of soil problems should not be developed for agriculture and should remain uncleared.

Holm (1994) produced guidelines for judging applications to clear remnant vegetation. These guidelines were based on the likelihood of water erosion, wind erosion or waterlogging and other problems that would result from clearing. Judgements were based on land capability classes. These classes indicate the capability of the land for agriculture and indicate the likely hazards if cleared. Soils classified as Class IV or V should generally not be cleared. Land capability classes were determined for these features for each major soil type in each reserve using the methodology developed by the Department of Agriculture. Ratings were simplified to low (Class I and II), moderate (Class III) and high (Class IV and V) risk of soil erosion or waterlogging due to the lack of resources to complete more detailed analyses.

Partly buried fences at the farm/reserve interface demonstrated the value of reserves for slowing wind derived soil erosion. In the wheatbelt, erosive winds often blow from the north-west and a reserve to the north of a paddock with wind erodeable soils is likely to be beneficial (Carter 1981). In this study the soils in neighbouring paddocks were not identified so the value of the reserve for prevention of wind erosion in adjacent paddocks could not be determined.

In this study reserves with soils ranked high for risk of soil erosion or waterlogging if cleared are recommended for retention of native vegetation for their soil conservation value.

Effects on hydrology and soil stabilisation

Coates (1987) reports that remnant vegetation can play an important role in regulating hydrological processes, nutrient cycling and erosion on surrounding land.

Holm (1994) lists areas that should not be cleared due to the risk of increased salinity and eutrophication. These areas are listed in Appendix 1 and 2. Reserves with these features were identified in the study.

Many reserves in severely cleared landscapes did not meet the criteria in Appendix 1 but appeared to play a valuable water use role. Some reserves protected the headwaters of seasonal creeks supplying farm dams. Where reserves appeared to be valuable but did not meet the criteria the survey report was annotated accordingly.

Reserves may also play a role in water retention. Increased runoff when bushland is replaced by pasture and cropping land could put pressure on existing waterways and affect infrastructure such as culverts and possibly result in flooding. These possibilities were not taken into account in the study.

Figure 7 provides a "picture" of the number of reserves playing an important role in preventing eutrophication, soil degradation and salinity.

In this study the Department of Agriculture, Western Australia's guidelines for salinity, eutrophication and soil erosion were used to judge the benefits of retaining reserves for these values.

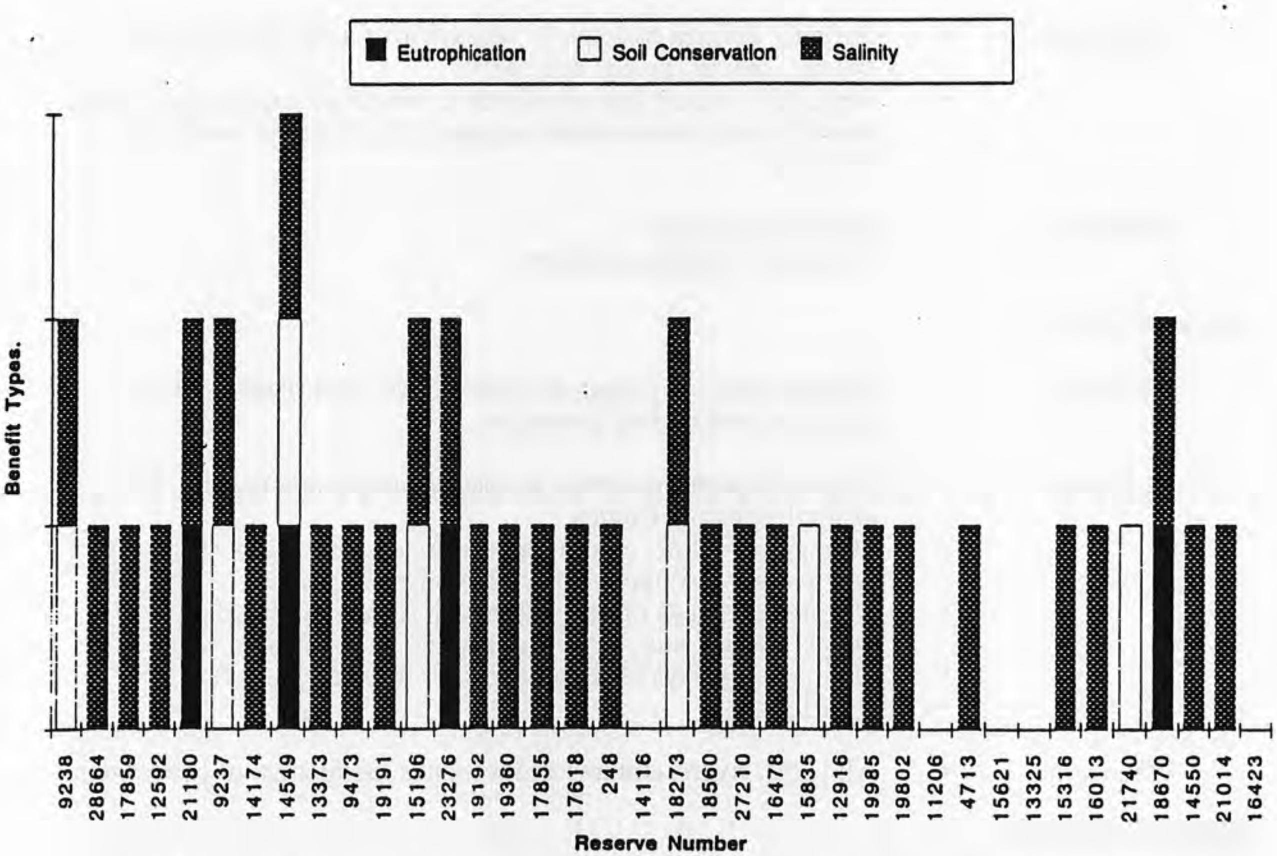

Figure 7. Soil conservation values of reserves

Water catchment

Reserves within the catchment of a town or farm water supply were identified as well as those that have a dam or well. In some cases this was a competing land use where water harvesting could alter the plant associations which formerly received water. In cases where there appeared to be potential to harvest water this was also recorded.

Landscape

The landscape characters of WA have been described in "Reading the Remote: Landscape characters of Western Australia" by CALM (1994). The wheatbelt plateau landscape character type is divided into four sub types, two of which encompass the central wheatbelt. The Dryandra uplands extend from the Darling plateau to the division which marks the westerly limit of the wide shallow valleys of the Merredin plateau subtype. The Merredin plateau subtype extends from the Dryandra Uplands subtype to the westerly edge of the Kalgoorlie plain character type and north to the Meekatharra plateau character type. *The remnants were assessed for their scenic quality according to the scenic quality classification and frame of reference for each subtype. A note in the survey records was made for those reserves exibiting the following features which are deemed to be of high landscape value.*

Dryandra uplands:

Landform:
- Isolated peaks or hills with distinctive form that become focal points
- Rock outcrops or jumbles of large boulders for example Boyagin rock
- Distinctive U shaped valleys for example Hotham river

Vegetation:
- Strongly defined patterns of vegetation of some diversity of species, colour, height and density
- Vegetation which shows distinctive form, line, colour and texture contrasts with surrounding vegetation for example wandoo at Dryandra

Waterform:
- Rivers and streams
- Wetlands, swamps and lakes

Merredin Plateau:

Landform:
- Isolated peaks or ranges with distinctive form rising starkly from the surrounding landscape

Vegetation:
- Trees with some diversity of species, height and density, for example wetland fringes
- Strong, form, line, colour and texture contrasts with surrounding landscape for example clumped remnant vegetation
- Distinctive stands of vegetation with strongly defined growth habits, texture and colour for example Salmon gums
- Dramatic displays of seasonal colour for example spring wildflowers

Waterform:
- All lakes, rivers, streams and wetlands, permanent or intermittent.

Special features

Special features such as geological or physiographic features were recorded. Examples would include greenstone outcrops and dykes.

Aboriginal sites

No aboriginal sites were observed but an investigation by people skilled in this area would no doubt find evidence of aboriginal use of some of the reserves.

"Sinks" for nutrients

Wallace (1994) reports that it is likely that eutrophication and the associated development of toxic water supplies will continue to increase. Therefore, the value of remnant wetlands as areas where excess nutrients may be trapped and used by plants is increasing.

Few of the reserves included wetlands and where they did their value as "sinks" for nutrients may be limited due to degradation caused by salinity. It is noted, however, that some saline lakes are very productive.

CRITERIA FOR RANKING SOCIAL AND RESOURCE ISSUES - COMMUNITY ATTITUDES AND INVOLVEMENT OF LOCAL GOVERNMENT

Community attitudes

An important criteria for reserve ranking could be community attitudes towards the reserve. In Victoria and increasingly in Western Australia the general public is playing an active role in managing conservation reserves. In some cases local municipalities have a positive attitude towards remnant vegetation and are promoting programs to retain and enhance local remnants. Some landowners take a keen interest in adjacent reserves and may have the potential to manage them.

The following groups could be consulted: Local Authorities, Land Conservation District Committees (LCDCs), catchment groups, community groups and adjacent land managers. Their attitude towards the reserve could be assessed, to determine willingness to manage the reserve together with any comments on their current uses of the reserves

In this study resources did not allow investigation of community attitudes for every reserve, but landowners were consulted on an opportunistic basis during the survey and the results noted in the survey records.

Local government and LCDC

Mukinbudin Shire and Mukinbudin Land Conservation District Committee (LCDC) were chosen for consultation regarding shire attitudes towards Water Authority reserves and their future uses. The Mukinbudin Community is progressive and keen to adopt management practices to reduce land degradation. It is recognised that shires further east where there is more native vegetation and salinity problems are yet to emerge may have been less sympathetic. There were five Water Authority reserves surveyed in Mukinbudin Shire, none of which were recommended to become NPNCA reserves.

Mukinbudin Shire had a positive attitude towards retaining remnant vegetation. They indicated interest in managing reserves which were not to be vested in the NPNCA, particularly if they had water harvesting potential. They have plans to rehabilitate reserves from which gravel has been extracted. The Shire indicated that it would prefer that reserves not be sold to the private sector.

The Mukinbudin LCDC also indicated a positive attitude towards remnant vegetation and retaining the natural values of the Water Authority reserves. They considered that the LCDC should not have responsibility for managing reserves but thought that some reserves could be managed by a sympathetic neighbour.

Management

The ability and willingness of the community to fund or otherwise achieve management of reserves will be important. Reserves with very high management costs to solve problems such as weed invasion will be less attractive than relatively intact reserves. In this study notes on management requirements were made for weeds, vermin, fencing, water balance, and other issues such as rubbish dumping. Recommendations were made for the most significant management issues encountered.

EVALUATION OF CURRENT METHODS FOR RANKING AND SELECTING RESERVES FOR NATURE CONSERVATION VALUES

So far we have examined attributes of reserves which could be used to rank them for nature conservation. Reserves could be ranked according to each individual attribute or the attributes could be combined in some way to give an overall score. The purpose of this section is to compare ranking systems which have been used in the past and to determine if any of these systems are appropriate for the wheatbelt or whether a new system needs to be developed.

Kirby (1993) has provided a study on methods for assessing nature conservation values. While his study is related to British woods the findings are relevant to this study.

He listed the following criteria as being generally accepted for consideration of the nature conservation value of a remnant:

- size;
- naturalness;
- rarity;
- fragility;
- diversity;
- typicality/representativeness;
- ecological geographic position;
- recorded history;
- potential value; and
- intrinsic appeal.

We should add connectivity, the spatial relationship between the remnant and its neighbouring remnants, viability, and competing and compatible landuses to this list.

Kirby (1993) considered that these criteria are not independent measures of a wood's value, but may be regarded as different ways of looking at the same thing, in the same way as different facets of a gem can be viewed.

