4 The Geographic Information System

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This Section describes the methodology, data, design, processing and stratification used in the project GIS. The project GIS was implemented on a Sun Sparc Ultra-10 running the SunOS 5.8 operating system, using ArcInfo™ version 8.2 for UNIX, and on a personal computer running the Microsoft Windows 2000 operating system, using ArcGIS™ Version 8.1 modules ArcMap™, ArcCatalog™, ArcTools™ and Spatial Analyst™ under an Arcview™ licence type.

4.1 Coordinate system

The first requirement before implementing the GIS was to choose a coordinate system for all of the spatial data used and produced by the project. After discussion with Paul Nanninga of the Murray Darling Basin Commission (MDBC) the project co-ordinate system, spheroid and datum have been set to the following:

Lamberts Conformal Conic
False_Easting: 0.000000
False_Northing: 0.000000
Central_Meridian: 146.000000
Standard_Parallel_1: -34.500000
Standard_Parallel_2: -28.500000
Latitude_Of_Origin: -31.500000
Spheroid: GRS1980
Datum: GDA1994

The Lamberts Conformal Conic is preferred by the MDBC (Paul Nanninga pers. comm.). Lamberts Conformal Conic is a good compromise projection because it deals with angles very well, it is good at calculating areas and it is good at calculating distances. The other option considered, i.e. Albers Equal Area, is excellent for calculation of areas but not as appropriate for distances or angles. For this project both distance and area were important. Our main concern was to ensure relative areas were calculated accurately across the MDB. The results of a comparison of the two projections, by projecting the MDB boundary (Dataset 1, Appendix 3 Section 1.1) from its original UTM Zone 55 projection to both Lamberts and Albers (using the parameters shown above for each projection) are summarised in Table 4.1.

Table 4.1 Results of a comparison of area and perimeter of the MDB, between the projection Lamberts Conformal Conic (Lamberts) and Albers Equal Area (Albers).

Area (ha)				Perimeter (km)			
Albers	**Lamberts**	**difference**	**%diff**	**Albers**	**Lamberts**	**difference**	**%diff**
105,806,621	105,849,681	43060	0.04%	7,559	7,569	9.9	0.06%

The differences between the projections were insignificant, so we chose to use the projection preferred by the MDBC, namely the Lamberts Conformal Conic projection as described above. All original GIS data datasets were converted to this projection.

4.2 Data

After the exploitation criteria had been developed (Section 3), the next step was to design a preliminary data processing flowchart, the final version of which can be found in Appendix 2. The detail of the flowchart was developed in an iterative process throughout the life of the project, however in its preliminary form, it allowed for the identification of the datasets which were required. It was not within the ambit of this project to develop the original spatial datasets to meet the objectives, so we relied upon data which were readily available from Government and other sources (Appendix 3 Section 1 and this report Section 4.2.1). The methods employed to find data included literature searches, web searches and seeking advice from experts.

4.2.1 Data sources

The success of the project hinged upon finding adequate data upon which the exploitation criteria could be applied. Spatial data used for the project needed to be as consistent as possible across the whole study area, to allow comparability across the whole MDB. It was also important to understand the assumptions and limitations implicit in the data. All data have associated limitations, so where choices between datasets existed, the most recent datasets with the most explicit data items and lineages were chosen.

Availability, resolution and consistency of data vary widely. Many datasets were reviewed and rejected as unsuitable for a variety of reasons, ranging from difficulties in obtaining them, time penalties required to process them to a usable state and data inadequacies, e.g. poor coverage, unsuitable resolution, missing projection information, missing metadata.

The quality and availability of data substantially constrained the project to what could be done rather than what might be considered optimal. The major data availability requirements which could ***not*** be met consistently across the whole area of the MDB were:

1. data on the distribution of all species suitable for firewood harvesting;
2. data on the distribution of threatened species;
3. data for cultural and historic sites;
4. data allowing spatial assessment of the quality of firewood; i.e. species distributions;
5. data allowing spatial assessment of the age classes of native stands;
6. data allowing spatial assessment of habitat condition; and
7. data allowing spatial assessment of ecological impacts e.g. regeneration potential.

Vegetation species distribution maps at the appropriate detail, scale and consistency do not exist for the whole study area. Neither are there consistent datasets documenting the distribution of threatened species.

Certain areas should be excluded from harvesting through forestry best management practices on the basis of cultural and aesthetic importance or because of the presence of rare and threatened species. We could find no consistent data covering the whole of the MDB to allow us to apply any of these constraints.

Firewood "quality" depends on the tree species in question. Again the lack of specific spatial information for all or any native species and/or communities extant in the MDB did not allow spatial elucidation of firewood quality.

There are no spatial data on the age of native remnants. The project has developed a method of assigning age class using data from the field case studies (Sections 5 and 6).

Habitat "condition", however it is defined, depends on the disturbance history of each patch of native vegetation and such data do not exist across the MDB.

Regeneration potential depends in part on the condition of each stand. As we could not spatially represent condition, we used data from field case studies to assess the results from the growth and yield modelling (Sections 5 and 6). Data on the regeneration of the dominant potential firewood species from each of the field study sites across the MDB are more fully discussed in Section 9 (Ecological impacts of the green-wood scenario). However, regeneration potential also depends on the climate, substrate and vegetation composition of each patch and also on the existence of a sufficient body of knowledge to provide reliable growth curve and carbon cycling response data (Section 6).

Table 4.2 lists the original datasets which provided all source data for the project, and the exploitation criteria to which they pertain. The descriptions and metadata sources for each original dataset are provided in Appendix 3 Section 1.

Table 4.2 The original data datasets used for the project.

Original Dataset	Source	Exploitation Criteria
1. MDB Boundary	Basin-in-a-Box; Murray-Darling Basin Commission	1
2. Woody cover in broad forest types associated with tenure	National Forest Inventory, Bureau of Rural Sciences	3, 4, 5, 8, 9, 10
3. Urban Areas	Geoscience Australia	2
4. Digital Elevation Model	Geoscience Australia	6, 11
5. Water courses	Geoscience Australia	7

Three additional datasets provided data necessary for the growth and yield analyses of the scenarios. Table 4.3 shows these datasets. The metadata sources for these are provided in Appendix 3 Section 1.

Table 4.3 The additional datasets and the scenarios to which they pertained

Dataset	Source	Scenario
6. Net Primary Productivity	Dr Damien Barrett, CSIRO Plant Industry	All
7. Salinity Risk	National Land and Water Resources Audit	Plantation scenario Option 4
8. Soil depth, nutrient and water holding capacity data	MDBSIS, CSIRO Land and Water	Plantation scenario.

