

**Clearing of native vegetation on Victoria
Location 10323, Shire of Dandaragan**

Mr Thomas Glover

**Report and recommendations
of the Environmental Protection Authority**

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Summary and recommendations

The proponent, Mr Thomas Glover proposes to clear approximately 183 hectares of native vegetation on Victoria Location 10323, Shire of Dandaragan. This report provides the Environmental Protection Authority's (EPA's) advice and recommendations to the Minister for the Environment on the environmental factors relevant to the proposal.

Section 44 of the *Environmental Protection Act 1986* requires the EPA to report to the Minister for the Environment on the environmental factors relevant to the proposal and on the conditions and procedures to which the proposal should be subject, if implemented. In addition, the EPA may make recommendations as it sees fit.

Relevant environmental factors

Although a number of environmental factors were considered by the EPA in the assessment, it is the EPA's opinion that the following are the environmental factors relevant to the proposal, which require detailed evaluation in the report:

- (a) plant diversity and species richness;
- (b) Declared Rare and Priority Flora;
- (c) regional representation of vegetation;
- (d) vegetation and fauna corridors; and
- (e) viability of remnant vegetation on the property.

Conclusion

The EPA has considered the proposal by Mr Glover to clear 183 ha of native vegetation on Victoria Location 10825.

The EPA has noted that Mr Glover has previously entered into an Agreement to Reserve 312 ha of remnant vegetation on the property (21% of the property). As part of the current Notice of Intent to clear, Mr Glover has indicated that a further 46 ha (3% of the property) of vegetation will be included in an Agreement to Reserve.

The EPA also notes that the proponent intends to retain vegetation corridors within the property, to maintain a continuous vegetated link between the large area of remnant vegetation to the north of the property referred to as Big Soak Plains, Watheroo National Park to the east, and privately owned land to the south. It is the EPA's view that the retention of these linkages will help to maintain the nature conservation values of the remnant vegetation.

Following consideration of this information, the EPA concludes that the proposal by Mr Glover to clear 183 ha, as indicated in Figure 2, is environmentally acceptable. In reaching this conclusion, the EPA commends the proponent's initiative and co-operation in retaining vegetated corridors within the property, and including a significant portion of Location 10323 within in an Agreement to Reserve under the provisions of the Soil and Land Conservation Act.

Recommendations

Section 44 of the *Environmental Protection Act 1986* requires the EPA to report to the Minister for the Environment on the environmental factors relevant to the proposal and on the conditions and procedures to which the proposal should be subject, if implemented. In addition, the EPA may make recommendations as it sees fit.

The EPA submits the following recommendations to the Minister for the Environment:

1. That the Minister notes that this assessment is in relation to an agricultural land clearing proposal.

2. That the Minister notes that following consultation with the proponent, and agreed modifications to the proposal, the EPA has concluded that the proposal is unlikely to have an unacceptable environmental impact and could be permitted to proceed.
3. That the Minister for the Environment considers the report on the relevant environmental factors of plant diversity and species richness; Declared Rare and Priority Flora; regional representation of vegetation; vegetation and fauna corridors; and viability of remnant vegetation on the property; as set out in Section 3 of this report.

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1. Introduction and background

This report is to provide advice and recommendations of the Environmental Protection Authority (EPA) to the Minister for the Environment on a proposal to clear native vegetation for agricultural purposes in the West Midlands area.

The proponent, Mr Thomas Glover, proposes to clear approximately 183 ha of native vegetation on Victoria Location 10323 within the Shire of Dandaragan. He intends to use the cleared land for mixed farming purposes, i.e. grazing sheep and cattle, and cropping.

A Notice of Intent to Clear (NOIC) for Location 10323 was received by Agriculture WA (AgWA) in December 1996. In view of the possibility of the vegetation proposed to be cleared containing rare or threatened flora, the proposal was forwarded to the 'Inter Agency Working Group' in accordance with the Memorandum of Understanding between Commissioner for Soil and Land Conservation, Environmental Protection Authority, Department of Environmental Protection, Agriculture WA, Department of Conservation and Land Management, and the Water and Rivers Commission. The Working Group considered that there was potential for the proposal to have an impact on the environment and referred the NOIC to the EPA in December 1997. The EPA determined in April 1998 that the potential environmental impacts were sufficient for the proposal to be formally assessed under the provisions of Part IV of the Environmental Protection Act.

Further details of the proposal are presented in Section 2 of this report. Section 3 discusses the environmental factors relevant to the proposal, Section 4 presents the EPA's conclusion, and Section 5 contains the EPA's recommendations.

2. The proposal

The proponent, Mr Thomas Glover, proposes to clear an area of native vegetation on Victoria Location 10323. This property is located approximately 65 kms north of Dandaragan on the Marchagee - Coomallo Road, and is indicated in Figure 1. He intends to use the cleared land for mixed farming purposes, i.e. grazing sheep and cattle, and cropping.

Location 10323 is approximately 1500 ha in area. Mr Glover originally proposed to clear 200 ha of native vegetation on his property. However following on-site discussions between the proponent and officers of the Department of Environmental Protection and Agriculture WA in September 1998, the proposal to clear was modified. Mr Glover now intends to clear approximately 183 ha (12% of the property) as indicated in Figure 2. A total of approximately 651 ha of native vegetation (43% of the property) would remain on his property after the proposed clearing with 312 ha (21% of this property) of this native vegetation currently included within an Agreement to Reserve (ATR). The proponent has indicated that a further 46 ha (3% of the property) would be included in an Agreement to Reserve on approval of the clearing application.

3. Environmental factors

3.1 Relevant environmental factors

Section 44 of the *Environmental Protection Act 1986* requires the EPA to report to the Minister for the Environment on the environmental factors relevant to the proposal and on the conditions and procedures to which the proposal should be subject, if implemented. In addition, the EPA may make recommendations as it sees fit.

Table 1 presents a summary of the relevant environmental factors.