PRINCIPLES FOR EVALUATION

Smith and Theberge (1987) stated 8 principles for the choice of an evaluation method for ranking the priority for protection of natural areas:

"The evaluation method should:

1. Be based on principles and assumptions that are valid and easily interpreted

2. Yield results understandable to decision makers and the public

3. Make explicit subjective values and judgements

4. Yield results that are repeatable given certain explicit assumptions

5. Allow use of qualitative and quantitative information in a methodologically sound way

6. Stimulate the imagination of decision makers and increase insight into the choices to be made

7. Enable use of information at different spatial scales

8. Allow consideration of alternatives both separately and in combination."

These principles have been used as a guide for judging the validity of current methods and the method developed for this study.

RANKING THE CRITERIA USING SCORING SYSTEMS

Scoring systems have been used as a method of judging the value of a remnant and for comparing the value of one remnant against the values of the other remnants but various concerns have been raised as summarised by Kirby (1993) below.

"Small difference say in the number of species or area may receive undue prominence because they can be quantified easily.

Simple combination of numeric scores for different attributes may be criticised for positive or negative correlations.

There is no definitive basis for comparing the score of one feature against another. Scores may create the illusion of precision and certainty about the results that is at odds with the reality of the recording process."

Smith and Theberge (1987) also considered this issue and concluded that evaluation methods should not be allowed to cloud important issues or conceal value judgements. Furthermore the assumptions of any evaluation method should be clearly stated and rationalised in terms of data and areas being compared.

Kirby (1993) concluded that the enthusiasm of the early eighties for multiple numeric scores of different features have been replaced by a more realistic appreciation that some aspects are best described in qualitative terms. Parallel rankings of woods for different features may be more appropriate to highlight their strengths and weaknesses than a single index.

The author's personal attempts to develop a scoring system for evaluating Conservation Covenant proposals for the Victorian Conservation Trust did not produce meaningful results. It was concluded that a remnant may warrant protection for one special feature or an "ordinary" remnant may warrant protection for the range of habitats provided or for its value as a corridor or stepping stone.

ITERATIVE SELECTION ALGORITHMS

Development of iterative selection algorithms

Iterative selection algorithms have been explored by a number of researchers in an attempt to overcome the difficulties in scoring systems and to meet the principles stated above.

The aim of the procedures emphasises the goal of representing the full range of conservation features in a region. The system has been analysed for, amongst others:

- selection of conservation reserves in forest areas of south eastern NSW Bedward, Pressey and Keith (1992);
- selection of reserves representing all land systems from the Western Division of NSW Pressey and Nicholls (1987);
- selection of remnants in the Eyre Peninsula Margules and Nicholls (1987).

Early attempts to find the minimum set of reserves that would represent all the biological diversity of a region were criticised as the reserves selected were often scattered and failed to address reserve design principles such as the value of large and continuous reserves.

These difficulties have been overcome by methods developed by Bedward, Pressey and Keith (1992), who introduced elements of reserve design into the methodology.

Nicholls and Margules (1993) overcame the scattered nature of the reserves that resulted from earlier work by including the closest site to other selections in the process and special sites, for example, Ramsar sites, to be selected first. They describe three distinct advantages of using algorithms. Algorithms are:

- explicit so that others can see clearly how the results are arrived at. Reserve networks chosen explicitly are more easily defended.

- efficient - a minimum set is only proposed as a core, not the final reserve network. It is a base on which to build regional nature conservation plans.

- flexible - the data base can be amended and different solutions can be compared and the algorithm itself or the rules governing choices at each step can be changed.

An example of flexibility is provided by Margules and Nicholls (1987) for the Eyre Peninsula where the largest and nearest patch was chosen where there was a choice. In this study the authors stated that: *adequate representation is unlikely to be achieved simply by ensuring that each (plant) community is represented at least once.* They found that there were insufficient remnant patches to ensure that each community was represented at least 5 times.

The applicability of iterative selection algorithms in the central wheatbelt

Do iterative selection algorithms have application to reserves in the central wheatbelt? Do we wish to select the minimum number of reserves which will adequately represent the natural diversity?

A minimum set of sites that samples all species, communities, or environments will almost certainly not be sufficient to maintain ecological processes in the long run. The value of iterative selection algorithms is the assistance they provide in selecting protected area networks that sample a greater proportion of biological diversity on fewer sites (Margules *et al.* 1994).

In the wheatbelt there has been extensive clearing, followed by degradation of remnants. Given also the high genetic turnover with distance, we already have less than the minimum number of reserves to represent the original natural communities. This situation is further complicated given that metapopulations, using a number of remnants, are important for regional nature conservation. If all these factors are properly considered, then the algorithm process will simply result in a list of all the reserves and we should instead be studying how best to manage them all!

For the minimum set algorithm system to work in the wheatbelt the following three aspects need to be resolved:

- the lack of a common data set
- criteria limitations
- the need for measures of reserve quality (or intactness).

Each is considered in more detail below.

Lack of a common data set

This study was limited to 38 Water Authority reserves for which a common data set was prepared from the field work component of the study (the field work did not include seasonal variations). An algorithm could be developed to select the reserves that will represent, for example, the key communities. As the data does not encompass all remnant vegetation in the central wheatbelt it will not be possible to compare the selected reserves with, say, NPNCA reserves or reserves on private land.

Margules and Nicholls (1987) used a logistic regression model to predict unsampled areas. This approach is unlikely to be applicable for the central wheatbelt due to the degree of endemism, species turnover, variety of vegetation associations, scarcity of remnants and presence of threatened species.

Criteria limitations

Where iterative algorithms have been used the criteria for selection have been limited to the variables that were known for all areas. In the case of the wheatbelt there are multiple criteria for nature conservation values. It could be difficult to decide which values are the most important - for example, land systems, or plant communities or rare species, etc. We would also need to build in extra criteria for fauna conservation - for example, the value of remnants as stepping stones, or special features such as plant communities which provide autumn/winter food sources.

Reserve quality/intactness

This concept has generally not been included in iterative selection algorithms. It adds an extra dimension of complexity but is very important, particularly for small isolated reserves.

Conclusion

It is concluded that iterative selection algorithms are not a useful tool for ranking reserves in the central wheatbelt due to lack of a complete data set and high diversity, endemism and species turnover. Iterative selection algorithms may be useful where habitats are similar across a wide area but even then they still do not take into account fauna movements and metapopulations.

IRREPLACEABILITY

The Irreplaceability concept

Pressey *et al.* (in press) have introduced the concept of irreplaceability which can be used for ranking reserves in highly fragmented landscapes. Irreplaceability is defined as: (i) the potential contribution of any site to a reservation goal; and (ii) the extent to which the options for a representative reserve system are lost if that site is lost. The irreplaceability of sites is a fundamental measure of conservation importance as well as a basis for negotiations over individual sites or whole networks of protected areas.

While irreplaceability was developed for selecting a reserve network in a large area of forest Pressey (in press) is confident that the system would work for vegetation fragments in the wheatbelt of New South Wales; and it would work for any data base listing one or more natural features of each site, whether the sites were part of a continuous landscape of natural vegetation or remnants of vegetation separated by large expanses of cleared land.

Values for irreplaceability can take into account special areas or areas essential for conservation. Such sites can simply be nominated in the system as mandatory for conservation so that any calculations and graphics treat them as having irreplaceabilities of 100 (maximum). All the deliberations for other sites in the region then take into account the extent to which the representation goal has been achieved with the mandatory sites. Examples of mandatory sites in the wheatbelt might include remnants in groundwater recharge zones and in areas with potential for dryland salinity, streambank erosion or serious degradation of soils and remnants with rare species and threatened communities.

The concept utilises an interactive computer system consisting of three components: Windows E-RMS, the software for predicting irreplaceability, and the data base management system.

The applicability of irreplaceability in the central wheatbelt

This study has discussed a number of attributes of reserves which could be used in a ranking process. The work on irreplaceability to date has worked with a much more limited data set. The challenge of using irreplaceability will be to work with the multiple criteria which have been identified.

R. Pressey (pers. comm.) has suggested that irreplaceability could be based on intrinsic biological values: rare species, species and associations. He suggests then adding information on priority for protection - a function of threat, feasibility for protection, and the type of protection measures that are appropriate.

There appear to be a number of difficulties in applying irreplaceability to the selection process. These include:

- The irreplaceability methodology does not seem to cater for the number of criteria that have been identified. Different decision makers will have different opinions regarding which criteria should be included as mandatory. There would have to be a rerun of the selection process for each decision.

- There is concern that the subjective selection of scores for different criteria will not yield results that are understandable to decision makers nor increase insight into the choices being made.

- The use of irreplaceability is limited by the amount of computing required (Pressey *et al.* 1993).

- GIS information is not available at this time for the reserves in this study.

The methodology suggested in this report for the wheatbelt incorporates a data base of the criteria which could be readily adapted to the irreplaceability concept. The approach may be worth pursuing if a method of incorporating the range of criteria identified in this study can be found.

MULTIPLE CRITERIA ANALYSIS

Multiple-criteria analysis is part of a collection of decision-support techniques that range from simple graphical methods to sophisticated mathematical programming. This discussion is based on the analysis of multiple-criteria analysis by the Resource Assessment Commission (1992). It uses the term multi-criteria analysis to refer to techniques that have the following components:

- a finite number of alternative plans or options

- a set of criteria by which the alternatives are to be judged

- a method for ranking the alternatives based on how well they satisfy the criteria.

Multi-criteria analysis can deal with qualitative scores or a mixture of quantitative and qualitative scores.

The ability of multi-criteria analysis to cater explicitly for different points of view is one of its strengths - people with different values will arrive at different answers to the same problem.

Steps in the analysis

Specifying the alternatives

Agreement must be reached on the alternatives to be considered. In the wheatbelt study the alternatives could be to identify reserves that should be managed:

- solely for nature conservation
- primarily for nature conservation, but also for compatible, non-consumptive uses
- primarily for consumptive uses (for example, firewood gathering, seed collection or gravel extraction)
- for private use - that is, reserves that could be sold.

Specifying the criteria

In specifying criteria to be used in multi-criteria analysis, compromises may be necessary between selecting criteria that are relatively easy to measure and selecting criteria which are difficult to measure. There is a general rule of thumb that criteria should number less than 12.

An important rule is that no aspect of the problem is accounted for more than once. It has already been argued that many reserve criteria are linked, for example, diversity and area. The addition of scores for each factor will weight the factor unfairly compared with a factor which has only one criteria. This may not be a problem if the process is explicit.

A second problem occurs when criteria are not linked with nature conservation values in a linear fashion. For example, in many cases increasing diversity will be better for nature conservation. But for some species, increasing diversity will be at the expense of reducing essential habitats to a size that is not viable for that species. A second example is the relationship to other conservation reserves. From a species movement point of view the closer reserves are the better. However, once reserves are over a certain distance apart, say 15 kilometres, their value may increase as their isolation suggests that they will contain species or genotypes not represented elsewhere in the reserve system.

Scoring the criteria

Some value or score must be assigned to the range in values of each criteria and all criteria need to be reduced to a comparable or standardised basis to eliminate the effects of scale.

There are a number of concerns regarding the arbitrary assignment of scores. While such scoring has intuitive appeal, the allocation of points is arbitrary and subjective. Scores assigned to different levels of criteria often have little relation to ecological theory and practice (Smith and Theberge 1987). This is a concern because, from the faunal studies, it was found that selection criteria could be applied to individual and groups of similar species but could not be applied generally.

Assigning weights to the criteria

This can be the most valuable aspect of multi-criteria analysis because it allows different views and their impact on the rankings to be expressed explicitly. Weights can be assigned by different groups of people with different points of view and the results compared. It is then possible to determine how much a particular weight must change before the ranking of two alternatives changes.

The applicability of multi-criteria analysis in the central wheatbelt

Multi-criteria analysis has similar attributes to scoring systems in that it is necessary to assign a numeric score to the criteria. The biggest difference is that weighting of the scores can be changed. Different weightings can be assigned from different points of view and the results compared. It can be an interactive process that guides decision making rather than providing an "ideal" solution dependent on the viewpoint of the participant.