All data for this project were produced from these eight basic datasets.

4.2.2 Data limitations

The most crucial data requirements were forest cover, land tenure and net primary productivity (NPP) datasets and it was particularly necessary to understand the limitations inherent in each. We needed the first to provide us with the actual cover of woody/non-woody vegetation in broad forest types, the second was required to distinguish private from publicly owned land, and the third was required to allow us to stratify areas of different forest types by the net primary productivity index, for the modelling of sustainable firewood yield.

Forest type and tenure

The National Forest Inventory (NFI), Bureau of Rural Sciences (BRS), provided us with the National Forest Inventory 2003 Forest by Tenure dataset (Dataset 2, Appendix 2 and Appendix 3 Section 1.2) for use in this project. This dataset had land cover and tenure data updated in 2003 from data provided by State agencies, and it provided both the woody/non-woody cover classified into NFI forest types, and the tenure data for the project. The dataset came with accompanying lookup tables for crown cover classes, height classes and forest formation classes. The details and metadata of this dataset can be found in Appendix 3 Section 1.2.

The NFI 2003 dataset was the most recent and consistent example of its kind, covering the whole of the MDB, and as such it was the best existing dataset available, and was used for the project. However it was constructed from a variety of datasets from different sources and with different attributes, scales and currency dates. As such, the NFI 2003 dataset suffers from the usual caveats with regard to consistency and compatibility. The methods of dealing with issues of consistency and compatibility were explicitly addressed by the NFI in the production of the dataset (see the metadata). The limitations imposed by the dataset on estimating firewood are documented in the following paragraphs. The resolution of this dataset, i.e. 100 metre gridcells, dictated the resolution of the project GIS. It should be noted that the cell size of 100m is not necessarily representative of the scale of all of the input datasets used in its construction, but rather this is the minimum mapping unit.

The resolution of the NFI 2003 dataset constrained the project to ignore all woodland patches smaller than 100 x 100m, or 1 hectare. Again, the scale of the original mapping may not necessarily have captured all areas of this size . The NFI has no minimum mapping unit, however the smallest unit captured would be dependent on the scale of the mapping. With this caveat in mind, we considered that the harvesting of firewood for general sale from isolated patches smaller than 1 hectare was likely not to be economically feasible, although private-owner wood collection from such sites may be significant.

The hierarchy of precedence for the data used for each Australian State is described in the metadata for the NFI 2003 dataset. The issue for this project was to separate privately tenured land classified as non-forest or non-woodland from the forest or woodland areas which could be treated as a source of firewood from private lands. The NFI 2003 dataset classified the land into various forest types (Table 4.4). Map 1 (Appendix 4) shows the geographic distribution of the classes in Table 4.4.

Table 4.4 The forest type classification for the gridcells of the MDB.

Forest Type	Area (ha)	% Area [a]
“blank”	35	0.00%
Acacia [a]	3,523,742	3.33%
Callitris [a]	1,499,895	1.42%
Casuarina [a]	1,100,900	1.04%
Eucalypt Low Open Forest [a]	72,596	0.07%
Eucalypt Low Woodland [a]	216,652	0.20%
Eucalypt Mallee Open Forest [a]	24,809	0.02%
Eucalypt Mallee Woodland [a]	2,591,844	2.45%
Eucalypt Medium Open Forest [a]	14,050,898	13.28%
Eucalypt Medium Woodland [a]	6,037,171	5.70%
Eucalypt Tall Open Forest [a]	1,198,042	1.13%
Eucalypt Tall Woodland [a]	35,231	0.03%
Hardwood Plantation [a]	1,642	0.00%
Melaleuca	77,665	0.07%
No Data	27,105,353	25.61%
Non Forest	47,436,345	44.82%
Other	451,894	0.43%

Forest Type	**Area (ha)**	**% Area [a]**
Rainforest	51,966	0.05%
Softwood Plantation [a]	351,164	0.33%
Unknown Plantation [a]	2,116	0.00%
Total area of the MDB	**105,829,960**	**100.00%**
Total area non-firewood	**75,123,258**	**70.98%**
Potentially eligible woody gridcells [a]	**30,706,702**	**29.02%**

[a] forest types initially assessed to be potentially eligible woody gridcells for the scenarios.

The community descriptions for the forest types in Table 4.4 are provided in Section 5.5.3, Table 5.1. The implications of these forest types, with regard to the selection of field sites and the collection of forest mensuration data for the growth and yield model (Section 6), are addressed in Section 5.

It was possible to classify woodlands and forests, according to the NFI classifications above, into the "mallee" and "non-mallee" classifications required for the growth and yield model (Section 6). The forest type "blank" (i.e. no classification provided), consisting only of 35 gridcells, was excluded from the analysis. Also, we excluded the forest types "melaleuca", "rainforest", "softwood plantation" and "unknown plantation" as they contribute little to either firewood harvesting (the dead-wood and green-wood scenarios) or to land which might potentially be available for hardwood plantation (the plantation scenario) because they constitute areas with native vegetation cover.

The "no data" category covers a large part of the study area. Information from the NFI confirmed that this category is equivalent to "non-forest". We chose to treat it as combined non-woody vegetation and urban land cover, i.e. a virtual equivalent to the "non-forest" category.

The "non-forest" category was treated as non-woody vegetation which might be potentially suitable for plantation. The limitation of this approach was that native grasslands were included in the "non-forest" classification. The implications of this are discussed below.

The "other forest" forest type category included minor forest types, such as banksia and leptospermum, mixed forest types and unknown forest types, all of which meet the NFI definition of forest i.e. "an area dominated by trees with a height of greater than 2 metres and crown cover ≥ 20%". After consideration it was decided to exclude the "other" forest type from further analyses because most of the area was unlikely to be either suitable for firewood harvesting or available for future plantation, and small in total extent (0.43% of the MDB).

A more serious issue relates to the actual definition of "forest" adopted by the NFI. The NFI used the definition of forest from the National Forest Policy Statement (NFPS), i.e. having a crown cover of 20%. All States/Territories provide forest mapping using this definition. The cover is classified into three classes; woodland (20-50%), open (51-80% and closed (81-100%). Section 5 addresses the issue of definitions of "forest" and "woodland" in more detail.

From Table 4.4 it can be seen that there are no closed forests in the MDB, that is, no forest with a crown cover classification greater than 80%. However, there are likely to be areas of the MDB where there is woody vegetation with a crown cover < 20%, and these have been classified as "non-forest" in the NFI 2003 dataset. These areas, which otherwise might contribute to the harvesting of firewood, do not contribute to the dataset. This has caused some under-prediction of the sustainable supply of firewood from the dead-wood and the green-wood scenarios, although how much we cannot easily estimate.