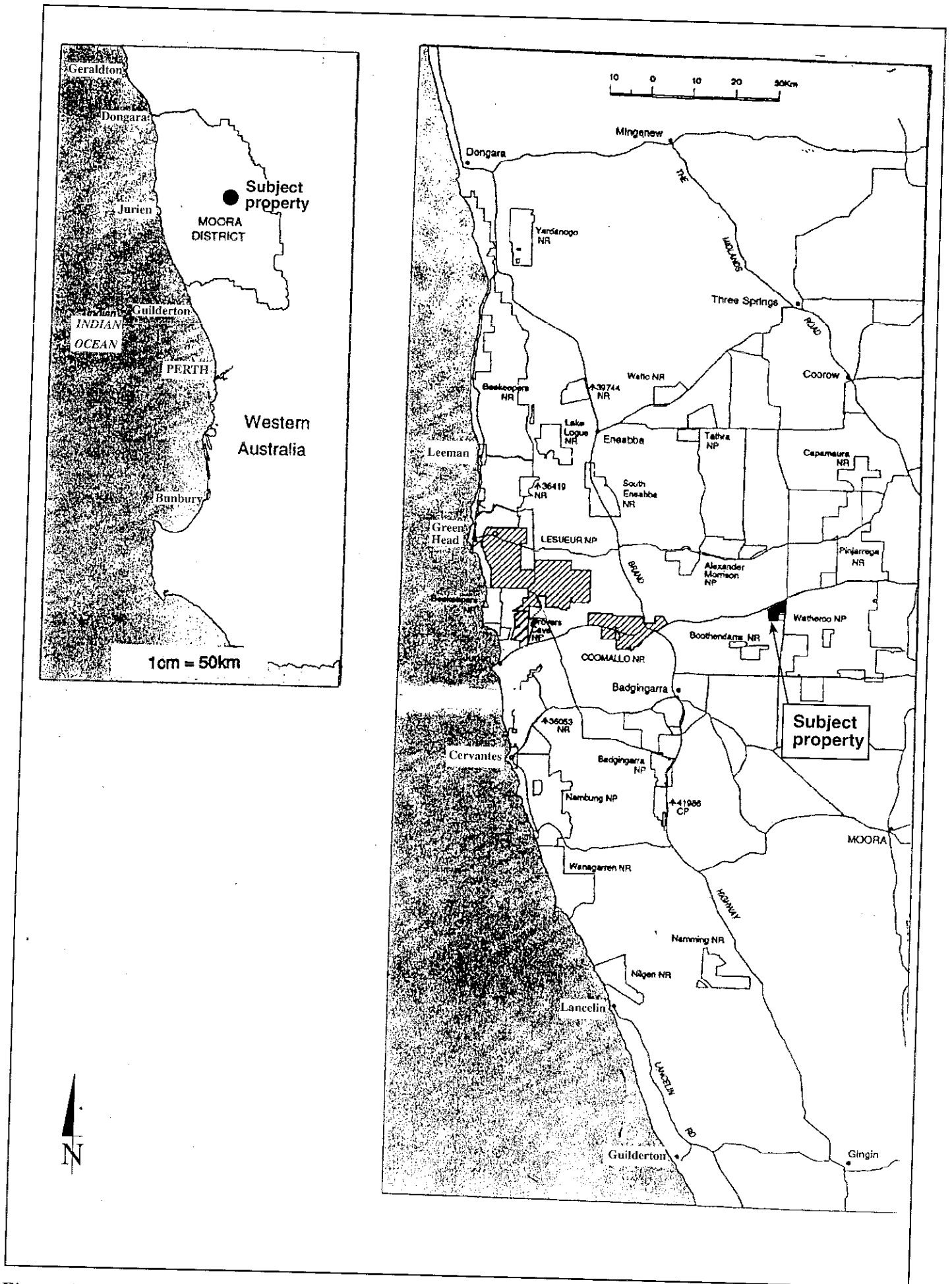


Figure 1. Locality of Victoria Location 10323, Shire of Dandaragan.

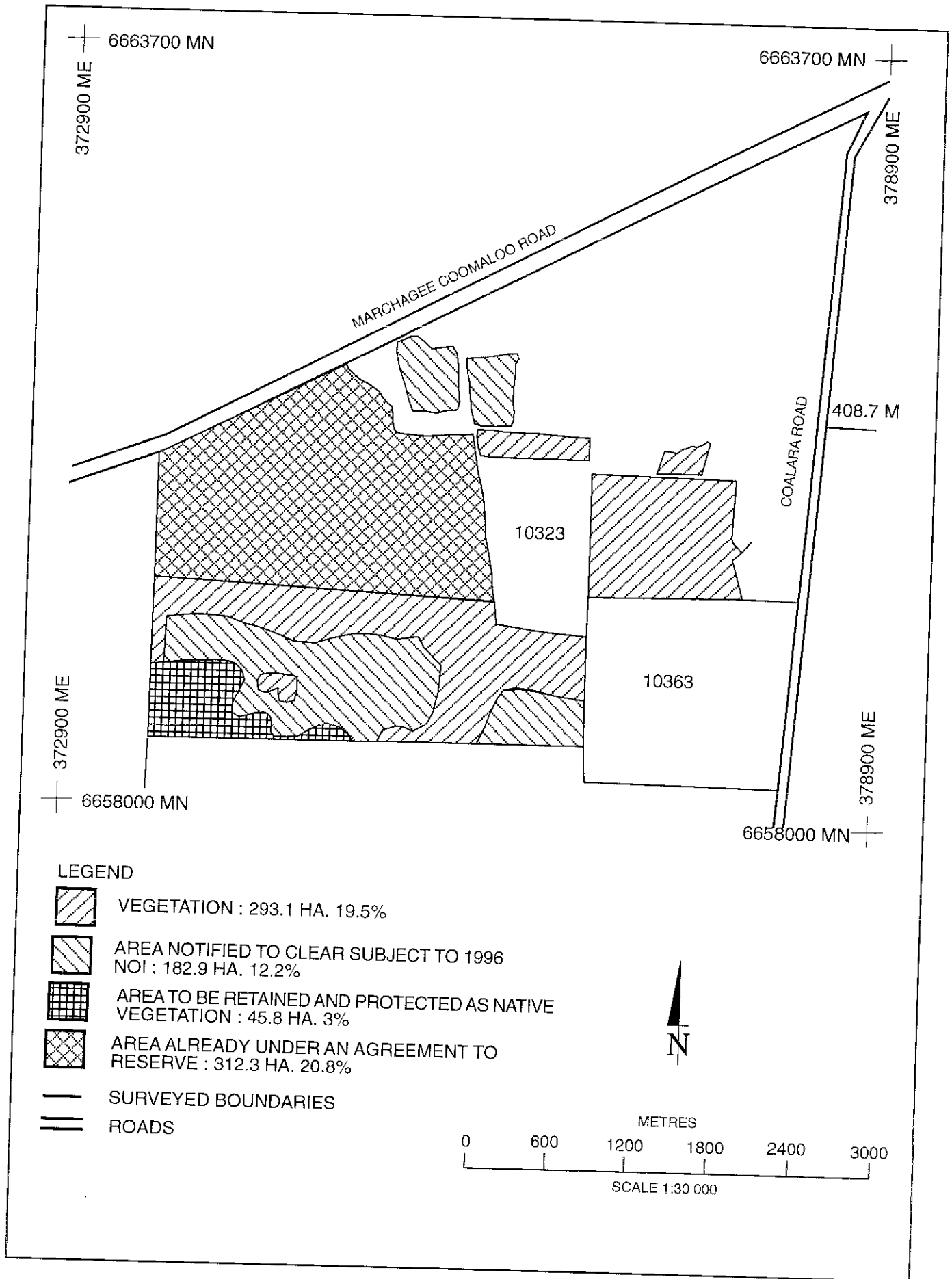


Figure 2. 'Notice of Intent' to clear native vegetation on the Glover property (amended September 1998)