But there are difficulties in selecting criteria that are not independent, scoring the criteria in an ecologically sound way and in dealing with non linear criteria. There is also concern that if many criteria are used details will be absorbed in a "black box" and the results will not be readily understandable.

Multi- criteria analysis does not have to be mathematically based and presentation of rankings of the data in a visual fashion could be of greatest benefit to decision makers and is a legitimate form of multi-criteria analysis. Limited resources prevented exploration of a mathematical approach but presentation of the data in a visual fashion is suggested as a partial solution to some of the problems discussed above.

Summary of methods for ranking reserves and their applicability in the central wheatbelt for a subset of reserves (No judgement is made regarding the suitability of these methods in different situations)

Method	Suitability	Reasons
Scoring systems	Not suitable	No definitive basis for comparing the score of one feature against another, positive and negative correlations between criteria can occur, easily quantified measures receive undue prominence, create the illusion of precision.
Iterative selection algorithms	Not suitable	Only a sub sample of reserves were surveyed, difficult to apply multiple criteria, criteria for all variables not known for each reserve eg rare species. Minimum set of reserves more difficult to define in WA wheatbelt with high diversity, endemism and species turnover.
Irreplaceability	Not suitable	Subjective selection of score for irreplaceability, difficult to apply multiple criteria, high computer power required, GIS information not available for this study.
Multi-criteria analysis -mathematical modelling	Potentially suitable for some criteria	Can provide rankings for relative value of subset of reserves but difficult to apply with dependent criteria eg area and number of associations. Difficult to apply if no direct correlation between increasing criteria value and conservation value. Eg increasing habitat diversity may not be positive for some species. Limited time in this study prevented a mathematical approach being explored.
Multi-criteria analysis - visual approach	yes	Allows the trends in value of criteria to be seen visually. Numeric scores not required. Different users can choose appropriate criteria to their needs, transparent, not a black box.

A PROPOSED RANKING METHOD FOR THE CENTRAL WHEATBELT

Each reserve in the central wheatbelt has a unique set of values not only for nature conservation but also for viability, competing uses, compatible uses, management and community attitudes. A system that enables the different reserves to be compared in a manner that meets the principles detailed on page 34 of Smith and Theberge (1987) is required. Of the systems analysed multi-criteria analysis appears to meet these objectives provided the criteria and the scores assigned are valid. This study does not have the resources to explore a mathematical approach to multi-criteria analysis for the wheatbelt but considers that a data base of key reserve attributes can be used to express the range of reserve attributes in a visual fashion as well as being useful for selecting reserves that meet particular criteria.

The concept is to show pictorially through graphs the values of different criteria so that the range of reserves can be compared and to interrogate the data base with selection criteria to suit different requirements. A range of such diagrams have been used in this report, see Figures 2-7. They show the range of values, for example, in the case of area, that few reserves are greater than 100 hectares in area and there are many small reserves. It is also useful to show relationships between criteria for example area and diversity. This broad knowledge of the range of values of all reserves provides an overall understanding of the reserves studied and can be helpful in deciding cut off values for recommendations. For example the number of reserves greater than 30 hectares may not capture sufficient reserves and the cut off may be made at 25 ha.

The reserve reports are designed to be descriptive so that they can be used to provide a "picture" of each reserve to assist in decision making. Information on feasibility for protection, and the type of protection measures that are appropriate can then be added to the decision making process.

DECISION MAKING PROCESS

The decision making process is outlined below:

1. Consider which criteria will be important in decision making
2. Develop graphs of the criteria
3. Compare all reserves, or a selection of reserves
4. Decide values of criteria to be used in selecting reserves
5. Search data base for reserves which meet each of the criteria
6. Interrogate field reports to gain additional information
7. Consider social objectives and financial limitations
8. Select reserves

There will be a feedback process as knowledge of the reserves is increased

DATA BASE AND SPREADSHEET

The key criteria were entered into File Maker Pro, a data base for Apple computers. A sample of the data is tabled in Appendix 3. The data base information can be exported to DOS based systems and was exported to an EXCEL spreadsheet to produce graphs for a range of reserve values. Refer Figures 2-7.

INTERROGATING THE DATA BASE FOR RESERVES WITH HIGH NATURE CONSERVATION VALUES

Once an understanding of the range of values and qualities represented in the data set is achieved the data base can be used to select lists of reserves which meet certain criteria. This process enables different decision makers to select reserves according to the criteria they feel are important. A comparison of the selected reserves can then be made.

One of the purposes of this survey was to recommend reserves which should be vested in the NPNCA for their high nature conservation values. The following criteria have been chosen and the reasons for the choice explained. It is stressed that these criteria have been chosen to demonstrate the methodology, they do not represent actual criteria that might be used by the NPNCA or government agencies to select nature reserves. Note that the criteria used are quite strict and, in particular, over-emphasise the value of Class 1 vegetation.

Area

A study of the graph of total area and intact area shows there are a number of reserves that, while large, have relatively small intact areas. It is assumed that weediness in these reserves may be increasing and their nature conservation values decreasing. Hence it may be better to select for intact area rather than total area. A cut off value for area is difficult to select. Thirty hectares has been chosen because many of the fauna studies indicated that (in the order of) thirty hectares was a total area under which it would be difficult for fauna to survive. Thirty hectares of intact vegetation is therefore a conservative cut off.

Priority associations

Class 1 vegetation is a high priority for reservation. Figure 2 on page 9 shows that most of the larger reserves contain some Class 1 vegetation. All reserves containing Class 1 vegetation and over 30 ha were included.

Viability

There is little point vesting in the NPNCA reserves which have poor viability. Any such reserves are excluded.

Diversity

Because greater diversity does not necessarily indicate greater nature conservation value for fauna it was decided not to use diversity as a criteria for selecting reserves for vesting in NPNCA.

Relationship to NPNCA reserves

Reserves adjacent to NPNCA reserves add to the value of those reserves because of the recognised trend that the larger the reserve the greater the nature conservation value. Provided these areas are viable it is sensible to incorporate them into the NPNCA reserve.

Rare and special occurrences of flora and fauna

A number of reserves which did not meet the above criteria for vesting in the NPNCA contained threatened and priority flora. These reserves could be considered for inclusion if their other values warrant inclusion or some other mechanism for securing the reserve is required.

SELECTING RESERVES WITH HIGH NATURE CONSERVATION VALUES FOR POSSIBLE VESTING IN NPNCA

From the discussion above the following criteria have been selected for high nature conservation values:

Reserves should have intact areas greater than 30 hectares and
Reserves should contain Class 1 vegetation and
Reserves should not be ranked low for viability.

Reserves which meet these criteria are: 9237, 9238, 9473, 13373, 14549, 17859, 28664. (Reserve description summaries appear in the table below).

There is a second set of reserves which while they may not meet the above criteria are potential NPNCA reserves due to their location adjacent to NPNCA reserves:

Reserves are adjacent to NPNCA reserves and
Reserves are not ranked low for viability

Reserves which meet these criteria and are additional to the above reserves are: 21180 and 14116. (Reserve description summaries appear in the table below).

A third set of reserves for possible vesting in the NPNCA are those with rare or special occurrences of flora and fauna.

Reserves contain threatened flora or special occurrences of flora or
Reserves contain rare fauna

Reserves which meet these criteria and are additional to the above reserves are: 248, 15621, 15835, 17618, 18273 and 19192.

A different decision maker could just as easily choose different criteria and cut off values and the two selections can then be compared. As an example reserve 14174 does not contain Class 1 vegetation but has an intact area greater than 30 hectares. It also has high diversity with six vegetation associations. If high diversity was a criteria for choosing NPNCA reserves then this reserve would have been chosen. It is interesting that the survey team intuitively considered that reserve 14174 should be considered for vesting in the NPNCA. This shows the importance of using the criteria as a guide, being open to other selection criteria and review of the field reports.

The importance of reviewing the field reports has been shown above. The following table shows the reserves which were suggested as NPNCA reserves by interrogating the data base and the recommendations made intuitively by the survey team.

Comparisons between reserves selected intuitively and selected by interrogating the data base.

Reserve	Intuitive	Data base*	Description
9237	yes	yes	A diverse reserve of 81 ha. with Class 1 vegetation adjacent to a NPNCA reserve
9238	yes	yes	A diverse 259 ha. reserve with Class 1 vegetation in excellent condition
9473	yes	yes	A diverse 53 ha. reserve with Class 1 vegetation in good condition
13373	yes	yes	A diverse 67 ha reserve in good condition with Class 1 vegetation
14116	yes	yes	A diverse 32 ha reserve, mostly intact, adjacent to an NPNCA reserve
14174	yes	no	A diverse 75 ha reserve, largely intact, no Class 1 vegetation.
14549	yes	yes	A diverse 71 ha. reserve in reasonable condition but part subject to rising salinity
16478	yes	no	A 21 ha reserve with Class 1 vegetation adjacent to a large shire flora reserve. With the shire reserve there would be 400 ha. possibly suitable as an NPNCA reserve
17618	yes	no	A 36 ha. largely intact reserve with Class 1 vegetation adjacent to 23276 below and a large water reserve. With the water reserve could warrant protection as an NPNCA reserve
17859	yes	yes	A 94 ha. diverse reserve with Class 1 vegetation, largely intact
21180	yes	yes	A 81 ha. reserve with Class 1 vegetation (salmon gum) but no large area of the reserve is free of weeds
23276	yes	no	A 40 ha. diverse reserve with Class 1 vegetation adjacent to 17618 above and a large water reserve. With the water reserve could warrant protection as an NPNCA reserve
28664	yes	yes	A 101 ha. diverse reserve with Class 1 vegetation

* Data base selections for reserves with intact area greater than 30 ha and Class 1 communities or adjacent to NPNCA reserves and not low viability (excluding reserves with rare or special occurrences of flora or fauna).

The importance of reviewing the field reports is demonstrated by the above table. There are a number of reserves which were recommended by the survey team to be NPNCA reserves which were not identified by interrogating the data base. In a number of cases proximity to large shire or water authority reserves suggested that as a whole they could warrant recommendation as NPNCA reserves. It appears that the study should have investigated adjacent reserves and included this data and criterion when selecting reserves for NPNCA status.

The above discussion highlights the interactive transparent process which has been developed. Selection procedures can be modified and different points of view accommodated. There is no black box computer program, all processes are easily understood by decision makers and interaction between decision makers is encouraged.

INTERROGATING THE DATA BASE FOR RESERVES WITH HIGH SOIL CONSERVATION VALUES

It is also possible to select for reserves for other values such as high soil conservation values. Again the overall data can be viewed graphically to determine the range of values. It can be seen from Figure 7 that only three reserves are valuable for eutrophication control and six have high values for soil conservation. There are many reserves valuable for salinity control. It may be desired to choose only those reserves with an area say greater than 50 hectares or those reserves for which there is no competing uses such as gravel extraction. Those reserves that are greater than 50 hectares and are valuable for salinity are as follows: (50 hectares is an arbitrary cut off value and any other value could be chosen to suit management requirements)

> Reserves that are greater than 50 hectares and
> Reserves that are valuable for salinity control

Reserves which meet these criteria are: 9237*, 9238*, 9473*, 12592, 13373*, 14174*, 14594*, 17859*, 21180* and 28664*.

Reserves with an asterisk * have also been recommended as NPNCA reserves. It is interesting to note that all but one of the reserves selected for salinity control are also recommended to be NPNCA reserves.

APPLYING THE METHODOLOGY TO LARGER DATA BASES AND OTHER AREAS

The methodology has been found to work for 38 reserves but how will it work for a larger number of reserves? There is no problem working with a larger data base but for the graphical presentations the following solutions are suggested:

- The graphical presentation pre-sorts the reserves into two or more area classes. For example all the reserves greater than 50 hectares are displayed separately from the smaller reserves, or

- The reserves are divided into regional groups and displayed on a regional basis.