The lack of separate cover classifications for low percentage cover woodlands and native grasslands, will also lead to an overestimation of the extent of land with non-native vegetation cover for the plantation scenario (Sections 3.4, 4.3.7, 4.3.8 and Section 10). The plantation scenario required estimates of the area potentially eligible for plantations, i.e. land defined as having "non-native vegetation cover", including pasture and agricultural land. The only surrogates for non-native vegetation cover in the NFI 2003 dataset were the "non-forest" and "no data" categories. This was not an issue for the project, however, as the area was used only as an indication of the areas relating to different levels of the net primary productivity index which might be available for growing plantations. The modelling for the plantation scenario estimated the minimum areas of plantation forests that would need to be established in the MDB to provide a long term sustainable supply of firewood annually, under four sub-scenarios.

The tenure data for the NFI 2003 dataset also classifies about 5 million hectares, or 4.89% of the MDB as "No Data". By far the majority of this classification falls in parts of the MDB which were excluded by the application of exploitation criterion 2 (further than 500km from a capital city). After review, we chose to exclude this land from the analysis, effectively treating it as public land. Table 4.5 gives the areas in each of the NFI tenure categories given by the NFI attribute "Nfi_summ", which is a summary of the set of more detailed classes also available with the dataset, and the percentage of the total area of the MDB. Map 2 (Appendix 4) shows the distribution of the tenure classes shown in Table 4.5.

Table 4.5 The tenure classifications for the gridcells of the MDB.

Tenure	**Nfi_summ**	**Area (ha)**	**% Area**
Leasehold	LEASE	41,083,229	38.82%
Multiple use forests	MUF	4,074,927	3.85%
Nature conservation reserves	NCR	4,905,376	4.64%
No tenure data	ND	5,171,363	4.89%
Other crown land	OCL	2,831,681	2.68%
Freehold	PRIV	47,763,384	45.13%
Total area MDB		**105,829,960**	**100.00%**
Total private/leasehold area		**88,846,613**	**83.95%**
Total No Tenure Data		**5,171,363**	**4.89%**
Total public land		**11,811,984**	**11.16%**

Net primary productivity

The net primary productivity dataset (Dataset 6; Appendix 2 and Appendix 3 Section 1.6) was made available to the project (Barrett 2000) for the purpose of allowing net primary productivity values to be associated with areas of the different broad forest types, in order to calculate measures of potential site productive capacity for the growth and yield models (Section 6.4.2). The theoretical implications of the use of this dataset are discussed in detail in Appendix 5.

The original dataset provided values equating to net primary productivity in tonnes of carbon/hectare/month. The resolution of this dataset was fairly coarse i.e. 0.05 degrees which, after re-projection to Lamberts conformal conic, gives a gridcell size of about 5.2 x 5.2km. For the purposes of this project these data were re-sampled to the same resolution as the NFI 2003 dataset (i.e. to a gridcell size of 100 x 100m or 1 ha) in the course of the processing (see Appendix 3 Table 1, Dataset 10).

Another limitation of the net primary productivity dataset was that there were 174,641 hectares of "NoData" values inside the MDB. These coincided with several large lakes for which the Barrett data did not provide net primary productivity estimates. The coarse resolution of the dataset caused the loss of woody gridcells abutting the lakes when the grid was used to stratify the scenario data for modelling. We did not attempt to extrapolate into these "NoData" areas. The results would have been dubious and the effort required to do so was considerable. The area lost in terms of woody gridcells amounted to only 0.02% of the woody gridcells available, and the area of non-forest lost amounted to 0.11% of the possible area, so the effects of the loss on the final results was negligible. Appendix 6, Tables 8-16 document the actual loss of area to lakes for each scenario.

The processing of the net primary productivity data

Section 6 addresses the development of the model system used in this project predict sustainable yield from each scenario. The data inputs for the model system for each scenario were ***area of eligible land by broad forest type by net primary productivity class***, where "class" could be equated to a net primary productivity index value. The net primary productivity index (Sections 6, 7, 8 and 10) is the midpoint of each class interval, in tonnes of biomass/hectare/year (t ha^{-1} yr^{-1}).

The original net primary productivity dataset (Dataset 6) was processed to a net primary productivity classification dataset (see Appendix 3 Table 1 Dataset 16 *bioclas69* for the details) with 69 classes of net primary productivity, class interval of 0.2 t ha^{-1} yr^{-1}. Appendix 3 Table 1 Dataset 16 describes the processing in detail and the flowchart (Appendix 2) illustrates the process. Map 3 (Appendix 4) shows the geographic distribution of net primary productivity in classes of 1 t ha^{-1} yr^{-1}. Dataset 16 was used for the stratification of the data from the scenarios to produce the data for the model system. Figure 4.1 shows the breakdown of the area of the MDB by net primary productivity index.

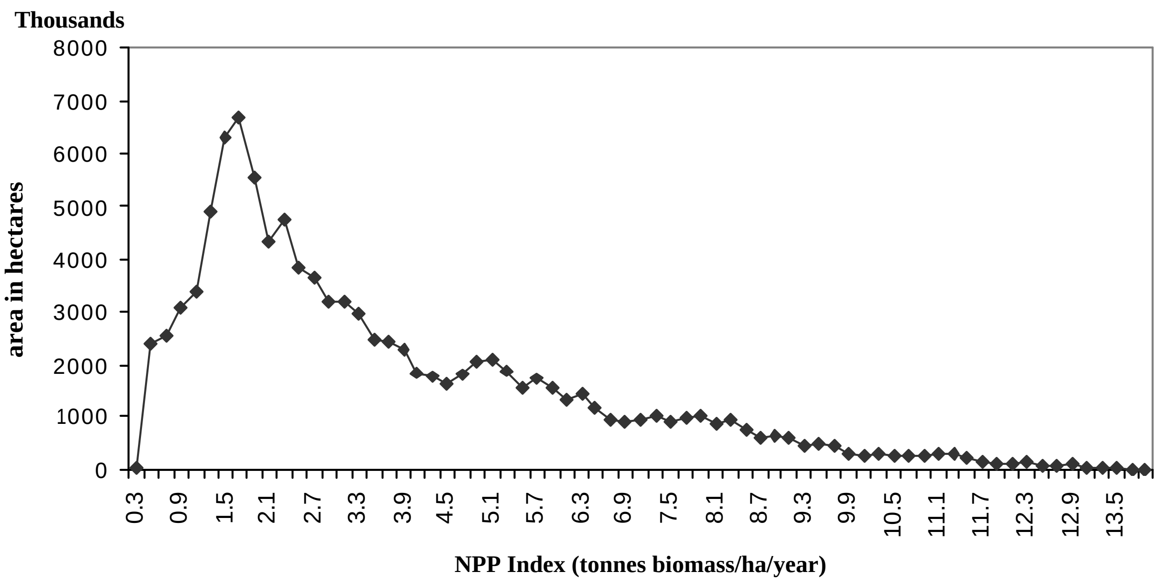

Figure 4.1 The area of the Murray-Darling Basin by net primary productivity index.