Table 1. Summary of assessment of relevant factors

KEY ENVIRONMENTAL FACTORS	OBJECTIVES	EVALUATION FRAMEWORK	EPA EVALUATION
1. Plant diversity and species richness.	<ul style="list-style-type: none"> to maintain adequate areas of high plant diversity and species richness. 	The species richness of the vegetation proposed to be cleared is moderate in comparison to vegetation occurring within and near the Lesueur National Park. Even after clearing, approx. 651 ha of remnant vegetation will remain on the property.	The EPA concludes that adequate areas of vegetation are to be retained on the property.
2. Declared Rare Flora and priority flora.	<ul style="list-style-type: none"> to protect DRF and priority flora consistent with the provisions of the Wildlife Conservation Act. 	Site specific data for vegetation proposed to be cleared indicates that it is unlikely that significant priority species are present within the area proposed to be cleared.	The EPA concludes that it is unlikely the clearing will impact on declare rare or priority flora.
3. Regional representation of vegetation proposed to be cleared.	<ul style="list-style-type: none"> to maintain the abundance, species diversity, geographic distribution and productivity of vegetation communities. 	Vegetation proposed to be cleared falls within the Beltara South bioregion, which is reasonably well represented within the conservation estate and vacant crown land.	The EPA concludes that proposed clearing is unlikely to have a significant impact on the regional representation of the Beltara South bioregion.
4. Impact of vegetation clearing on corridors.	<ul style="list-style-type: none"> to maintain adequate vegetation corridors between substantial areas of remnant native vegetation. 	Vegetation proposed to be cleared forms part of a non-contiguous corridor for native fauna between Watheroo National Park and the proposed Big Soak Plains.	The EPA considers that the retention of vegetation corridors to link remnant native vegetation and national parks will add significantly to the environmental values of these areas in the region.
5. Viability of remnant vegetation.	<ul style="list-style-type: none"> to maintain the viability of remnant vegetation blocks. 	Approximately 651 ha (443% of the property) of native vegetation is proposed to be retained on the property. This vegetation is considered to be in good condition.	The EPA considers that remnant vegetation proposed to be retained on the property within an ATR under the provisions of the Soil and Land Conservation Act will maintain the viability of a significant area of vegetation on the property.

It is the EPA's opinion that the following are the environmental factors relevant to the proposal, which require detailed evaluation in this report:

- (a) plant diversity and species richness;
- (b) Declared Rare and Priority Flora;
- (c) regional representation of vegetation;
- (d) vegetation and fauna corridors; and
- (e) viability of remnant vegetation on the property.

Information was also sought by the EPA from Mr Ted Griffin, a botanist who has carried out extensive surveys and investigation of vegetation in the Lesueur region. Mr Griffin's report to the Department of Environmental Protection entitled 'Interim Bioregions West Midlands - Unpublished report to the Department of Environmental Protection' is included as Appendix 2 to this report.

The relevant environmental factors are discussed in Sections 3.2 to 3.6 of this report.

3.2 Plant diversity and species richness

Description

Advice on plant diversity and species richness has been provided by the Department of Conservation and Land Management. The advice of Mr Ted Griffin has also been used by the EPA to help in the assessment of this factor.

Assessment

Mr Griffin advises that vegetation proposed to be cleared is located on sand and gravel areas which are likely to have species numbers in the order of 50 species per 100 m². The EPA notes that the species richness for vegetation proposed to be cleared is moderate in comparison to the high species richness vegetation which occurs within and near to the Lesueur National Park. The EPA notes that even after clearing, approximately 651 ha (43% of the property) of remnant vegetation will be retained on the property. Following consideration of this information, the EPA concludes that the proposed clearing is unlikely to have an unacceptable impact on plant diversity and species.

3.3 Declared Rare and Priority Flora

Description

Advice on the presence of declared rare flora and priority flora has been provided to Agriculture WA by the Department of Conservation and Land Management (CALM). This information has been referred to by the EPA as part of this evaluation.

The Department of Conservation and Land Management (CALM) advises that according to the regional data base, a significant number of declared rare and priority flora occur in the general region of the property. Thirteen species of priority flora and one declared rare flora are recorded for the surrounding area.

Mr Griffin has advised the EPA that in relation to landscape within the area proposed to be cleared, there is a moderate to low chance that priority flora would occur, as most of the priority flora would be likely to occur on the gravel ridges with powderbark wandoo, which are not proposed to be cleared. Mr Griffin further advised that while some priority 2 flora may be present within the area proposed to be cleared, these are likely to be reclassified as priority 4 when observations about their distribution are incorporated into CALM's database.

Assessment

The EPA notes that the advice provided by CALM is based on information provided within a regional data base. The EPA also notes that site specific advice provided by Mr Griffin indicates that it is unlikely that significant priority flora species would be present within the area proposed to be cleared.

Following consideration of this advice, the EPA concludes that the proposed clearing is unlikely to have an unacceptable impact on declared rare or priority flora.

3.4 Regional representation of vegetation

Description

Vegetation of the Dandaragan-Lesueur area has not been mapped in detail. This presents difficulties in determining how adequately vegetation types are represented within remaining remnant vegetation areas within the region, and particularly in conservation reserves. Beard (1979) has mapped the vegetation of Western Australia based on an interpretation of vegetation structure and associations correlated against mapped geological surface types. From this basis, Beard has defined a series of vegetation units. These were defined by a few dominant species. Within the Dandaragan region, the mapping was undertaken on a scale of 1 : 250,000. Each mapped unit, therefore, would normally include several vegetation types.