The methodology should also work for other areas. Naturally the criteria for selection may be different. For example if there is not a high degree of endemism the distance between reserves may be less important. The methodology has been developed for a subset of reserves in a region where there appear to be already too few reserves to conserve the remaining biota. While the methodology could be applied to all the reserves in a region it is suggested that the other approaches such as iterative selection algorithms could be used if a minimum set of reserves to meet a particular objective was required.

THE FIELD SURVEY

THE SURVEY FORM

The survey form and field methodology for this study was developed to meet the needs of the selection process. The form (Appendix 4) incorporates a summary front page so that descriptions of the key criteria for each reserve can be seen at a glance. The form is designed to be descriptive and understandable and does not use codes. The report is divided into sections to clearly differentiate between intrinsic values, viability, competing uses, compatible uses, community attitudes and management issues. Site plans include maps of vegetation associations, site features including levels of weed invasion. A photo location plan and photos of the reserves are incorporated into the report. A sample of a completed reserve report is attached as Appendix 5.

COLLECTING THE FIELD DATA

The survey team comprised a team leader with experience in habitat assessment, habitat management and land capability assessment and a qualified botanist with experience in wheatbelt vegetation. A specialist wheatbelt botanist provided plant identifications where required.

The survey area comprised part of the central wheatbelt of Western Australia, Figure 1. The majority of reserves were less than 100 ha (one reserve was over 250 ha) with an average size of 41 hectares. The smallest reserve was 5 ha. Sufficient resources were available to spend an average of half a day per reserve including travelling. The survey was carried out during spring 1994 which was unusually dry.

Plans of each reserve were prepared from cadastral plans and aerial photos at 1:5 000 and 1:10 000 depending on reserve size (so that the plan would fit on an A4 page). Tentative vegetation formation and association boundaries were drawn from the aerial photos (1:50 000 or 1:80 000 scale, not available for each reserve).

Equipment included two cameras, two pairs binoculars for fauna sightings, five centimetre sand auger, water bottle for soil texture analysis, hand lens, identification books, plastic bags and labels for specimens, day packs, record sheets and note books.

At the reserve an overview of vegetation and condition was obtained by driving boundaries and tracks or walking where access was difficult. Distances to vegetation association boundaries were recorded where possible. Confirmation of the tentative mapping of associations was obtained. Each member of the survey team then worked independently but coordinated transport as required. The team leader mapped and photographed the reserve for weed cover classes, tracks, gravel pits and other impacts, obtained soil profile information for each vegetation association, mapped and recorded external influences on the reserve and assessed connectivity. The botanist studied and photographed each association, confirmed aerial photo interpretation, recorded all species and cover classes and habitat variables such as hollows in a wandering traverse. Specimens were collected where identification was not certain. Both the team leader and botanist recorded fauna sightings. On completion of the survey discussions confirmed vegetation association mapping and weed cover classes mapping; fauna sightings were combined and issues relating to viability and reserve management were discussed.

Final survey forms were completed as soon after the survey as possible, that evening or following the field trip. At this time additional information was recorded, for example, map references, measures of connectivity, etc.

The survey methodology was efficient. A team of two people with complementary skills were able to work together when required but also independently on different parts of the survey. Because team members looked at different parts of the reserves more of each reserve was covered than if the team members always worked together. Discussions on all facets of the survey and reserve took place ensuring that little was overlooked and areas of difficulty were resolved. There was a safety issue of working independently which will be resolved by carrying radios. This will also improve efficiency.

INTERPRETING THE FIELD REPORTS

There were several challenges of collecting the information for the reports in the field and these together with suggestions for future surveys follow:

Aerial photos

- Aerial photos were not supplied for a number of reserves. This made it difficult to map vegetation, features and to determine connectivity for these reserves.
  Aerial photos were generally 10 years old, many changes including clearing and salinity have occurred since that time.
- Aerial photos were at 1:50 000 and 1:80 000 scale. Larger scale, preferably 1:25 000 colour photos, would improve the accuracy and efficiency of mapping both vegetation associations and disturbance features.

It is suggested that up to date colour satellite imagery be made available for future studies to provide an overview of each area particularly to assist in determining connectivity and relationship to other reserves. They would be most helpful if larger scale aerial photos are not available.

Connectivity

- Connectivity was estimated for each reserve where there was an aerial photo available.
- The estimate of connectivity was difficult because of changes since the aerial photos were taken, insufficient time to field check each nearby remnant and its connectivity and difficulty in determining consistently from the aerial photos acceptable corridors and acceptable remnants to count.

It is suggested that up to date aerial or colour satellite imagery and more time to field check adjacent remnants and corridors is required if meaningful measures of isolation are to be produced.

Relationship to CALM reserves

- Information was sought from CALM office in Merredin and Muir's reports on reserves in the wheatbelt circa 1978. Insufficient information was available in all cases to compare vegetation types between the reserve being studied and the closest NPNCA reserve, nor was there time to field check nearby reserves. Connectivity could not be determined in a number of cases.
- It was felt that it would be more meaningful to compare each reserve with three or more nearby reserves to provide a better comparison.

Intactness

- The mapping of intactness classes is intended as a guide to levels of weediness in reserves. There is difficulty in determining precise boundaries as weeds are often patchy and different levels of infestation merge with each other, lack of reference points can make accurate mapping difficult.

Wildflower harvesting

- There were no observations of wildflower harvesting, past or current, nor was it possible to determine if commercial quantities of desirable species are available.

Land capability

- Save for the completed Northam study (Lantzke and Fulton) there was little complete land capability information available. For most reserves soil profiles were described from augured profiles for each vegetation association. Land capability classes were determined by comparing the described soils with draft information from the Department of Agriculture and the Northam report.

Catchment cleared

- Percentage of catchment cleared was determined from information supplied by the Department of Agriculture. Scattered and modified vegetation was not included in the analysis.

Community attitudes

- Community attitudes were determined for the Shire of Mukinbudin otherwise on a opportunistic basis if an adjacent landowner was contacted.

SURVEY COSTS

On the basis of the work required to survey and describe the thirty-eight reserves discussed in this report, the total costs for survey, report writing and preparing recommendations is $37/ha for 38 reserves with an average size of 41ha, and ranging from 5ha to 259ha. This assumes:

- 69 days work each for 2 consultants at $300/hr.
- 10 days work for consultant (plant identification)
- 11400km travel involved in a 4x4 to complete the project.

RECOMMENDATIONS

The following reserves should be considered as a high priority for vesting in the NPNCA because of their high nature conservation values. The reserves meet the following criteria: they have intact areas greater than 30 hectares, they contain Class 1 vegetation types, and they are not ranked low for viability, or they are adjacent to NPNCA reserves and not ranked low for viability. Some of the reserves also contain special features such as rare species.

9237	A diverse remnant of 81.8 hectares adjacent to a NPNCA nature reserve and private remnant vegetation. Contains a small area of uncut gimlet woodland. The extent of grassy weed invasion is surprising.
9238	A large diverse remnant of 259 hectares in excellent condition save for grassy weed invasion in the lithic complex and edges and a gravel pit. Proximity to other remnants adds to its value.
9437	A rich, diverse, largely intact remnant of 53.3 hectares with salmon gum woodland, high granite outcrop, lithic complexes and breakaway. The old dam which was fed by a channel from the rock outcrop is now in disrepair.
13373	A diverse reserve of 67.3 hectares with attractive salmon gum woodland, areas degraded by weeds and gravel extraction. It is adjacent to other vegetated Crown Land but an adjacent piggery/rubbish dump detracts.
14116	A diverse remnant of 32.3 hectares, mostly intact, very valuable due to its proximity to an adjacent NPNCA reserve.
14549	This is a diverse reserve of 71 hectares of mallee, Acacia shrubland, Melaleuca thicket and woodland of considerable conservation value. These values have been reduced significantly by: 1. Timber cutting in the past depleting the salmon gum woodland. 2. Construction of a drain from farmland into the reserve affecting almost 16% of the area.
17859	This reserve of 94.7 hectares is largely intact and a good example of the diversity in the area. The salmon gum, wandoo, gimlet woodland is excellent despite past timber cutting.
21180	A diverse reserve of 81.82 hectares with some valuable woodland areas of salmon gum and gimlet. No large area of the reserve is free of weeds save for 26 hectares which is almost free of weeds.
28664	A diverse reserve of 101.19 hectares with a large area of granite outcrop plus woodland, mallee and shrubland communities. Unfortunately the lithic complex is invaded with grassy weeds and the shrubland community is almost destroyed by gravel extraction.

The following reserves did not meet the above criteria but were considered by the survey team to have either by themselves or with adjacent reserves to have sufficiently high nature conservation values to be worthy of NPNCA vesting:

14174	This is a large, mostly intact diverse remnant of 75.27 hectares with high conservation values. The new road and large gravel pit are a detraction as is the recent rubbish dumping within the reserve.

16478 A 21.2 hectare reserve with an attractive York gum woodland and small area of shrubland on gravel. The reserve is included within reserve 12614 which is a large shire reserve which appears to be of considerable conservation value. There is a dam which holds water and rubbish dumping.

17618 A reserve of 36.4 hectares with mallee, shrubland and salmon gum woodland with very few weeds, but degraded by gravel stripping and timber cutting in the past. It is connected to reserve 23276 (below) by Water Reserve 12693.

23276 A diverse reserve of 40.5 hectares of lake (dry), mallee and York gum woodland and shrubland. Rising salinity is affecting the lake bed and adjacent vegetation and grassy weeds cover approximately 48% of reserve. It has 2 boundaries with Water Reserve 12693 which also connects it to reserve 17618 above.

The following reserves should be considered (as a second priority to those listed above) for vesting in the NPNCA, given their special features such as rare species:

248 This reserve of 32.3 hectares with wandoo and York gum jam woodland is species poor and has high levels of weed invasion. The seasonal watercourse is moderately saline and rubbish dumping is a problem. Mature trees provide wildlife values. Contains Priority 3 species *Stenanthenum tridentatum* 8005.

15621 This 12.2 hectare reserve is largely intact with Mallee Shrubland and Mallee on deep sands and Allocasuarina thicket/shrubland. Weed and rubbish occur on edges to roads and in one previously cleared area. Gravel exploration scrapes occur but have not shown commercial quantities of gravel. Contains Priority 3 species *Acacia scalena* 8093.

15835 This reserve of 20.6 hectares with mallee, shrubland and York gum is largely intact and has not been grazed for a long time. The old well is an historic feature and the area near the well has been cleared. Contains undescribed species *Mubelia* sp. *aff. multiculmis* which has only been collected on two other occasions.

18273 A reserve of 29 hectares with unfenced, grazed, degraded shrubland, mallee, gimlet woodland and a prominent rock outcrop. The rock outcrop has deep pools with soil accumulation which contain the DRF *Myriophyllum petraeum.* Sand pits require rehabilitation and rabbits are prolific.

19192 A reserve of 40.47 hectares with an attractive high rock outcrop surrounded by shrubland, tall *Allocasuarina huegeliana* thicket and York gum woodland. Grassy weeds are a problem particularly on open areas. There is an access track to an attractive picnic site. Is believed to contain the DRF *Eucalyptus crucis ssp. crucis.*

The following reserves should be considered for nature conservation and other land uses including vesting in the Lands and Forests Commission for testing the commercial potential of woody perennials and the development of specialist seed orchards; and vesting in shires, particularly for use (where cleared land is included) for the establishment of landcare seed orchards, use for the establishment of firewood plots, etc. It must be stressed that the larger reserves, in particular, may be worthy of vesting in the NPNCA, and may warrant further assessment.

4713 This 14.19 hectare reserve is a rugged broken granite outcrop surrounded by gentle outwash slopes with shrubland and jam woodland vegetation. Grazing and weeds have greatly reduced plant diversity.

11206 Remnant of 15 hectares with shrubland and emergent mallee on shallow granite possibly previously cleared, has high weed cover.

12592 This remnant of 82.4 hectares is in 2 parts. The northern side of 46 hectares has not been grazed, 44% has been partly cleared but otherwise contains 26 hectares of diverse associations of shrubland, mallee, York gum, salmon gum and gimlet woodland. Of these areas only 37% is mostly free of weeds. The south side has been heavily grazed and has a catchment dam. There is virtually no understorey vegetation and a high weed cover.