From Figure 4.1 it can be seen that the highest productivity values for the net primary productivity index comprise the smallest area (ie. the eastern and higher rainfall areas) of the MDB and that the majority of the MDB falls in areas of lowest productivity (i.e. in the west).

4.3 The application of the exploitation criteria in the GIS

This Section provides a general description of the methods for the application of the exploitation criteria to the eight original datasets used for the project. Thirteen key output datasets (Datasets 9-21 inclusive) and the stratified data for modelling were produced from these eight datasets.

Appendix 2 provides the data processing flowchart, including some important interim datasets, beginning with the eight original datasets and culminating in the production of Datasets 9-21. Appendix 2, Boxes 1, 2 and 3 present the details of the methods used to produce the stratified datasets for the estimations of yield from the three scenarios.

Appendix 3 Table 1 provides the dataset identification for Datasets 9-21 and the detailed steps in the processing lineage for each. The information in Appendix 3 Table 1 should allow critical assessment and replication of the methods used in this project. Note that unless otherwise stated, all grids used in the grid calculations to produce the data for the model system were matched to the cell alignment and resolution defined by the National Forest Inventory 2003 dataset (Dataset 2).

Appendix 4 contains the maps which illustrate the geographic implications of the methods, exploitation criteria and scenarios.

Appendix 6 (file *Appendix_5.pdf*, which will be found on the CD accompanying the final version of this draft report) shows, in a series of tables adapted from the value attribute tables of the relevant GIS datasets, the sequence of changes in area as the exploitation criteria were applied, and the data produced for the yield estimations for each scenario.

4.3.1 The overall exploitation criteria; methods

The application of the overall exploitation criteria (Section 3.1) required the availability of original datasets to delineate the boundary of the MDB (exploitation criterion 1, Dataset 1), to limit its extent by distance from the major capital cities (EC2, Dataset 4) and to include only private land (exploitation criteria 3, Dataset 2). The processing methods for the datasets for each criterion were as follows:

EC 1 The MDB boundary Shapefile (Dataset 1) was projected to the project coordinate system and the resulting Shapefile converted to a grid (Dataset 9). The Shapefile was used in some processing of subsequent datasets, but its main use was for the production of the maps for this report. The grid was used to clip other data grids to the extent of the study area, while also setting the resolution of the project GIS.

EC 2 The Shapefile of the urban areas of Australia (Dataset 4) was used to produce a “masking” grid (Dataset 14) which coded as “NoData” all areas beyond 500km of the major capital cities which take firewood from the MDB (Adelaide, Melbourne, Canberra, Sydney, Brisbane).

EC 3 The NFI 2003 dataset (Dataset 2) was clipped to the extent of the MDB (interim dataset *mdbften*) and reclassified on the basis of the “Nfi-summ” attribute to produce a grid which classified all land previously classified as “private” or “leasehold” to a value of “1” and the rest to “NoData” (interim dataset *ftenure*).

No map calculations were required to apply the overall exploitation criteria at this point in the processing. The datasets for the overall exploitation criteria were employed in a logical sequence according to the processing flowchart (Appendix 2), documented in the Sections 4.3.3 - 4.3.8.

4.3.2 The overall exploitation criteria; results

There were 88,846,613 hectares of private and leasehold tenure in the MDB. Map 4 (Appendix 4) shows the datasets for the overall exploitation criteria.

4.3.3 The dead-wood scenario; methods

The exploitation criteria for this scenario were exploitation criteria 4-5, which are described in Section 3.2. The processing methods for the dataset for exploitation criterion 4 were as follows:

EC 4 The interim dataset *mdbften* (produced for exploitation criterion 3, see previous Section) was reclassified on the basis of the forest type attribute "For_Type", and all public tenure was removed. The results were reclassified to give Dataset 10, i.e. all private land in the MDB designated as native hardwood forest types. The forest type breakdown was: 1 = mallee, 2 = non-mallee, 3 = plantation, because the model system (Section 6) deals only with forest types of "mallee" and "non-mallee", and to allow separation of existing plantations from subsequent analyses.

The stratified data for the dead-wood scenario were then produced. Firstly, exploitation criteria 1-4 were applied simultaneously (Appendix 2, Box 1, Step 1). The resulting dataset was then stratified by net primary productivity class (Appendix 2, Box 1, Step 2). The stratification method is illustrated by Table 4.6.

Table 4.6 The stratification method, illustrated with net primary productivity classes 1-12 and forest types 1 (mallee) and 2 (non-mallee).

NPP class value	Forest type value	Grid calculation (NPP class * 10) + Forest type	Stratified grid value
2	1	(2*10) + 1	21
3	1	(3*10) + 1	31
4	1	(4*10) + 1	41
5	1	(5*10) + 1	51
6	1	(6*10) + 1	61
7	1	(7*10) + 1	71
8	1	(8*10) + 1	81
9	1	(9*10) + 1	91
10	1	(10*10) + 1	101
11	1	(11*10) + 1	111
12	1	(12*10) + 1	121
1	2	(1*10) + 2	12
2	2	(2*10) + 2	22
3	2	(3*10) + 2	32
4	2	(4*10) + 2	42
5	2	(5*10) + 2	52
6	2	(6*10) + 2	62
7	2	(7*10) + 2	72
8	2	(8*10) + 2	82
9	2	(9*10) + 2	92
10	2	(10*10) + 2	102
11	2	(11*10) + 2	112
12	2	(12*10) + 2	122

The value attribute table was imported into a relational database, where the stratified grid value was broken down into the separate net primary productivity and forest type components (see Table 4.6) and the net primary productivity classes equated with their net primary productivity index values for the stratified dataset. The stratified dataset provided the area of each forest type (mallee, non-mallee and plantation) by net primary productivity class and index.

EC 5 All that was required to apply exploitation criterion 5 was to exclude the plantation data from the stratified dataset.

4.3.4 The dead-wood scenario; results

Appendix 6, Tables 1 and 2a,b,c and Table 6 show the cumulative changes in areas of forest types as exploitation criteria 1-4 were applied.