The EPA considers that it is difficult to make a judgement on the representativeness of vegetation on a particular property within the region at this scale of mapping. The vegetation types of the Dandaragan-Lesueur area are structurally similar (low shrub dominated) but are highly variable in composition. Assessment of these areas requires detailed analysis of how the floristic composition changes across the area. Griffin (1994) has undertaken a study over much of the area which provides a basis for a regional assessment. The only difficulty is to provide a geographic distribution to that analysis. Mr Griffin (Appendix 2 of this report) has developed interim bioregions based on a correlation with the soil-landscape mapping systems prepared by Agriculture WA. This mapping is prepared from interpretation of aerial photos at the scale of 1:20,000 to 1:50,000. This approach has also been taken for vegetation mapping on the Swan Coastal Plain.

The Glover property is located in the Beltara south bioregion, as defined by Griffin, 1998.

Assessment

The vegetation proposed to be cleared falls within Beltara south bioregion. At present there is approximately 15 % of this vegetation included in NPNCA vested land (National Parks and Nature Reserves). In addition, there is a further 6 % of this vegetation in vacant Crown land, in particular Big Soak Plains, which is located immediately north of the Glover property, and for which CALM has initiated a request for conservation. With the inclusion of the Big Soak Plains in the conservation estate, the Beltara south vegetation will be reasonably well represented in conservation reserves. However, the EPA notes that there would be some portions, for example gravel ridges, which are less well represented within the conservation estate, as these areas have been mostly cleared. It is understood by the EPA that these ridges are significant for a number of species with limited distribution which grow with powderbark Wandoo.

The EPA is aware that the gravel areas within the Glover property which are likely to contain powderbark Wandoo communities are proposed to be left uncleared. Accordingly, the EPA concludes that the clearing as proposed is unlikely to have a significant impact on the regional representation of vegetation in the Beltara south bioregion.

3.5 Vegetation and fauna corridors

Description

A 'corridor' can be defined as 'a linear feature of vegetation which differs from the surrounding vegetation and connects at least two patches, which were connected in historical time' (Saunders and Hobbs, 1991). When considering faunal movement, the important component is that it allows movement *from* somewhere *to* somewhere (Hobbs, 1992).

Extensive clearing of native vegetation has occurred in the Lesueur-Dandaragan area in past years. However, a number of nature reserves and national parks have been established in the region (Figure 3).

The location of the property is such that it forms a corridor between the Watheroo National Park to the east of the property, and the Big Soak Plains to the north.

Assessment

The EPA is aware that extensive clearing in the West Midlands district of Western Australia in past years has resulted in a landscape which has a number of fragmented areas of native vegetation remaining. Some of this vegetation is included within conservation reserves. Other areas of remnant native vegetation within private ownership represent significant stands comprising several hundreds of hectares which provide valuable flora and fauna habitats. If these areas were linked these could be considered to be potentially viable vegetation corridors.

Various research has been undertaken on the relationship between the size of remnant vegetation and corridor values for native fauna movement. This research has been documented in reports such as 'The Role of Corridors' (Saunders and Hobbs, 1991). This report presents a number of research papers on the subject of vegetation corridors which are considered to be applicable to the Australian environment. The advantages of retaining corridors include the fact that they allow organisms and natural ecological processes to maintain biological diversity. (Harris and Scheck in 'The Role of Corridors' 1991, p.189). Another paper expands on the values of vegetation corridors as follows;

'As conduits, linear features or corridors may foster the movement of biota and may change the degree of ecological isolation of populations in fragmented landscapes. If they foster the movement of species dependent on remnant vegetation, corridors will make a positive contribution to conservation' (Saunders and Hobbs in 'The Role of Corridors' 1991, p. 422)

The width of corridors is considered to be particularly important as the edges are vulnerable to outside disturbances including exotic weed invasion and human disturbance. This is known as the 'edge effect'. While it is difficult to be precise in determining an optimum size and/or width of vegetation corridors, where specific species of native fauna are known to occur in the vicinity, an informed decision on an appropriate width can be made by specialists to optimise the possibility of ensuring that the corridor is viable for those species (Hobbs, 1992).

In order to maintain a viable corridor in the 'long term', and to minimise the 'edge effect', it is generally accepted that a minimum width of several hundred metres is required in order for a remnant vegetation corridor to remain viable in the medium to long term

The EPA notes that the vegetation proposed to be cleared on the Glover property provides part of a continuous corridor between the Big Soak Plains, and beyond to the Alexander Morrison National Park to the north. Further, it is directly linked with Watheroo National Park to the east, and stands of remnant native vegetation on privately owned land to the south. The EPA considers that if vegetation corridors were retained on the Glover property, these linkages could be preserved.

As indicated in the amended NOIC (Figure 2), the proponent intends to retain vegetation corridors along the southern and eastern edges of the property, to maintain a continuous vegetated link between the Big Soak Plains, Watheroo National Park and privately owned land to the south. It is the EPA's view that the retention of these linkages would help to maintain the nature conservation values of the remnant vegetation, and the EPA compliments the proponent's initiative in retaining the vegetation corridors.