12916 This remnant of 20.25 hectares was formerly a valuable woodland, degraded by clearing, grazing and salinity. It has some wildlife and water use value.

13325 Over half the remnant of 12.14 hectares has been cleared, the rest mainly salmon gum, York gum and gimlet woodland is moderately and severely degraded but the structure of the woodland is intact.

14550 This reserve of 8.09 hectares with granite rock outcrop and associated vegetation is 62% cleared, is over run with rabbits and has high weed cover.

15196 A remnant of 42.03 hectares, degraded by salt and grazing. But contains valuable wetland fringe woodland areas with good habitat values which could recover if grazing ceased. Close to large 400ha granite outcrop private remnant.

15316 This reserve of 10.1 hectares with mainly mallee shrubland is not fenced and has been heavily grazed by rabbits and stock in the past. The result is open bare hard areas with sheet erosion being a problem.

16013 This reserve of 10.1 hectares with shrubland and mallee has been seriously disturbed by ongoing gravel stripping which has impacted on over 40% of the area. There has been no rehabilitation.

16423 This 5.06 hectare remnant of shrubland with mallee is suffering from past disturbances, weed encroachment and rubbish dumping. The old well is a historic feature.

17855 This diverse remnant of 38.4 hectares has a long history of human activity and is consequently partly cleared and quite weedy. The salmon gum woodland is attractive. There is an adjacent old school site and well (on the reserve) - both historic features.

18560 A valuable small reserve with 24.2 hectares of shrubland, mallee, shrubs and granite outcrop, with good intact areas. A recent fire has increased weeds in already weedy areas, but few weeds in previously intact areas.

18670 A partly degraded reserve of 8.1 hectares containing York gum mallee, shrubland and Melaleuca uncinata thicket. Lower parts could be affected by rising water tables in the future.

19191 A valuable reserve of 48.5 hectares with a prominent rock outcrop and shrubland and mallee vegetation. Unfortunately it appears to have been grazed in the past so the lithic complex is very weedy. The rock is a significant water catchment for the adjacent farm which has retained large areas of remnant vegetation including a valuable woodland area adjacent to the reserve. The presence of nearby permanent water may affect bird numbers positively.

19360 This reserve of 40.7 hectares is included within a large private area of remnant bushland which is grazed. It is a complex of granite outcrops with mallee, Acacia and shrubland. Grassy weed invasion is high, particularly in open areas adjacent to rock outcrops due to grazing.

19802 The small reserve of 16.18 hectares is adjacent to a large area of granite outcrop and lithic complex on private property. It has been damaged by previous clearing and granitic sand extraction.

19985 An attractive reserve of 16.2 hectares with gimlet/salmon gum woodland and York gum mallee but generally infested with weeds although some intact areas (not mappable) exist. Old paddock, well, windmill and yards in one corner indicate heavy past usage and grazing.

21014 A reserve of 5.1 hectares with granite outcrop and shrubland which is severely grazed and degraded due to lack of fencing and provision of a dam fed from the rock catchment.

21740 A narrow reserve of 9.7 hectares with heavily weed infested shrubland and York gum mallee. It could be valuable, as a node on the road side corridor between two large remnants.

27210 A small reserve of 22.6 hectares with granite outcrop, shrubland and York gum, part of which appears to have been previously cleared. There is an old well and unfortunately only 25% of the reserve has less than 20% cover of grassy weeds.

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Appendix 1. Areas identified as valuable for salinity protection (Holm 1994)

Salinity
(all regions)

Rainfall greater than 1100 mm – no salinity risk if drainage lines are present.

Rainfall less than 1100 mm – there may be a risk due to high levels of salt storage in the regolith. This risk can be minimised by not clearing:

1. Rocky ridges and hill tops with freely draining soil profiles.
2. An area upslope of dykes and other geological features (where evident), which may act as hydrological barriers. Sufficient vegetation should be left (or established):
   (a) to cope with the extra recharge from upslope cleared areas assuming that extra recharge will not be < 7% of mean annual rainfall; and
   (b) the vegetation will transpire saline groundwater at 0.4 of Class pan A (see footnote). A minimum strip of 50 m width should be left.
3. An area adjacent to outcrops of country rock. Sufficient fringing vegetation should be left around the outcrop to transpire the runoff from the rock. The area can be calculated assuming runoff from the rock is 60% of annual rainfall and that the vegetation, in a water accumulating zone, will transpire at a rate equal to 0.8 of Class A pan evaporation. The calculation must also account for the rain falling directly on the vegetation (see footnote). A minimum strip of 50 m width should be left.
4. An area adjacent to existing defined streamlines. Where the streams are perennial a strip at least 75 m should be left on each side of the stream. For ephemeral streams the buffer width should be sufficient to cope with the extra recharge expected to result from upslope clearing (see 2 and 3).
5. An area adjacent to swamps, lakes and waterlogged depressions.

   The vegetative buffer strip must be of sufficient width to cope with the expected additional recharge resulting from upslope clearing (see 2 and 3 for assumptions).
6. Areas where it is known that the saline water table is currently less than 5 m from the natural soil surface in spring.
7. In areas where the potential spring line is the intersection of sandplain and heavier textured soils (i.e.: where a sandplain seep is likely) more hydrologic advantage would be gained by permitting clearing on the condition that an appropriately placed strip of exotic trees are planted sufficient to cope with the expected recharge from the upslope sandplain.
8. Naturally saline soils.
9. The total area of protected native vegetation left within a **sub-catchment*** should be relative to the mean annual rainfall. Suggested guideline figures are:

700–1100	mm rainfall	30%
500– 700	mm rainfall	25%
less than 500	mm rainfall	20%

   This figure will comprise of the areas left for purposes defined in 3–5 plus areas left for other conservation purposes. If these do not satisfy the requirement then the additional vegetation should be left on the upper 30% of the sub catchment.

Appendix 2. Areas identified as valuable for eutrophication protection (Holm 1994)

Eutrophication
(South West and South Coast regions)

1 Land with the following characteristics should not be cleared:

- land subject to regular flooding (flood interval < 1 year)
- land subject to prolonged inundation (> 2 weeks)

2 Buffer zones should be maintained around water bodies:

Water bodies	Site characteristics
Inlets	– no clearing within 75 m of high water mark
Rivers	– no clearing within 50 m of stream bank
Minor creeks, waterways and wetlands	– no clearing within 25 m of the stream bank.

3 Soils with a low to very low Phosphorous retention ability should not be cleared.

Soil description	Phosphate retention ability*	Land capability class
Deep (> 1 m) grey leached siliceous sands where iron–organic pans or coloured subsoils, if present, occur at depths greater than 1 m.	Very low	V
Grey leached sands or sandy loams with an iron–organic hard–pan within 1 m of the soil surface. Duplex soils with moderately deep (50–100 cm) sandy leached topsoils, or leached sands of similar depth overlying unrelated clays or a hardpan. Shallow (<50 cm) gravelly sands over rock.	Low	V

* Ranges of P retention index are: very low 0–2; low 2–10; moderate 10–20; moderately high 20–100 and high > 100.

Appendix 3. Sample entry in data base

Reserve Name	
Reserve Number	19192
Total Area	40.47
Area Class	30-80
Species Rarity	DRF
Priority Association Class	2
Diversity	7
Intactness	3.5

Relationship To CALM Reserves

Distance	3
Distance Class	1-5
Connectivity	Connected
Significance	Not Significant
Isolation Index	1-2
Accessability Index	7-8
Viability	See Report
Competing Land Uses	
Extractive Industries	No
Recreation	Yes
Grazing	No
Rubbish	No
Potential For Timber Cutting	No
Compatible Land Uses	
Soil Conservation	No
Salinity	Yes
Water Harvest Potential	Yes
Eutrophication	No
Shade, Shelter	No
Landscape Character	No
Physiographic Features	No
Community Attitudes	
Shire	Not Known
LCDC	Not Known
Neighbour	Not Known

Appendix 4. Field report form

CONSERVATION VALUES OF WATER AUTHORITY RESERVES

Inspection Report

Reserve identification: ....

Site number:......................
Survey date:......................
Surveyors:.......................

Location: Shire:....................**LCDC:**............... **Nearest town:**..................

Locality name:...................................... **Nearest road:** ....

Map reference:...................................... **Latitude:**......**Longitude:**......

Area of remnant:.................... **Vegetation associations:**
Area of remnant vegetation:.........

A:... Number.......... Area........
B:... Number.......... Area........
C:... Number.......... Area........
D:... Number.......... Area........
E:... Number.......... Area........
F:... Number.......... Area........

General description: ....
....
....

Intrinsic values:
Species rarity:...
Formations:...
Diversity:..
Intactness:...
Relationship to CALM reserves:..

Viability: ....
....
....

Competing land uses:..
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....

Compatible land uses:...
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....

Community attitudes:..
....
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Management:...
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Recommendation:
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LOCALITY MAP Figure 1

Site number:................
Survey date:.................
Surveyors:..................

This plan is designed to show the relationship of the remnant to other remnants including corridors.

SITE MAP Figure 2

Site number:................
Survey date:.................
Surveyors:...................

This plan is designed to show vegetation quality classes and features such as rock outcrops, gravel pits, tracks, dams as well as adjacent land uses.

Approximate scale: 1:5000. This plan is derived from aerial photo ...., WA 2189, Kellerberrin 1:250000. Run ...... Scale 1:50000. Date............

VEGETATION MAP Figure 3

Site number:.................
Survey date:..................
Surveyors:...................

This plan is designed to show vegetation associations.

Approximate scale: 1:5000. This plan is derived from aerial photo ...., WA ....
Kellerberrin 1:250000. Run ...... Scale 1:50000. Date............

FAUNA

Site number:.................
Survey date:................
Surveyors:..................

Observations:

Birds:

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Introduced:...
....
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Rare species:

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Mammals:

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Introduced:...
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Rare species:

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Reptiles:

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Rare species:

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Invertebrates:

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Notes on species indicative of disturbance/intactness:

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RELATIONSHIP OF REMNANT TO OTHER CONSERVATION AREAS

Site number:................
Survey date:................
Surveyors:..................

Distance to nearest national park, nature reserve or State forest: .....km.

Is the remnant joined by vegetated crown land to national park, nature reserve or State forest? **yes/no.**

Is the remnant joined by vegetated road reserver to national park, nature reserve or State forest? **yes/no.**

If joined, what is the total area:. ....ha.

In comparison with the nearest national park, nature reserve or State forest does the remnant contain:

habitat not already conserved **yes/no**

significantly add (50% or more) to habitat already conserved **yes/no**

INTACTNESS

The remnant will be mapped for levels of weed invasion (figure 2) and within these units grazing intensity (if grazed) will be measured by counting the number of sheep pellets/sq.m.

Unit	Type of degradation	Weed cover % class	Grazing Av. pellets/sq.m.	Area	% of total area

Results: Remnants will be ranked according to total area with less than 20% weed cover and the percentage area with less than 20% weed cover. For remnants with greater than 20% weed cover ranking will continue for percentage areas between 20% and 50% weeds and then between 50% and 80% weed cover.

Remnants can also be ranked for grazing intensity from no grazing down to increasing numbers of pellets for the best area of the remnant.

VIABILITY - non human biological and physical influences

Site number:................
Survey date:................
Surveyors:..................

Total area of remnant:..........
Area of remnant vegetation:.........

Number of areas and areas of vegetation associations

Formation	Association	Number	Area

Connectivity and isolation: Remnants within 5 kilometres

Number	Area (hectares)	Distance (kilometres)	Corridors (yes/no)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
Totals			

Isolation Index:.(mean distance to ten nearest neighbours)..................

Accessibility Index: (number connected).............

Edge effects, remnant shape: The site map provides a picture of edge effects and remnant shape.

Is more than 50% of the remnant less than 100 m wide?: **yes/no**

Time since clearing (estimated):...........years.