Map 5 (Appendix 4) shows the geographic distribution of the broad forest types after application of exploitation criteria 1, 3 and 4. Map 6 (Appendix 4) shows the geographic distribution of the broad forest types after the application of exploitation criterion 2 (within 500km of capital cities), i.e. the area available for the dead-wood scenario. Table 4.7 shows the forest type by area for the dead-wood scenario.

Table 4.7. Areas by forest type of woody-covered land in the MDB, within 500km of capital cities. The mallee and non-mallee forest types provide the eligible areas for the dead-wood scenario. The plantation area was removed by exploitation criterion 5.

Forest type	Area (ha)	%Area
Mallee [a]	[a] 1,230,552	9.11%
Non-mallee [a]	[a] 12,281,388	90.89%
Plantation	1,536	0.01%
Total private hardwood cover within 500km of Capital Cities	**13,511,940**	**100.00%**
Total beyond 500km from Capital Cities	**8,203,255**	[b] **26.71%**
Total private hardwood cove in the MDB	**21,715,195**	[b] **70.72%**
Potentially eligible woody gridcells	**30,706,702**	

[a] Eligible area for the dead-wood scenario.
[b] Expressed as a percentage of the initial area assessed as potentially eligible woody gridcells for the whole area (Table 4.4 and the last row of this Table).

The stratified data for the dead-wood scenario can be found in Appendix 6, Table 8, which shows the net primary productivity class. The net primary productivity class can be related to the net primary productivity index value through Appendix 6 Table 7 Dataset 16. Section 7 describes the use of the stratified data to predict the sustainable yield for the dead-wood scenario.

4.3.5 The green-wood scenario; methods

Exploitation criteria 6-7 were based on forestry "best management practice" criteria. Exploitation criteria 8-9 were "ecological sustainability" criteria, in that they applied criteria for ecological sustainability for firewood harvesting. They are described in Section 3.3.

Exploitation criteria 6 and 7 were the simplest to apply. They required the availability of adequate original datasets to allow the exclusion of all areas of the MDB which were within 50 metres of a designated river (exploitation criterion 6, Dataset 5) and the exclusion of all areas of the MDB with a slope ≥ 15° (exploitation criterion 7, Dataset 3).

The processing methods for the dataset for exploitation criterion 4 were as follows:

EC 6 The Shapefile of the watercourses of Australia (Dataset 5) was used to produce a "masking" grid (Dataset 15) which coded as "NoData" all areas within 50m of the perennial watercourses and other watercourses designated as "rivers".

EC 7 The 11 tiles of the 9 Second DEM (Dataset 3) were stitched together, and projected to the project coordinate system (interim dataset *basedemlam*). Surface analysis was applied to produce a percent slope dataset, which was reclassified such that all areas with a slope < 15° were coded as "1", and all with a slope ≥ 15° were coded as "NoData." (Dataset 12).

The production of the datasets for exploitation criteria 8 and 9 were conceptually more complex, which was reflected in the processing.

Exploitation Criterion 8; the "30% cover rule"

Exploitation criterion 8 excluded all parts of the landscape with <30% woody cover from firewood harvesting. Andren (1994), Reid (1999, 2000) and McIntyre et al.(2000) all support the conclusion that landscapes with < 30% cover are ecologically unsustainable. The aim of the green-wood scenario was to assess the sustainable yield of firewood harvested in an ecologically sustainable manner.

This raised the question of how to calculate the percent woody cover, on a landscape basis, for any gridcell. The GIS ArcInfo™ neighbourhood statistic "Focalsum" provided the basis for the approach. The Focalsum focuses on the gridcell at the centre of a window of user-defined dimensions and calculates the sum of the data values of all gridcells within the window, and assigns the sum as a value to the central gridcell. For our purpose, all gridcells which have woody cover were classified with the same value e.g. "1" and the rest designated "NoData" and have no value i.e. no woody cover. Therefore, in this case, the Focalsum is equivalent to the count of the number of woody gridcells inside the window. The window is moved progressively over the whole dataset, so that each gridcell in turn becomes the centre of the focus. Figure 4.2 illustrates the results of a focal sum calculation for two window sizes.

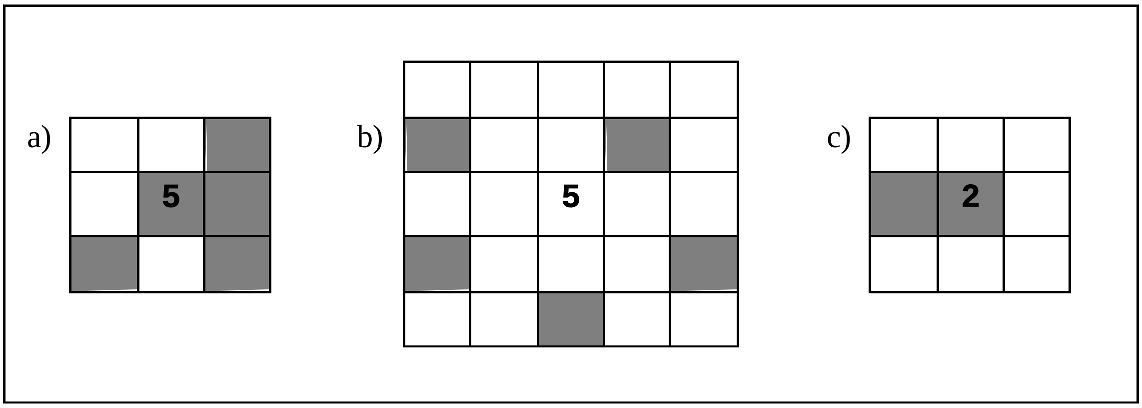

Figure 4.2. Calculation of the Focalsum of a gridcell. The shaded gridcells have woody cover, i.e. a value = "1", and the clear gridcells are "NoData" gridcells (no woody cover). For Figures 4.2a and 4.2b the Focalsum = 5. For Figure 4.2c the Focalsum is 2.

Percent cover for each gridcell is then calculated by dividing the Focalsum of each gridcell by the total number of gridcells in the window, and multiplying the result by 100. Figure 4.3 shows the results of this calculation for the same gridcells illustrated in Figure 4.2.