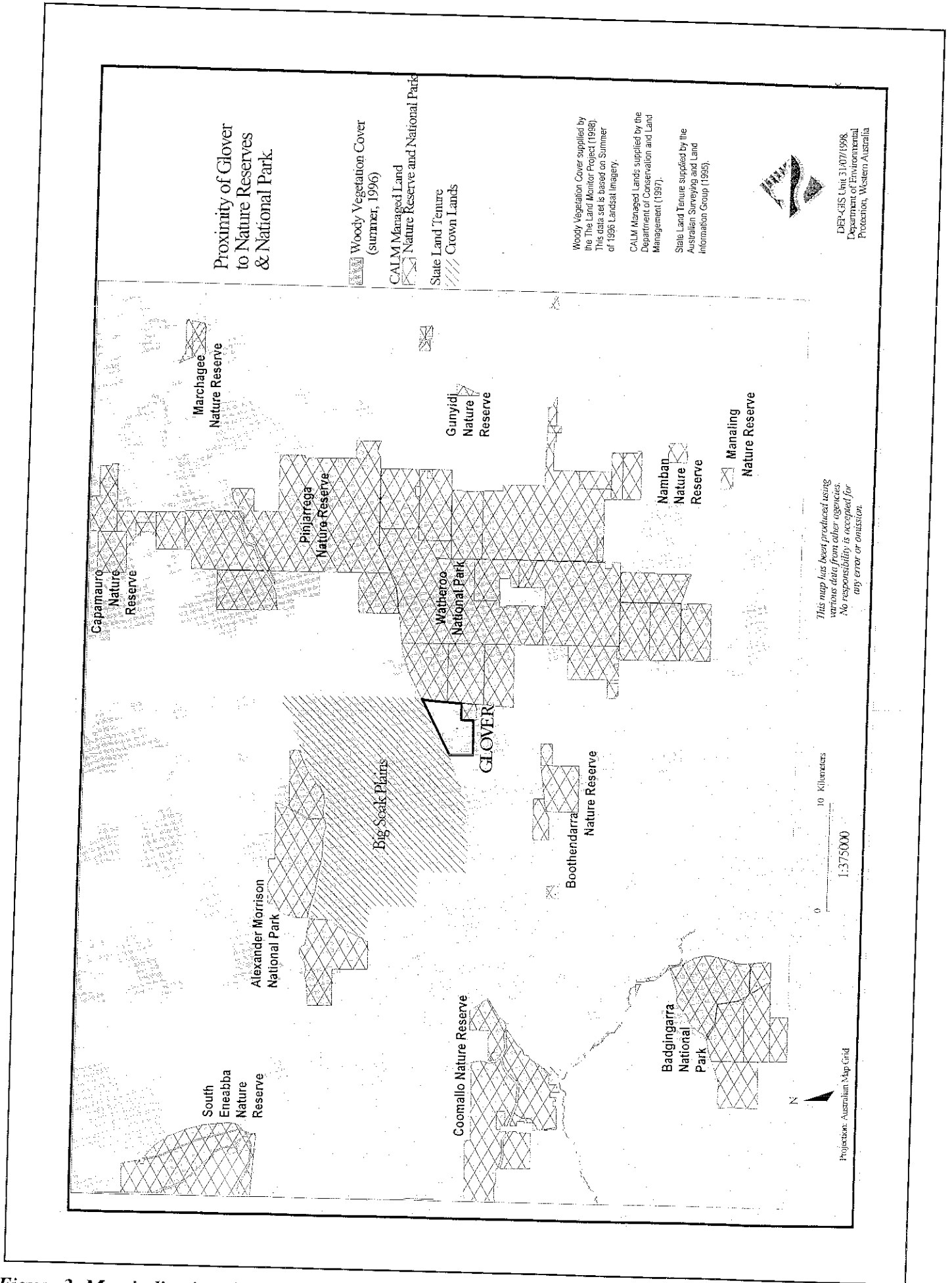


Figure 3. Map indicating the Glover property in relation to national parks and nature reserves in the Lesueur Region.

3.6 Viability of remnant vegetation on the property

Description

The total size of Location 10323 is 1500 ha. The amended NOIC, indicated in Figure 2, indicates that 183 ha is proposed to be cleared.

Approximately 651 ha (43.3% of the property) of native vegetation on the Glover property would remain after the proposed clearing. 21% of the property is already included within an ATR under the provisions of the Soil and Land Conservation Act. An additional 46 ha (3% of the property) is proposed to be included in an ATR by the proponent.

Assessment

The EPA has been advised that the vegetation proposed to be retained on the property is considered to be in good condition, with minimal weed invasion or disturbance from stock movement. Further, the proponent has voluntarily agreed to include a substantial portion of the remnant vegetation within an Agreement to Reserve under the provisions of the Soil and Land Conservation Act. This means that a total of 358 ha (24%) of remnant vegetation on the property will be protected within an ATR. This initiative by the proponent to protect this portion of vegetation is commended by the EPA.

The EPA considers that the proposed clearing is unlikely to have an unacceptable impact on the viability of remnant vegetation on the property.

4. Conclusions

The EPA has considered the proposal by Mr Glover to clear 183 ha of native vegetation on Victoria Location 10825.

The EPA has noted that Mr Glover has previously entered into an Agreement to Reserve 312 ha of remnant vegetation on the property (21% of the property). A part of the current Notice of Intent to Clear, Mr Glover has indicated that a further 46 ha (3% of the property) of vegetation will be included in an Agreement to Reserve.

The EPA also notes that the proponent intends to retain vegetation corridors and eastern edges within the property, to maintain a continuous vegetated link between the large area of remnant vegetation to the north of the property referred to as Big Soak Plains, Watheroo National Park to the east and privately owned land to the south. It is the EPA's view that the retention of these linkages would help to maintain the nature conservation values of the remnant vegetation.

Following consideration of this information, the EPA concludes that the proposal by Mr Glover to clear 183 ha, as indicated in Figure 2, is environmentally acceptable. In reaching this conclusion, the EPA commends the proponent's initiative and co-operation in retaining vegetated corridors within the property, and including a significant portion of Location 10323 within in an Agreement to Reserve under the provisions of the Soil and Land Conservation Act.

5. Recommendations

Section 44 of the *Environmental Protection Act 1986* requires the EPA to report to the Minister for the Environment on the environmental factors relevant to the proposal and on the conditions and procedures to which the proposal should be subject, if implemented. In addition, the EPA may make recommendations as it sees fit.

The EPA submits the following recommendations to the Minister for the Environment:

1. That the Minister notes that this assessment is in relation to an agricultural land clearing proposal.

2. That the Minister notes that following consultation with the proponent, and agreed modifications to the proposal, the EPA has concluded that the proposal is unlikely to have an unacceptable environmental impact and could be permitted to proceed.
3. That the Minister for the Environment considers the report on the relevant environmental factors of plant diversity and species richness; Declared Rare and Priority Flora; regional representation of vegetation; vegetation and fauna corridors; and viability of remnant vegetation on the property; as set out in Section 3 of this report.

Appendix 1

References

- Beard J. S. (1979) 'The vegetation of the Moora and Hill River area, Western Australia : Map and explanatory memoir'. Vegetation Survey of Western Australia. Vegmap publications, Perth.
- Griffin, E. A. (1998) 'Interim Bioregions West Midlands'. Unpublished report for Department of Environmental Protection. AGWEST Land Management Job 98/155.
- Harris, L. D. and Scheck, J (1991) 'From implications to applications: the dispersal corridor principle applied to the conservation of biological diversity' in Saunders, D. A. and Hobbs, R. J. (Eds.) 'Nature Conservation 2 : The Role of Corridors'. Surrey Beatty & Sons Pty Ltd
- Hobbs, R. J. (1992) 'The Role of Corridors in Conservation: Solution or Bandwagon?', in *Tree* Vol. 7, No. 11, November 1992.
- Memorandum of Understanding between the Commissioner for Soil and Land Conservation, Environmental Protection Authority, Department of Environmental Protection, Agriculture Western Australia, Department of Conservation and Land Management and the Water and Rivers Commission for the protection of remnant vegetation on private land in the agricultural region of Western Australia.
- Safstrom R and Craig G F (1996) 'Environmental Evaluation of native vegetation in the Wheatbelt of Western Australia : Principles and Criteria Used to Appraise Land Clearing Proposals'.
- Saunders, A. A and Hobbs, R. J (Eds.) (1991) 'Nature Conservation 2 : The Role of Corridors'. Surrey Beatty & Sons Pty Ltd.
- Saunders, D. A. and Hobbs, R. J. (1991) 'The role of corridors in conservation : what do we know and where do we go?' in Saunders, A. A and Hobbs, R. J (Eds.) 'Nature Conservation 2 : The Role of Corridors'. Surrey Beatty & Sons Pty Ltd.