Landform element: crest, upper slope, mid slope, lower slope, depression
Evidence of rising water tables: **yes/no**

Adjacent land uses:

Use:..Anticipated impact:..
Use:..Anticipated impact:..

Exotics, weeds /vermin:

Name:...Anticipated impact:..
....
Name:...Anticipated impact:..
....
Name:...Anticipated impact:..

COMPETING LAND USES

Site number:................
Survey date:................
Surveyors:..................

Extractive industries:

Type present:.. Percent of area affected:.............

Required by municipality? **Yes/no** Percent of area with gravel:..........

Comments:
....
....
....

Recreation:

Current uses and suitability: Impacts: **high/moderate/low**
....
....

Special feature of site, aesthetics:
....
....

Access type and condition:
....

Grazing:

Grazing: **present/absent.** Visual interpretation of impact: **high/moderate /low**

Timber cutting:

Timber cutting: **present/ absent.** Intensity: **high/moderate /low. Time** of cutting years.....

Desirable species and quantities for farm use: **yes/no** Brief description.........................
....

Wildflowers:

Harvesting: **present/ absent.** Intensity: high/**moderate/low. Time** of cutting years..........

Desirable species and quantities: **yes/no** Brief description......................................
....

Aboriginal Culture:

Use and potential use:...

Other uses and impacts: eg apiary...

COMPATIBLE LAND USES

Site number:................
Survey date:.................
Surveyors:..................

Soil conservation:

Soil Type	Formation	Area	Wind erosion class	Water erosion class	Water logging class

Water conservation:

Percent of catchment/shire cleared:....................

Salinity: Reason for retaining remnant vegetation:..

Eutrophication: Reasons for retaining remnant vegetation:..

Observations of soil and water conservation issues in the area and the possible importance of the remnant vegetation:

....
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....

Landscape character.

Reason for high landscape character/scenic quality:..

Value to adjacent farmers/community:

Shade: • Woodland on northern or westerly boundaries of farmland yes/no
Shelter: • Woodland on southerly or westerly boundaries of farm land yes/no

Water: • Water source on remnant used or potential use by farm yes/no
• Water catchment for community yes/no

Exotics: • Remnant is a source of weeds and vermin to adjacent farm yes/no

Aboriginal sites present: yes/no

Describe:

....
....

Physiographic features present: (eg greenstone outcrop) yes/no

....
....

COMMUNITY ATTITUDES TOWARDS REMNANT

Site number:...............
Survey date:...............
Surveyors:.................

Local Authority: positive/negative

Willing to manage for nature conservation values? yes/no

Comments:
....
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....

LCDC positive/negative

Willing to manage for nature conservation values? yes/no

Comments:
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Catchment group positive/negative

Willing to manage for nature conservation values? yes/no

Comments:
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Community group: positive/negative

Willing to manage for nature conservation values? yes/no

Comments:
....
....
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....

Adjacent land manager positive/negative

Willing to manage for nature conservation values? yes/no

Comments:
....
....
....

MANAGEMENT ISSUES

Site number:...............
Survey date:...............
Surveyors:.................

Management actions required should be stated including priority, reason for priority, equipment required and estimated cost. The purpose is to focus on priority issues not long term wish lists.

Weeds:

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Vermin:

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Fencing:

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Water balance:

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Other issues: Recreation causing degradation, rubbish dumping, deliberate illegal grazing

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Management recomendations:

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FLORA VALUES

Reserve No.	
Site No.	

SPECIES	age/cond	Ht (m)	% canopy cover	
Stratum No.			total	Av.
Stratum 9				
Stratum 10				
Stratum 11				

TOPOGRAPHY
Position in the landscape (Landform element):
SOIL COLOUR and TYPE:
Drainage lines: Y/N
Outcropping: Y/N laterite granite dolerite

LITTER - Type	**QUANTITY - %cover**	**depth (cm)**
leaves		
small twigs		
large logs		
BAREGROUND		

HABITAT

hollows	**Y/N**	**%**	
mistletoe	**Y/N**	**% infestation**	**host species**

DISTURBANCES: logging grazing other:

WEED INVASION: **<20%** **20-80%** **>80%**

DOMINANT WEEDS:

VEGETATION ASSOCIATION SURVEY SHEET

Reserve No.	
Site No.:	Film No./Photo No.

SPECIES	age/cond	Ht (m)	% canopy cover	
Stratum No.			total	Av.
Stratum 1.				
Stratum 2.				
Stratum 3.				
Stratum 4.				
Stratum 5.				
Stratum 6.				
Stratum 7.				
Stratum 8.				

Appendix 5. Sample completed inspection report form

CONSERVATION VALUES OF SMALL RESERVES IN THE CENTRAL WHEATBELT.

INSPECTION REPORT

Reserve name:		**Reserve number:**	19192
Surveyors:	R. Safstrom & D. True	**Survey date:**	29/10-9/11/1994
Shire:	Westonia	**Nearest town:**	
Area of reserve:	40.47 ha	**Nearest road:**	George Rd
Area native flora:	40.47 ha		
Map reference:	Westonia 2635 1:100 000	**AMG**	680 530

Vegetation associations	**Occurrences**	**Area (ha.)**
1 Shrubland	1	11.5
2 Tall shrubland Acacia - Melaleuca sp. thicket	1	3.4
3 York Gum - shrubs on shallow granite	1	2.5
4 Granite outcrop and lithic complex	2	12.0
5 Tall Allocasuarina huegelii thicket	1	2.8
6 Tall Acacia shrubland	1	2.4
7 Sparse York Gum - shrubs on shallow granite	1	5.9
8.		

General description:	An attractive high rock outcrop surrounded by shrubland, tall Allocasuarina huegeliana thicket and York Gum shrubland. Grass weeds are a problem particularly on open areas. There is an access track to an attractive picnic site.
Intrinsic values:	
Species rarity:	D.R.F. - Eucalyptus ssp.crucis
Priority Associations:	Class 2. Vegetation on granite outcrops.
Diversity:	7 vegetation associations
Intactness:	8 to 10% of reserve or 3 to 4 hectares intact.
Relationship CALM reserves	3 km to closest CALM reserve, connected by road corridor but does not contain significant vegetation in comparison to CALM reserve.
Viability:	Viability is affected by grassy weed invasion although reserve is reasonably connected and close to other remnants.
Competing land uses:	Minor use as a picnic site.
Compatible land uses:	Water use for salinity control, potential for water collection.
Community attitudes:	Not known
Management:	Control vermin, periodically clean up picnic area, grassy weeds too difficult to control.
Recommendations:	Suitable as a Shire reserve for recreation and nature conservation.

FAUNA

Birds:	Good pools in rocks. Rainbow Bee-eater, Pied Butcherbird, Crow/Raven, numerous Honeyeaters, 28 Parrot, Black Faced Cuckoo Shrike, Grey Shrike Thrush, Rufous Whistler
Rare species:	
Mammals:	Echidna
Rare species:	
Introduced:	Rabbits - numerous northern end of reserve
Reptiles:	
Rare species:	
Invertebrates:	
Species indicative of disturbance/intactness:	
Observation conditions:	

RELATIONSHIP OF REMNANT TO OTHER CONSERVATION AREAS

Distance to nearest government national park, nature reserve or State forest:	3
Is reserve joined by vegetated crown land to government park, reserve or forest?	no
Is reserve joined by vegetated road reserve to government park, reserve or forest?	yes
If joined what is the total area?	
Compared to nearest government park, reserve or forest does the remnant contain:	
habitat not already conserved	no
significantly add (50% or more) to habitat already conserved	no

INTACTNESS

Unit	**Type of degradation**	**Weed cover % class**	**Grazing Severity**	**Area (ha)**	**% of total area**
1	Grassy weeds	0-20% but 10% of area 50-80%	nil	3.1 0.3	8% 1%
2	Grassy weeds	20-50% but areas of 0-20% where shrubland dense	nil	18.7	46%
3	Grassy weeds	50-80%	nil	5.9	15%
4	Grassy weeds on lithic complex in open areas.	80+% in areas	nil	12.0	30%
5	Grassy weeds	80+%	nil	0.5	1%

2/19/92

VIABILITY - non human biological and physical influences

Total area of remnant:	40.47 ha
Area of remnant vegetation:	40.47 ha

Number of areas and areas of vegetation associations

Association	**Number**	**Area** ha
1 Shrubland	1	11.5
2 Tall shrubland Acacia - Melaleuca sp. thicket	1	3.4
3 York Gum - shrubs on shallow granite	1	2.5
4 Granite outcrop and lithic complex	2	12.0
5 Tall Allocasuarina huegelii thicket	1	2.8
6 Tall Acacia shrubland	1	2.4
7 Sparse York Gum - shrubs on shallow granite	1	5.9

Connectivity and isolation: Remnants within 5 kilometres

Number	**Area** (hectares)	**Distance** (kilometres)	**Corridors** (yes/no)
1		3.3	no
2		2.0	no
3		0	yes
4		0.9	yes
5		2.3	yes
6		3.1	yes
7		0.6	yes
8		0.6	yes
9		2.4	no
10		0	yes
Totals		15.2	

Isolation Index:.(mean distance to ten nearest neighbours)	1.5 km
Accessibility Index: (number connected)	7
Edge effects, remnant shape: Is more than 50% of the remnant less than 100 metres wide.	no
Time since clearing (estimated):	not known
Landform element: crest, upper slope, mid slope, lower slope, depression	crest, upper slope
Evidence of rising water tables:	no

Adjacent land uses which impact on nature conservation values

Use	**Anticipated impact**
Farming	minor

Exotics - weeds /vermin

Type	**Anticipated impact**
Grassy weeds	High impact in some vegetation associations.
Rabbits	High impact northern end of reserve.

3/9/92

COMPETING LAND USES

Extractive industries

Type present:	Nil	*Percent of area affected:*	n/a
Required by municipality?	not known	*Percent of area with gravel:*	None observed
Comments:			

Recreation:

Current uses and suitability:	Minor picnic spot, suitable use.
Impact	low - scattered rubbish.
Special feature of site, aesthetics:	Attractive woodland with rock outcrop to explore.
Access type and condition:	Bush track to picnic point.

Grazing:	absent	*Visual interpretation of impact:*	n/a
Comments:			

Timber cutting:	absent	*Intensity:*	n/a
Time since cutting:	n/a	*Timber suitable for farm use:*	no
Comments:			

Wildflower Harvesting:	not observed	*Intensity:*	n/a
Time since cutting:	n/a	*Desirable species and quantities:*	not known
Comments:			

Other uses and impacts:	None observed

4/19/92

COMPATIBLE LAND USES

Soil conservation

Soil Type	*Association*	*Area (ha)*	*Wind erosion class **	*Water erosion class **	*Water logging class **
Gritty sandy loams over rock	Sparse York Gum and shrubs		low	moderate	low
Coarse yellow sands	C. camp Calo shrubland		moderate	moderate	low

* No soils information available. Inferred from information from other areas.

Water conservation

Percent of catchment/shire cleared: 60.6%

Salinity: Reason for retaining remnant vegetation: Area adjacent outcrop country rock.

Eutrophication: Reasons for retaining remnant vegetation: Nil

Observations of soil and water conservation issues in the area and the possible importance of the remnant vegetation: Salinity not an apparent concern in this area at present.

Landscape character:

Reason for high landscape character/scenic quality: No

Value to adjacent farmer/community:

Shade:	*Woodland on north or west boundaries of farm:*	no.
Shelter:	*Woodland on south or west boundaries of farm:*	no.
Comments:		

Water:	*Water source used or potential use by farmer community:*	yes
Comments:	Potential to but difficult to collect.	