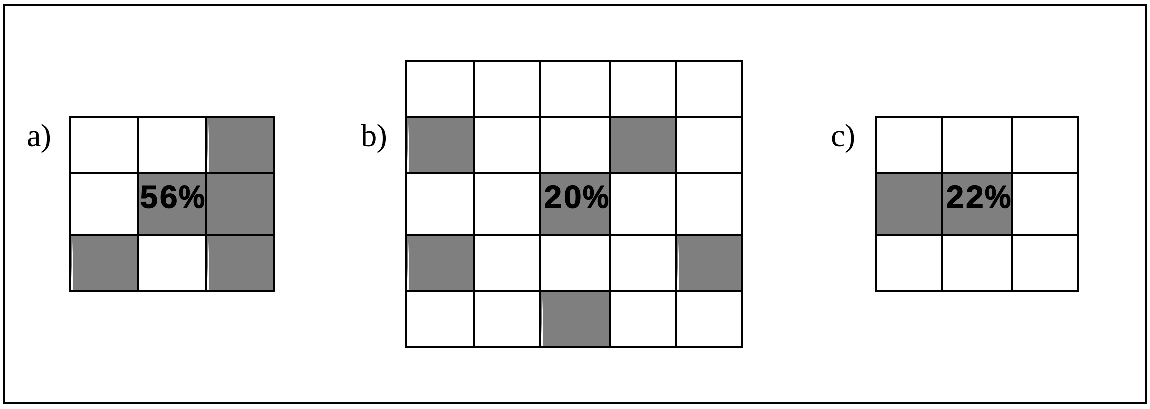

Figure 4.3. Percent woody cover values calculated from Figure 4.2.

The Focalsum method, if applied only to the gridcells within the boundary of the MDB, was likely to cause the unnecessary loss of gridcells at the edges. Woody cover does not stop at the boundary of a study area. An isolated woody gridcell at the very edge could well be in part of the landscape which, if areas outside the MDB were included in the calculation, would be calculated to have ≥ 30% cover.

The solution was to expand the size of the total land area eligible for the green-wood scenario by at least one half of a possible window size. Areas within 500km of capital cities but outside the boundaries of the MDB were removed from the original Dataset 14 (*citymask*) to give a new version of Dataset 14 (*citymdb*). We then expanded the boundary of *citymdb* by 200 gridcells. Map 7 (Appendix 4) illustrates this process.

It can be seen from Map 7 that there are a few points where the very edge of the MDB boundary either touch or come closer than 200 gridcells to the edges of the expanded grid. This occurred on the land-sea interface i.e. at the Murray mouth, and where Dataset 2, the NFI 2003 dataset was originally clipped to encompass the boundaries of the MDB (see interim dataset *ftenlam*, Appendix 3 Table 1 Dataset 10 point 2). The expanded grid could not extend beyond the edge which marks the boundary (including "NoData" values) of the dataset which defines the area within 500km of the capital cities (see Map 7).

This situation was reviewed and it was thought that we would lose few if any gridcells to this edge effect, because for the 30% cover rule we calculated the Focalsum and percent cover values tenure-blind and woody forest-type-blind, in the sense that all woody cover, including melaleuca, all plantations and rainforest, on all land tenures, was included as forest cover. This assumption was checked after calculating percent cover, and we could find no gridcells which were lost to the process through an edge effect.

The next step was to clip the interim forest/tenure grid (*ftenlam*) to the extent of the expanded grid and reclassify such that all gridcells with woody cover, regardless of tenure or woody forest type, had a value = "1" and the rest "NoData", producing the forest cover grid (*cov30mask*) upon which the Focalsum method was run.

It is immediately evident from Figure 4.3 that the size of the window crucially effects the percent woody cover value which will be obtained for each gridcell. Therefore it was important to choose an ecologically relevant window size for calculating the Focalsum and percent woody cover. This issue has been addressed by Andren (1994), Reid (1999, 2000), Bennett and Ford (1997) and Barrett et al.(2003). Andren (1994) used a window size of 100 "units", without specifying the size of the unit. Barrett et al. chose the window size for bird sampling as 10 minutes of latitude by 10 minutes of longitude. For the approximate centre of the MDB, a window of this dimension gives a window size in metres of (0.1667 x 5237.381)/0.05 = 17,461.4283 m^2 or 304km^2. With a gridcell resolution of 100 metres, this equates to a window size of about 170 x 170 gridcells or 289km^2.

We ran a test on a small part of the forest cover grid (see Map 7, Appendix 4), using three different window sizes, i.e. window sizes of 50 x 50 gridcells, 100 x 100 gridcells and 170 x 170 gridcells respectively. It was immediately obvious that at a window size of 50 x 50 gridcells, the effect was patchy, with small, isolated remnants in otherwise heavily cleared areas achieving a percent cover value ≥ 30% and small cleared areas within the more heavily wooded parts of the landscape were calculated to have <30% cover (Map 8, Appendix 4). At a window size of 100 x 100 gridcells, clearly defined corridors contained the larger remnants within the generally cleared areas and the smaller isolated remnants were calculated to have <30% cover, while smaller cleared areas within heavily wooded landscapes achieved percent cover values ≥ 30% (Map 9, Appendix 4). At a window size of 170 x 170 gridcells the corridors began to break down, as large remnants in the generally cleared areas were calculated to have <30% cover and large cleared areas within the heavily wooded landscape began to be classified with ≥ 30% cover (Map 10 Appendix 4).

Computation time became an issue at window sizes greater than 100 x 100 gridcells. We estimated that a window size of 170 x 170 gridcells would give a minium computation time of around 5 days on a dedicated PC, as the effect of increase in size of the window is not linear. For 100 x 100 gridcells a total of 10,000 calculations per gridcell for the 335,226,112 gridcells of the grid (including all "NoData" gridcells). For 170 x 170 gridcells, there would be 28,900 calculations per gridcell.

There exists no scientifically tested method of choosing window size and this should be addressed elsewhere. Taking into account the practical issues of computation time, we chose to take a compromise, between too many very small patches and too few very large and disconnected patches. The window size for the exploitation criterion 8 was set at 100 x 100 gridcells.

The Focalsum calculation was performed on the forest cover grid. The computation time was 29.25 hours on a dedicated PC with half a gigabyte of RAM.

The percent cover dataset (interim dataset *precov30*, Appendix 3 Dataset 17, point 5) was calculated from the Focalsum grid, and reclassified so that every value > 29 became "1", and the rest became "NoData" which provided a mask of all gridcells which obeyed the 30% cover rule i.e. met the constraints of exploitation criterion 8. However, the Focalsum method also gave percent cover values to gridcells which were previously non-woody cells i.e. "NoData" gridcells. Therefore the reclassified percent cover grid was masked by the original forest cover grid upon which the Focalsum had been performed. This simultaneously removed all non-woody gridcells which obeyed the 30% cover rule and all woody gridcells which didn't obey the 30% cover rule, producing a grid of woody cover gridcells for which percent woody cover over the landscape was ≥ 30%.