Appendix 2

**E A Griffin (1998) Interim Bioregions West Midlands.
Unpublished report for the Department of Environmental Protection.
AGWEST Land Management Job 98/155.**

Interim Bioregions
West Midlands

prepared for

Department of Environmental Protection

by

AGWEST Land Management

E. A. Griffin

July 7, 1998

to be quoted as

E.A. Griffin (1998) Interim Bioregions West Midlands. Unpublished report for Department of Environment Protection. AGWEST Land Management Job 98/155.

Introduction

This document is an interim attempt to define floristic bioregions in the West Midlands area. The assessment is necessary because the high floristic diversity in this area means that there is a need for more certainty in the definition bioregions. To date it has been Beard's (e.g. Beard 1976, 1979) vegetation types which have been used for regional analysis.

Griffin (1990, 1992, 1993 and 1994) demonstrated that Beard's vegetation types were unsatisfactory in describing many of the floristic patterns identified in those studies. In each of these three studies alternate bioregions were proposed. However, the limited geographic coverage of these studies has meant that the recommendations have not been utilised in such as IBRA boundaries.

In this study, an attempt is made to identify surrogate spatial data which can be used to extrapolate the floristic assessments of Griffin. Many of the boundaries identified by Griffin were geological or geomorphic in character. However, most Quaternary surface geology units (e.g. Lowry ???) were too generic to be useful, even though the mapping was reasonably detailed. The geomorphology units (Baxter 1977) was at too coarse a scale to be useful.

The soil-landscape mapping being prepared by Agriculture WA is at a detailed scale and has a hierarchy of map units which are analogs of Beard's systems, districts and provinces.

The method of correlation at this stage has been limited, however, it is expected that the relationship is strong enough for the essence to be clear in this study.

Study Area

The West Midlands area has been defined in a number of ways going back almost 100 years. Essentially it is the portion of the Perth Sedimentary Basin between the Moore and Irwin Rivers. This is roughly the area which Speck (1958) recognised as the Lesueur Botanical District. Most of the endemic species typical of this area are wholly contained within this area (Griffin 1981).

The Darling Fault has been recognised as a sound basis for separating geomorphic and bioregions. The greatest uncertainty appears to be any natural subdivision of the Swan Coastal Plain and subdivisions of the Dandaragan Plateau.

Why associate floristic patterns with soil-landscape patterns?

"It is concluded that geological substrate, as modified by soil development and stripping patterns, is fundamental to the variation in composition of the vegetation supported." (Griffin 1994, p ...).

Griffin (1990) in recognising floristic regions noted that the regions could be "... readily recognised on aerial photographs."

Soil-landscape mapping involves more than mapping of soil types. It is mapping landscapes with a particular combinations of soil types. It takes information such as geology and geomorphology into consideration. It is also hierarchical and the soil-landscape system is close to the landscape catena concept as outlined by Beard (1969):

"A Vegetation System consists of a particular series of plant communities recurring in a catenary sequence an mosaic pattern linked to topographic, pedogenic and/or geological features."

The recent soil-landscape mapping in the south-west of Australia is nearing completion. It is based on stereo interpretation of aerial photographs flown at the equivalent of the scale of 1:20,000 to 1:50,000. This mapping has several advantages over Beard's mapping. Firstly, much of Beard's mapping in the west midlands used a photomosaic but no aerial photo interpretation. It also relies on mental reconstruction of a fragmented vegetation coverage. In contrast, the soil-landscapes are relatively unaltered by agricultural clearing and can be readily interpreted from aerial photographs. Also, the soil-landscape mapping programme has had much greater resources including field verification than had the mapping which Beard did. The methods of capturing the mapping in a digital form has produced a more accurate product than was possible in Beard's time.

Floristic Patterns

Griffin (1994) identified a number of common geographic boundaries which described a significant portion of the floristic distribution in the present study area. The major ones also corresponded with some of the boundaries of Beard's units and soil-landscape system boundaries.

A visual correspondence between the scatter plots generated by Griffin (1994, Figure 10) and the soil-landscape system boundaries (Grose in prep, Schoknecht in prep, Griffin in prep) was undertaken. (An objectively based method would have been more appropriate but was beyond the time currently available.) Never-the-less the subjective assessment has produced a number of clear associations. The bioregions described here are those which are most relevant to the current round of assessment of land clearing applications. Further descriptions will be prepared as required.

Figure 1 indicates interim bioregions based on soil-landscape boundaries and subdivisions based on floristic patterns. This shows that the coastal dunes are distinct bioregions. Inland areas are mainly related to differences in Mesozoic sediments and the degree of landscape stripping. There were some subdivisions made solely on the basis of floristic patterns.

Bioregion Descriptions

The Quindalup bioregion include a number of floristic groups which are quite confined to these recent calcareous dunes (Fig 9o - 9t). Griffin (1993) identified further regional divisions.