Exotics:	Remnant is a source of weeds and vermin to adjacent farm	no
Comments:		

Aboriginal sites present:		no
Description	None observed	

Physiographic features present:		no
Description		

5/19/92

COMMUNITY ATTITUDES TOWARDS REMNANT

Local Authority:	not known
Willing to manage for nature conservation values?	not known
Comments:	

LCDC:	not known
Willing to manage for nature conservation values?	not known
Comments:	

Catchment group:	not known
Willing to manage for nature conservation values?	not known
Comments:	

Community Group	not known
Willing to manage for nature conservation values?	not known
Comments:	

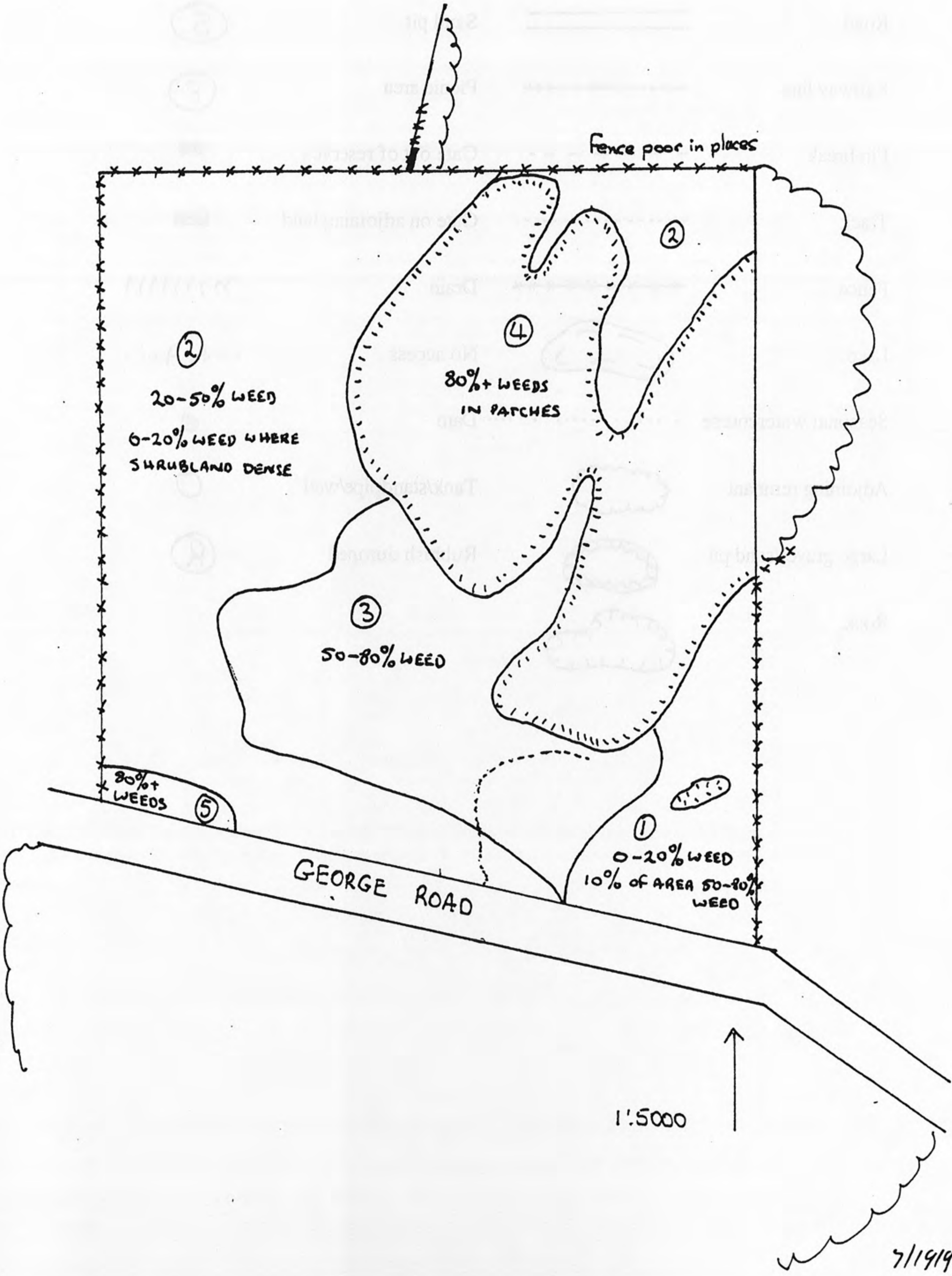
Adjacent land manager	not known
Willing to manage for nature conservation values?	not known
Comments:	

MANAGEMENT ISSUES

Weeds	Grassy weeds difficult to control.
Vermin	Rabbits in moderate numbers require control.
Fencing	Generally satisfactory, some gaps under fence to north but no evidence of stock entry.
Water balance	No concerns
Other issues	Minor picnic sites and minor rubbish - perhaps periodic patrol/clean up.
Recommendation	Although weedy a valuable reserve. Maintain control of vermin and periodically patrol and clean up picnic area.

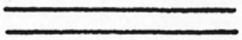
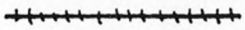
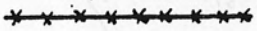
6/19/92

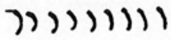
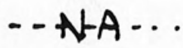
SITE PLAN



7/19/92

Site Plan Legend

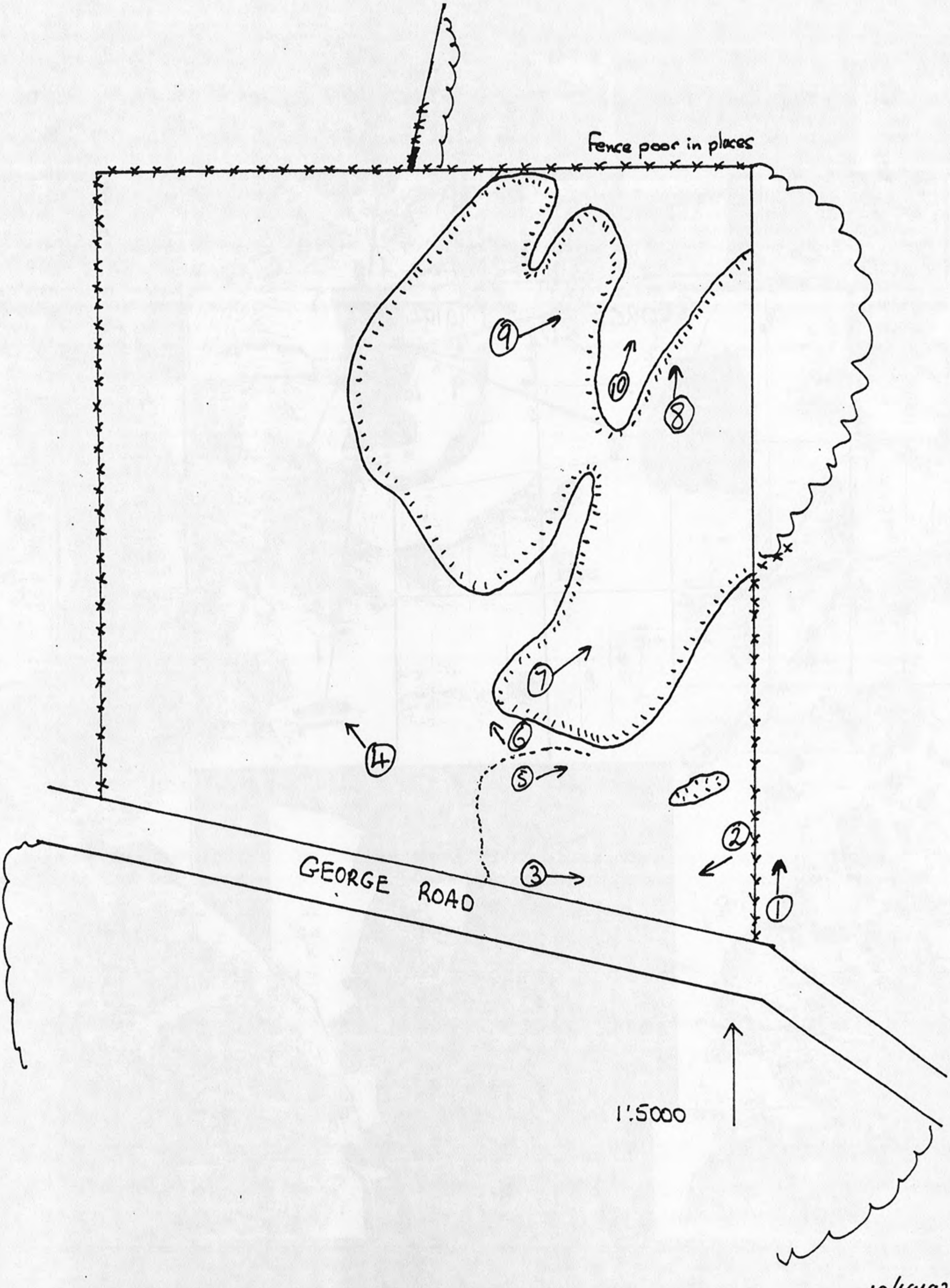
Reserve boundary	
Road	
Railway line	
Firebreak	
Track	
Fence	
Lake	
Seasonal watercourse	
Adjoining remnant	
Large gravel/sand pit	
Rock	

Gravel pit	
Sand pit	
Picnic area	
Gate out of reserve	
Gate on adjoining land	
Drain	
No access	
Dam	
Tank/standpipe/well	
Rubbish dumped	

9/19/92

LOCALITY PLAN

PHOTO PLAN



10/19/92

1

East boundary - small private rock area extends reserve.

2

Grassy weeds amongst rocky areas and open areas. South east boundary.

Wild oats in York Gum woodland along southern boundary.

4

Heavy weeds in open shrubland areas.

5

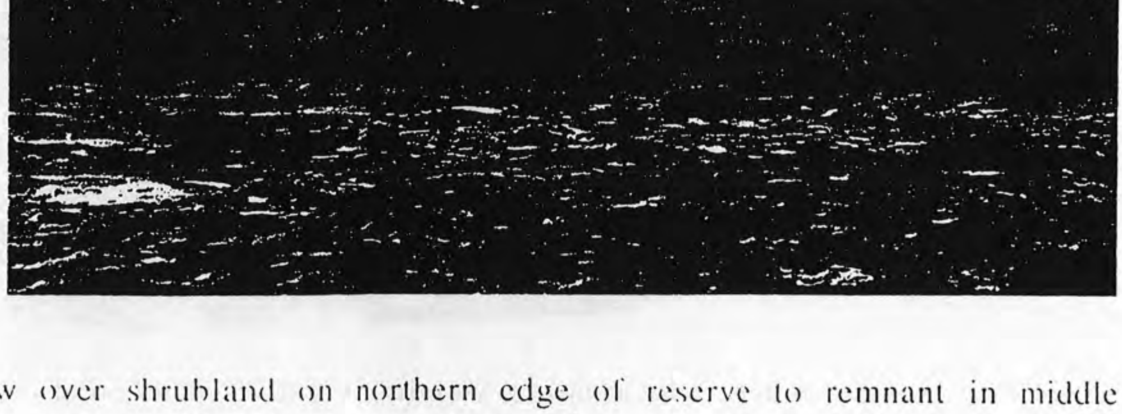
Picnic area - track stops at base of rocks.

Heavy weeds under Allocasuarina woodland and base of rocks.

7

Boulders and weeds where soil accumulates.

8



View over shrubland on northern edge of reserve to remnant in middle ground.

View over E. crucis in rocky gully to farmland beyond.

Denise True with Eucalyptus crucis.

Reserve 19192

FLORA OF THE RESERVE

Thirty five (35) vascular plant taxa (Appendix A) including two introduced species, were recorded for this reserve, during the 1994 field survey.

FLORA OF SIGNIFICANCE

A plant specimen collected from Reserve 19192 is believed to be the mallee known as *Eucalyptus crucis ssp. crucis* and gazetted as Declared Rare Flora , however a further collection of mature leaves is required to confirm this.

VEGETATION

The vegetation map for the reserve is provided as Figure 1, and a photographic record of vegetation associations provided in Appendix B. The approximate vegetation boundaries were mapped from aerial photographs at a scale of 1:50000 and drawn at a scale of 1:5000.