Exploitation Criterion 9; the "100 hectare rule"

The exploitation criterion 9 dataset was produced from the dataset produced for EC8. The rationale was that we wished to identify patches of native hardwood which occupied landscapes with a percent woody cover ≥ 30% ***and*** were at least 100 hectares in size.

The method used to identify woody patches with an area ≥ 100 hectares was adapted from the method developed by Briggs et al.(unpublished).

When defining contiguous areas of forest/woodland which have an area ≥ 100 hectares, it is not sensible to exclude a gridcell which is separated only by the width of a single gridcell from a larger remnant. It was considered desirable that gridcells be treated as connected to gridcells from which they were only one gridcell distant, including diagonally. Figure 4.4 illustrates possible configurations of woody gridcells in the 30% cover grid. Each gridcell is 100 x 100 metres.

							1
1							
		1	1	1			
		1	1	1			
1		1	1	1			
					1		
1	1	1					

Figure 4.4 Example configuration of woody gridcells. Woody gridcells with cover ≥ 30% are shaded grey, and have a value = "1". The blank gridcells are non-woody and have no value.

The Briggs et al.(in preparation) method commenced with the calculation of a grid of Euclidean distances between the centres of all gridcells to the centre of the nearest woody gridcell. Figure 4.5 illustrates the results of the distance calculation. The value in each cell is the distance from the nearest woody gridcell, calculated from the example in Figure 4.4. For woody gridcells the distance is zero.

100	141.4	200	300	300	200	100	0
0	100	200	200	200	200	141.4	100
100	141.4	100	100	100	141.4	200	200
200	100	0	0	0	100	200	300
100	100	0	0	0	100	200	300
0	100	0	0	0	100	141.4	200
100	100	100	100	100	0	100	200
0	0	0	100	141.4	100	141.4	200

Figure 4.5 Euclidean distances from the woody gridcells (shaded grey).

The next step in the method was to reclassify the distance grid such that all gridcells with a distance of 100m or less from another woody gridcell are distinguished from all others. This coded all gridcells which fall within 100m of a woody gridcell to "1" and the rest "NoData". Figure 4.6 illustrates the result of the reclassification of the grid from Figure 4.4.

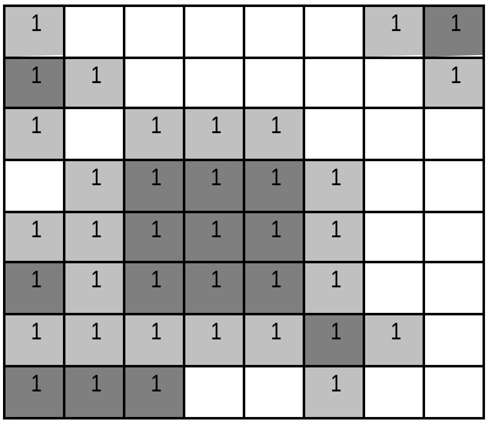

Figure 4.6 Gridcells which are within 100 metres of a woody gridcell. The darker shading indicates a woody gridcell. The lighter shading shows a non-woody gridcell which is within 100 metres of a woody gridcell. The blank gridcells are non-woody and further than 100m from the nearest woody gridcell.

The configuration in Figure 4.6 allowed each gridcell to be allocated to a particular region, using the ArcInfo™ "Regiongroup" function. This function assigns each gridcell to a uniquely numbered region, based on the patterns of contiguity. The method allows gridcells which adjoin on the diagonal to be treated as contiguous. Figure 4.7 illustrates the results of calculating Regiongroup on the grid from Figure 4.7.

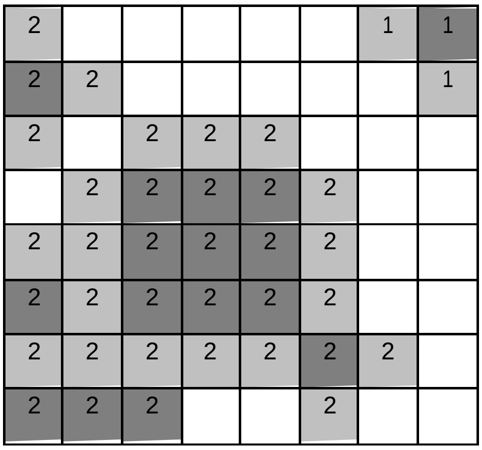

Figure 4.7 The results of the Regiongroup calculation on the grid from Figure 4.5. The value in each gridcell is the region number.

The next step was to remove the non-woody gridcells, i.e. those with the paler grey shade in Figure 4.7, leaving only woody gridcells for the remaining calculations. The method was simply to multiply the 30% cover grid with the grid from the previous step, which gives the result shown in Figure 4.8.

							1
2							
		2	2	2			
		2	2	2			
2		2	2	2			
					2		
2	2	2					

Figure 4.8 The woody gridcells classified into regions. Woody gridcells with cover ≥ 30% are shaded grey. The value in each gridcell is the region number. The blank cells are non-woody.

The regionalised grid illustrated in Figure 4.8 allowed the calculation of the area of each uniquely numbered region. The ArcInfo™ “Zonalarea” method gives each gridcell a value equal to the total number of gridcells in the region to which the gridcell belongs, multiplied by the gridcell area. Figure 4.9 illustrates the results of this calculation for the grid in Figure 4.8, assuming a cell size of 100 x 100 metres. The value is given in hectares in the figure, although the results from the actual calculation are in square metres.

							1
15							
		15	15	15			
		15	15	15			
15		15	15	15			
					15		
15	15	15					

Figure 4.9 The results of the Zonalarea calculation, showing the area (in hectares) of the region each woody gridcell (grey) belongs to. The blank gridcells are non-woody. This method allows adjacent woody gridcells to be included into a “single” remnant.

From Figure 4.9 it can be seen that the value for each gridcell gives the area of the region to which it was allocated. We reclassified this grid such that all cells which had an area of < 999,999 m^2 became “NoData”, and all others, i.e. those with an area ≥ 1,000,000 m^2 (or 100 gridcells, i.e. 100 hectares) were classified = “1”.

This dataset (Dataset 17) contained only those woody gridcells which met all the previous constraints (exploitation criteria 1-7) and were in areas of the landscape with ≥ 30% woody cover (exploitation criterion 8) and belonged to remnants with an area ≥ 100 hectares (exploitation criterion 9). Note that this dataset covered the expanded area.