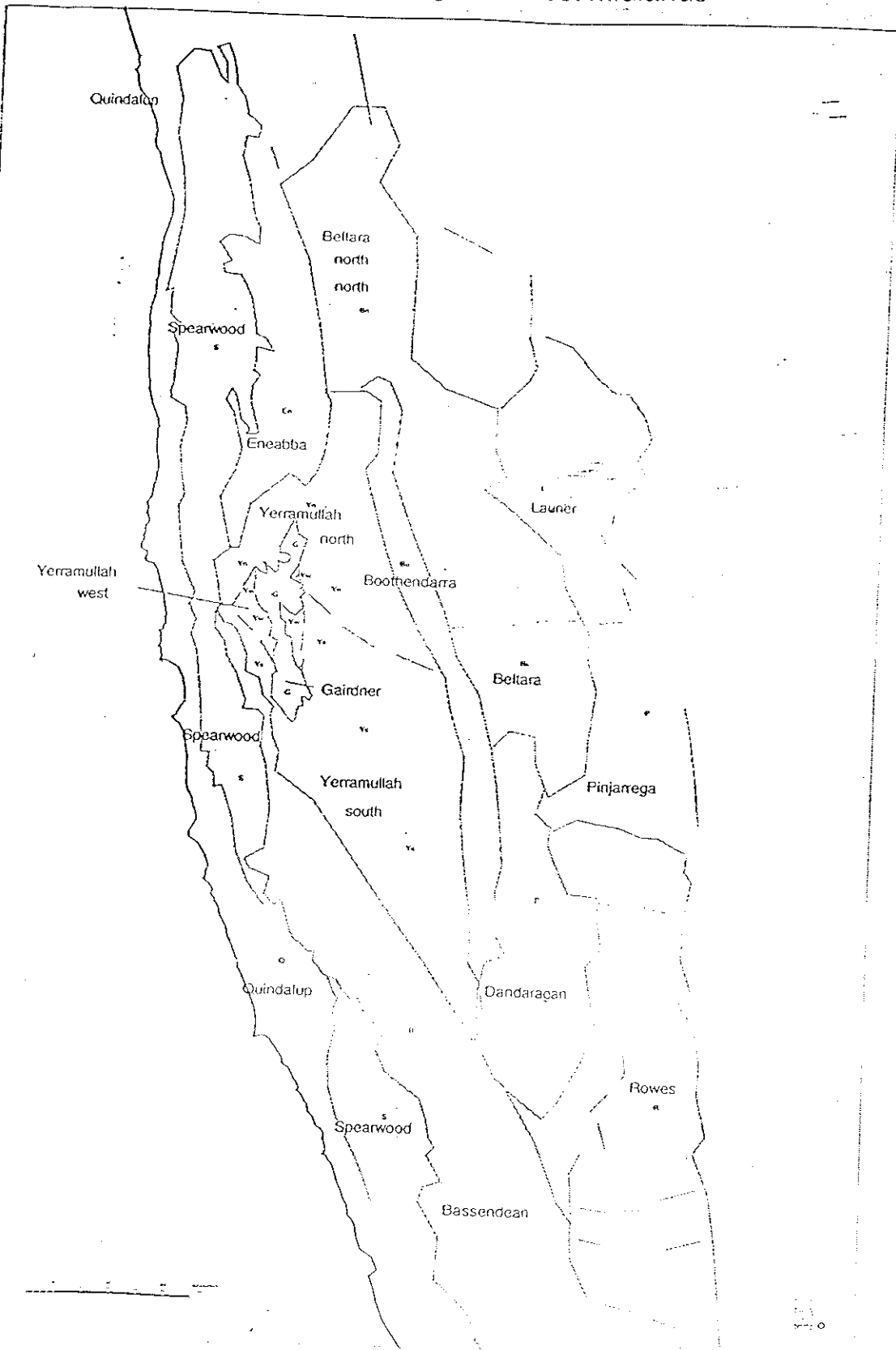
The Spearwood bioregion (Spearwood and the Tamala systems) include closely related floristic groups (Fig 10g). It is probable that these might be further sub-divided.

The Bassendean bioregion included a number of floristic groups. It is clear that it could be subdivided. (Griffin and Keighery 1989).

The Eneabba bioregion is the Eneabba system. This has been defined on an interim basis as it has similarities with part of the Yerramullah bioregion and undefined ones in the north.

The Gairdner bioregion is essentially the Mintaga Hills and the Lesueur soil-landscape systems. Potentially this could be amalgamated with the western portion of the Yerramullah bioregion. This might be reconciled with more detailed investigations of these data sets. It corresponds with much of the Cockleshell Gully Formation where it has not been covered by the coastal dunes.

Figure 1 Interim Bioregions West Midlands



The Yerramullah bioregion includes the Yerramullah and Nylagada soil-landscape systems and covers a significant portion of the Arrowsmith Region (a geomorphic unit, Baxter, 1977). It is also the majority of the Yarragadee Formation south of Eneabba where it has not been covered by the coastal plains. This bioregion is typical of the Badgingarra sandplain and ranges from Cataby to Eneabba. It was called the Badgingarra Floristic Region by Griffin (1990). On the basis of the floristic analysis, several clear divisions were possible; a small western, a northern and a southern portion. As mentioned earlier, the western portion might best be incorporated with the Gairdner bioregion. The eastern boundary between this and the southern portion is the Warradagee Fault which separates distinct geological formations. The boundary between the southern and northern portion was difficult to define due to limited data. It has been set at between the north-east corner of the Lesueur National Park and the eastern boundary of the Coomallo Nature Reserve.

The Boothendarra bioregion is equal to the Boothendarra soil-landscape system and corresponds to the Otorowiri member of the Yarragadee Formation and the Carnac member of the Parmelia Formation south of the Eneabba-Carnamah Road. It was called the Otorowiri Floristic Region by Griffin (1990). This region has a wide range of soils and many different vegetation types, most of which are documented poorly.

The Beltara bioregion is a major portion of the western half of the Parmelia Formation and lies on the Dandaragan Plateau (Baxter 1977). It was called Boothendarra Floristic Region by Griffin (1990). It has similar topography to the Yerramullah bioregion. However, its less dissected eastern portions are relatively intact plateau surfaces. It shares some floristic groups with the Yerramullah bioregion. Two divisions were recognised within Beltara. The Big Soak Plain appears to be a significant boundary and an interim line has been set to correspond with the southern boundary of the residual upland of Big Soak Plain. This might be an artifact of the low sampling effort along the Dandaragan Scarp (the western boundary of the Dandaragan Plateau) north of Big Soak Plain. The floristic composition of vegetation on the northern portion appears to intergrade with those on the northern portion of the Yerramullah bioregion.

The Launer bioregion is tentatively defined and is the sandplain west of Yarra Yarra lake.

The Pinjarrega bioregion is the alluvial plain and sand sheets associated with the ancient drainage line discharging southward from Yarra Yarra lakes.

The Dandaragan bioregion is the moderately stripped portion of the Cretaceous Lancelin Formation (and its various sub units) and corresponds roughly to the distribution of marri in the Dandaragan area.

The Rowes bioregion is an interim combination of the Rowes and Capitella soil-landscape systems. It is the less stripped areas of the Lancelin Formation between Moora and Dandaragan. Griffin (1990) implied that the Watheroo National Park would be part of this bioregion. But, this appears to not be the case.