Reserve 19192 was comprised of seven vegetation associations, these are described below:-

Shrubland - Thicket of *Allocasuarina campestris, Calothamnus gilesii* over Open Tall Sedges.

Tall shrubland - Dense Thicket of *Melaleuca uncinata, Acacia resinomarginea, Acacia acuminata.*

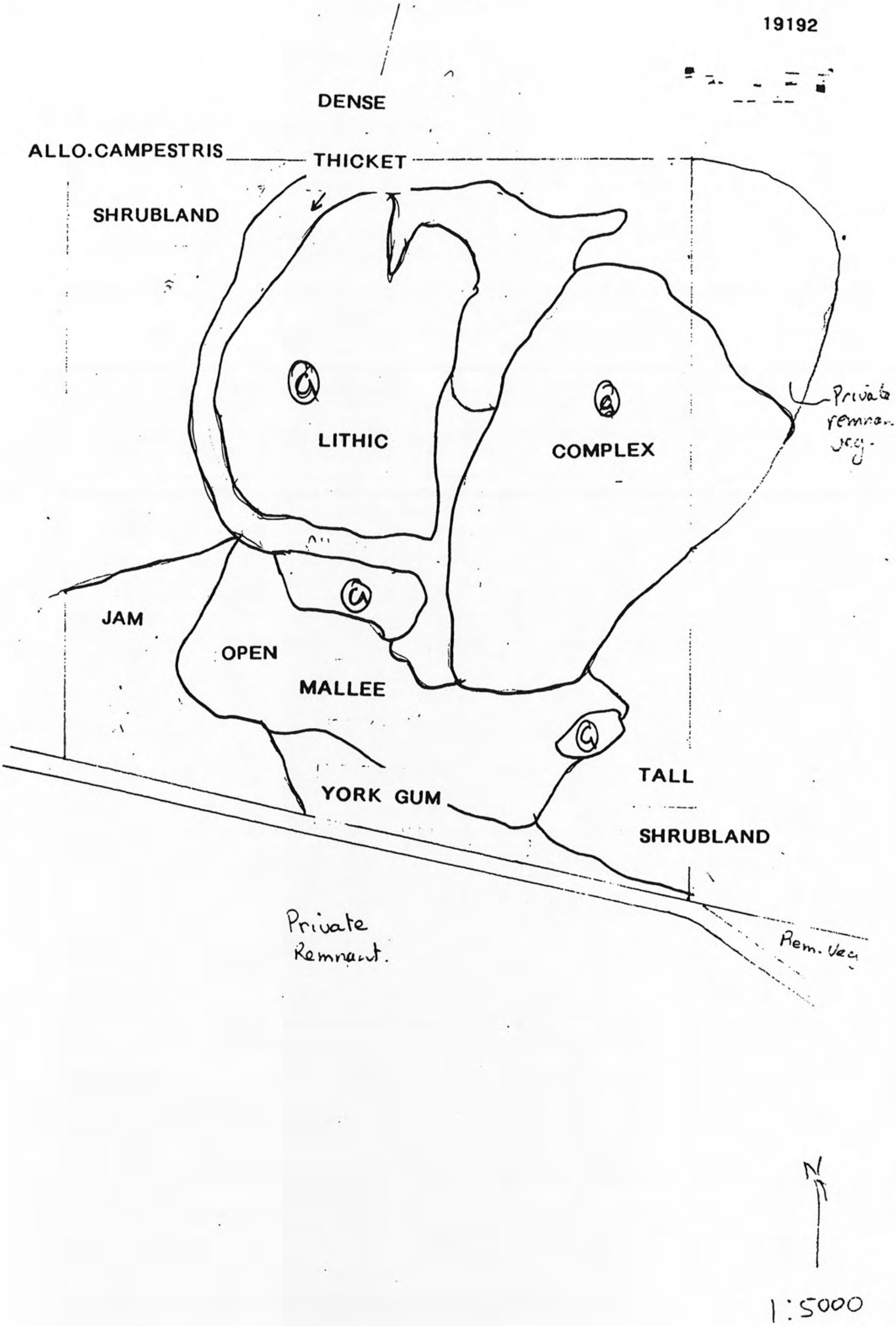
Mallee - Open Shrub Mallee of *Eucalyptus loxophleba* over Scrub of *Acacia spp.*

Lithic Complex - Very Open Herbs of *Borya sphaerocephala*, and Scrub of *Dodonaea viscosa ssp. angustissima, Kunzea pulchella, Calothamnus quadrifidus* and *Santalum spicatum.*

Thicket of *Allocasuarina huegeliana, Leptospermum roei* adjacent to granite outcropping over Tall Sedges.

Shrubland - Scrub of *Acacia acuminata.*

Mallee - Very Open Shrub Mallee of *Eucalyptus loxophleba* on shallow granite


DENSE
ALLO.CAMPESTRIS
THICKET
SHRUBLAND
G
G
LITHIC
COMPLEX
Private remnant veg.
G
JAM
OPEN
MALLEE
G
TALL
YORK GUM
SHRUBLAND
Private Remnant.
Rem. Veg
N
1:5000

APPENDIX A: VASCULAR PLANT SPECIES LIST

FAMILY		GENUS	SPECIES
POACEAE		*Amphipogon*	*turbinatus*
	*	*Avena*	*fatua*
		Stipa	*elegantissima*
	*	*Hordeum*	*leporimum*
RESTIONACEAE		*Lyginia*	*barbata*
PHORMIACEAE		*Dianella*	*revoluta*
ANTHERICACEAE		*Borya*	*sphaerocephala*
CASUARINACEAE		*Allocasuarina*	*campestris*
		Allocasuarina	*huegeliana*
PROTEACEAE		*Hakea*	*preissii*
SANTALACEAE		*Santalum*	*spicatum*
PITTOSPORACEAE		*Pittosporum*	*phylliraeoides*
MIMOSACEAE		*Acacia*	*acuminata*
		Acacia	*lasiocalyx*
		Acacia	*resinomarginea*
		Acacia	*tetragonophylla*
		Acacia	*sp.*
CAESALPINIACEAE		*Senna*	*glutinosa ssp. chatelainiana*
RUTACEAE		*Diplolaena*	*velutinia*
EUPHORBIACEAE		*Calycopeplus*	*ephedroides*
SAPINDACEAE		*Dodonaea*	*viscosa ssp. angustissima*
STERCULIACEAE		*Brachychiton*	*gregorii*
DILLENIACEAE		*Hibbertia*	*sp.*
MYRTACEAE		*Baeckea*	*crispiflora*
		Baeckea	*sp.*
		Calothamnus	*gilesii*
		Calytrix	*sp.*
	DRF	*Eucalyptus*	*crucis ssp. crucis 8372*
		Eucalyptus	*loxophleba*
		Kunzea	*baxteri*
		Leptospermum	*erubescens*
		Leptospermum	*roei*
		Malleostemon	*tuberculatus*
		Melaleuca	*macronychia ssp. macronychia*
		Melaleuca	*uncinata*

APPENDIX B: PHOTOGRAPHIC RECORD OF VEGETATION

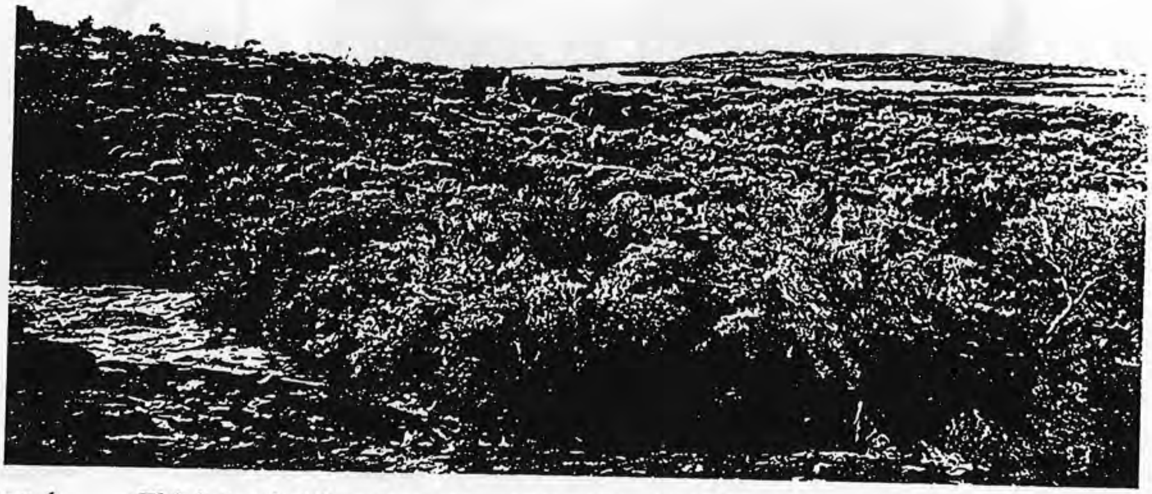


Figure 1 Thicket of *Allocasuarina campestris*, *Calothamnus gilesii* over Open Tall Sedges.

Figure 2 Dense Thicket of *Melaleuca uncinata*, *Acacia resinomarginea*, *Acacia acuminata*.

APPENDIX B: PHOTOGRAPHIC RECORD OF VEGETATION

Figure 3 Open Shrub Mallee of *Eucalyptus loxophleba* over Scrub of *Acacia spp.*

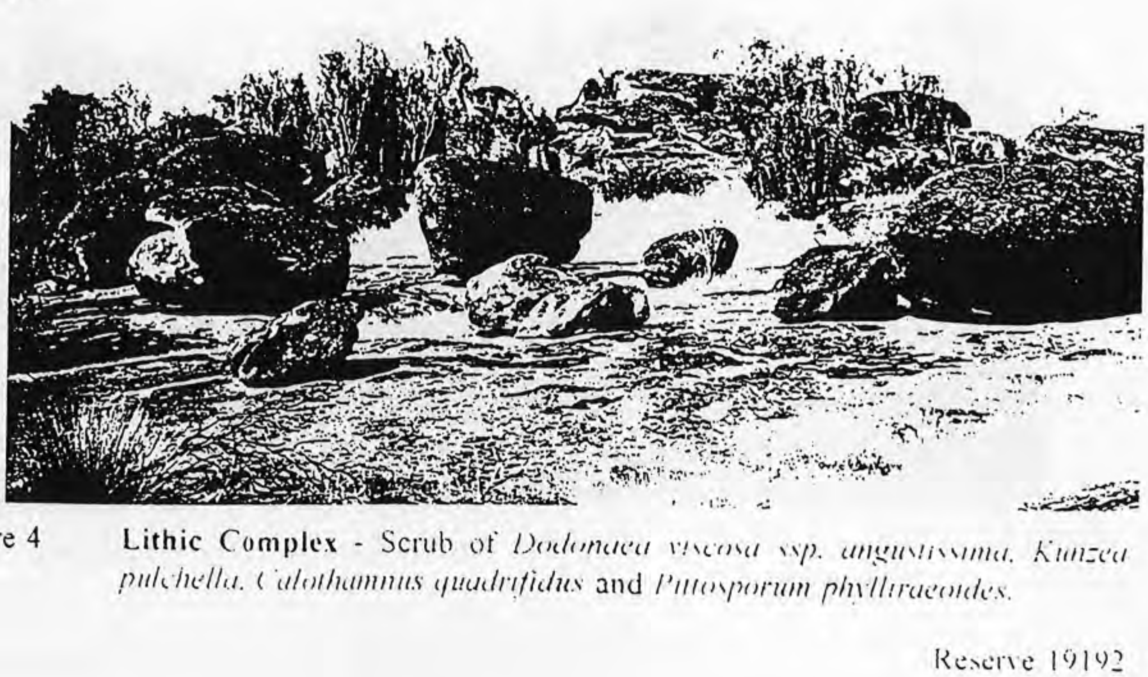


Figure 4 **Lithic Complex** - Scrub of *Dodonaea viscosa ssp. angustissima, Kunzea pulchella, Calothamnus quadrifidus* and *Pittosporum phyllraeoides.*