Conservation status of bioregions

The area of uncleared vegetation was obtained from an unpublished spatial data set generated from satellite imagery from 1995 (Wallace et al in prep.). The proportions uncleared and that in NPNCA reserves is summarised in Table 1.

The Quindalup bioregion is well conserved in this study area with some local deficiencies and threats.

The Spearwood bioregion is also well represented in this study area, though the southern portion is less well represented.

The Bassendean bioregion has much uncleared (mainly Crown) land but is poorly represented in the conservation estate and has significant threats from mineral sands mining.

Table 1 Area analysis of proportion of bioregion and soil-landscape system vegetated and in conservation reserves

Interim Bioregion	Soil-landscape system	proportion Vegetated	proportion NPNCA
Quindalup	Quindalup	0.76	0.46
	Eatha	0.64	0.89
Spearwood	Spearwood	0.64	0.16
	Tamala	0.92	0.66
Bassendean	Bassendean	0.70	0.09
Eneabba	Eneabba	0.40	0.18
Gairdner	Mintaga Hills	0.31	0.16
	Mount Lesueur	1.00	0.80
Yerramullah	Yerramullah	0.38	0.17
	Nylagarda	0.27	0.10
	western	0.76	0.60
	southern	0.38	0.20
Boothendara	Boothendara	0.37	0.12
	Boothendara	0.09	0.02
Beltara	Beltara	0.43	0.12
	northern	0.43	0.10
	southern	0.41	0.15
Launer	Launer	0.28	0.07
Pinjarrega	Pinjarrega	0.66	0.53
Dandaragan	Dandaragan	0.09	0.00
Rowes	Rowes	0.10	0.00
	Capitella	0.19	0.01
	Moore River	0.60	0.03

proportion vegetated

proportion of soil-landscape system which has native vegetation.

proportion NPNCA

proportion of soil-landscape system which is in NPNCA estate.

The Eneabba bioregion also has much uncleared Crown land but there are local deficiencies and significant threats from mineral sands mining.

The Gairdner bioregion (Mt Lesueur and Mintaga Hills soil-landscape systems) is well represented in the Lesueur National Park which includes at least 1/3 of its original extent. The Mintaga Hills soil-landscape system is less well represented than the Mt Lesueur.

The Yerramullah bioregion is moderately well represented in the Badgingarra and Lesueur National Parks and the Coomallo and South Eneabba Nature Reserves. These represent about 17% of its original extent. The sub-regions within the Yerramullah bioregion varied in their representation. The northern portion of Yerramullah is least well represented having only the South Eneabba Nature Reserve. There are several unvested Crown reserves which if included would increase the representation.

The Boothendarra bioregion is very poorly represented with only a small portion uncleared let-alone in the conservation estate; the western portion of the Alexander Morrison National Park.

The Beltara bioregion is moderately well represented in the conservation estate. The northern portion is represented by the Watto Nature Reserve, and the Tathra and Alexander Morrison National Parks. The southern portion is less well represented by the Boothendarra Nature Reserve and a part of the Watheroo National Park. In addition there is a big area of Vacant Crown Land in the northern portion (Big Soak Plain). However, this includes areas not well represented in the conservation estate, the residual upland, and only some of the land cleared for agriculture.

The Launer bioregion is poorly represented in the conservation estate. There are a few small Crown reserves in the area and some areas of uncleared private land.

The Pinjarrega bioregion is very well represented by the Watheroo National Park and Pinjarrega Nature Reserve. A minority of the vegetation types are poorly represented.

The Dandaragan bioregion is very poorly represented with just one small conservation reserve (Jam Hill Nature Reserve). There is very little of this bioregion left uncleared.

The Rowes bioregion (Rowes and Capitella soil-landscape systems) is poorly represented with only part of Jam Hill Nature Reserve and the small Bundarra Nature Reserve. Much of the area has been cleared but there are some uncleared parts of significance in private ownership.

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References

- Baxter, J.L. (1977). Heavy mineral sand deposits of Western Australia. Geo. Survey Min. Resources Bulletin 10.
- Beard, J.S. (1969). The vegetation of the Boorabbin and Lake Johnston areas, W.A. *Proc. Linn. Soc. N.S.W.* 93:239-269. Facsimile reprint, Vegmap Publications, Perth, 1976.
- Beard, J.S. (1976). Vegetation Survey of Western Australia. The Vegetation of the Dongara Area, Western Australia. Map and Explanatory Memoir. 1:250,000 series. Vegmap Publications, Perth. pp. 24
- Beard, J.S. (1979). Vegetation Survey of Western Australia. The Vegetation of the Moora and Hill River Areas, Western Australia. Map and Explanatory Memoir. 1:250,000 series. Vegmap Publications, Perth. pp. 40
- Griffin, E.A. (1981). *Rare and Geographically Restricted Plants of Western Australia. Geographically restricted plants of the Northern Sandplains between the Moore and Irwin Rivers.* Confidential unpublished report for Department of Fisheries & Wildlife. Report 10.
- Griffin, E.A. (1990). *Floristic Survey of Remnant Vegetation in the Dandaragan Area.* Unpublished report to Western Australian Heritage Committee. pp. 113
- Griffin, E.A. (1990). *Floristic Survey of Remnant Vegetation in the Dandaragan Area.* Unpublished report to Western Australian Heritage Committee. pp. 113
- Griffin, E.A. (1993). *Flora of the Quindalup Dunes between the Swan and Irwin Rivers.* Unpublished report to Coastal Planning Branch, Department of Planning and Urban Development and the Heritage Council of W.A. pp. 172
- Griffin, E.A. (1994). *Floristic Survey of Northern Sandplains between Perth and Geraldton.* Unpublished report to Heritage Council of W.A. pp. 200
- Griffin, E.A. and Keighery, B.J. (1989). *Moore River to Jurien Sandplain Survey.* Western Australian Wildflower Soc. Perth. pp. 90
- Lowry, D.C. (1974). Dongara - Hill River, Western Australia Sheets SH/50-5,9. 1:250,000 Geological Series-explanatory notes, Geological Survey of Western Australia, Perth. Australian Government Publishing Service, Canberra. pp. 33
- Speck, N.H. (1958). The Vegetation of the Darling - Irwin Botanical Districts and an Investigation of the Distribution of the Family Proteaceae in South-Western Australia, Ph.D. Thesis, Botany Department, University of Western Australia, Perth
- Wallace, J, Sheperd, D and Allen, A. (in prep.) Remote sensing of Agricultural land cover change project, 1990 - 1995.