Stratified data for the green-wood scenario

The stratified data for the green-wood scenario were then produced. Firstly exploitation criterion 6 (distance from rivers, Appendix 2, Box 2, Step 1), then exploitation criterion 7 (slope, Appendix 2, Box 2, Step 2), then exploitation criteria 8 and 9 (Appendix 2, Box 2, Step 3). The resulting dataset was then stratified by net primary productivity class (Appendix 2, Box 2, Step 4). The stratification method is illustrated by Table 4.6. The value attribute table for the stratified grid (*scen2*) was imported into a relational database, where the stratified grid value was broken down into the separate net primary productivity and forest type components (see Table 4.6) and the stratified dataset was produced. The stratified data gave the area of each forest type (mallee, non-mallee) by net primary productivity class.

4.3.6 The green-wood scenario; results

The results of the green-wood scenario are described in sequence, as the different exploitation criteria were applied. This demonstrates the cumulative changes in area of each forest type as each exploitation criterion takes effect.

Map 11 (Appendix 4) shows the combined effects of exploitation criterion 6 (excluding land < 50 metres from a river) and exploitation criterion 7 (excluding land where slope ≥ 15°) on the geographic distribution of the forest types. The effect of exploitation criterion 6 is very difficult to see at the scale of the map because of the relatively small number of woody gridcells removed. Table 4.8 shows the effects of exploitation criterion 6 on the available areas of each forest type.

Table 4.8. Areas by forest type after exclusion of areas <50 metres from rivers (exploitation criterion 6).

Forest type	**Area (ha)**	**%Area**
Mallee	1,230,528	9.12%
Non-mallee	12,264,636	90.88%
Total ^{3} 50m from rivers	**13,495,164**	**100.00%**
Total < 50m from rivers	**16,776**	[a] **0.05%**
Total	**13,511,940**	[a] **44.00%**
Potentially eligible woody gridcells	**30,706,702**	

[a] Expressed as a percentage of the initial area assessed as potentially eligible woody gridcells for the whole area (Table 4.4 and the last row of this Table).

Table 4.9 shows the cumulative effects of exploitation criterion 7 on the eligible areas of each forest type.

Table 4.9 Areas by forest type after exclusion of land with slope ≥ 15° (exploitation criterion 7).

Forest type	Area (ha)	%Area
Mallee	1,230,401	9.20%
Non-mallee	12,146,445	90.80%
Total <15° slope	**13,376,846**	**100.00%**
Total ^{3} 15° slope	**118,318**	[a] **0.39%**
Total ^{3} 50m from rivers	**13,495,164**	[a] **43.95%**
Potentially eligible woody gridcells	**30,706,702**	

[a] Expressed as a percentage of the initial area assessed as potentially eligible woody gridcells for the whole area (Table 4.4 and the last row of this Table).

Map 12 (Appendix 4) shows the effect of exploitation criterion 8 (the 30% cover rule). Table 4.10 shows the cumulative effects of EC8, applied after exploitation criteria 6 and 7, on the eligible areas of each forest type.

Table 4.10 Areas by forest type after the exclusion of land which does not obey the 30% cover rule (exploitation criterion 8).

Forest type	Area (ha)	%Area
Mallee	1,070,422	10.74%
Non-mallee	8,899,204	89.26%
total ^{3} 30% cover	**9,969,626**	**100.00%**
total < 30% cover	**3,407,220**	[a] **11.10%**
total <15° slope	**13,376,846**	[a] **43.56%**
potentially eligible woody gridcells	**30,706,702**	

[a] Expressed as a percentage of the initial area assessed as potentially eligible woody gridcells for the whole area (Table 4.4 and the last row of this Table).

Appendix 4 Map 13 shows the effect of the application of EC9 to the cumulative results of all previous exploitation criteria. This map represents the final geographic distribution of the eligible gridcells by forest type for the green-wood scenario. Table 4.11 shows the cumulative effects of EC9 on the eligible areas of each forest type.

Table 4.11 Areas by forest type after the exclusion of land which does not obey the 100 hectare rule (exploitation criterion 9).

Forest type	Area (ha)	%Area
Mallee	1,065,414	10.88%
Non-mallee	8,729,998	89.12%
the green-wood scenario eligible area	**9,795,412**	**100.00%**
< 100ha	**174,214**	[a] **0.57%**
total ^{3} 30% cover	**9,969,626**	[a] **32.47%**
potentially eligible woody gridcells	**30,706,702**	

[a] Expressed as a percentage of the initial area assessed as potentially eligible woody gridcells for the whole area (Table 4.4 and the last row of this Table).

In total, 4,196,420 hectares (i.e. gridcells) were removed by exploitation criteria 6-9. Most of the area, 3,329,182 hectares, was excluded by the 30% cover rule (exploitation criterion 8) alone, with only 169,652 hectares excluded by the 100 hectare rule (exploitation criterion 9). Table 4.12 documents the area lost to exploitation criterion's 8-9 by forest type. Map 14 (Appendix 4) shows the geographic distribution and forest types of the excluded area.

Table 4.12 Areas of the forest types removed by the application of both the 30% cover rule (exploitation criterion 8) and the 100 hectare rule (exploitation criterion 9).

Forest type	Area (ha)	%Area
Mallee	164,987	0.54%
Non-mallee	3,416,447	11.13%
area removed by exploitation criteria 8 and 9	**3,581,434**	[a] **11.66%**
area before exploitation criteria 8 and 9	**13,376,846**	[a] **43.56%**
potentially eligible woody gridcells	**30,706,702**	

[a] Expressed as a percentage of the initial area assessed as potentially eligible woody gridcells for the whole area (Table 4.4 and the last row of this Table).

The distribution of the area of the mallee forest type excluded by exploitation criteria 8 and 9, stratified by net primary productivity index, is shown in Figure 4.10. From Figure 4.10 it can be seen that the mallee forest type occurs in the net primary productivity index range of 0.4 - 9.8 t ha^{-1} yr^{-1} (net primary productivity classes 2 - 48), and is concentrated in the lower productivity areas, i.e. in the net primary productivity index range of 0.4 and 2.0 t ha^{-1} yr^{-1} (net primary productivity classes 2 - 9). The majority of the area of mallee excluded by exploitation criteria 8 and 9 fell in the net primary productivity index range of 0.4 - 2.0 t ha^{-1} yr^{-1}, amounting to an area of 122,643 hectares, or 74.5% of the total area of mallee excluded. Our understanding of the original distribution of mallee in the MDB indicates that the mallee forest type is still represented across the breadth of its original pre-1750 range, although it has been significantly cleared. Figure 4.10 is still likely to show the environmental preference of the mallee forest type, in terms of net primary productivity, i.e. in the lower rainfall, lower productivity areas of the MDB.

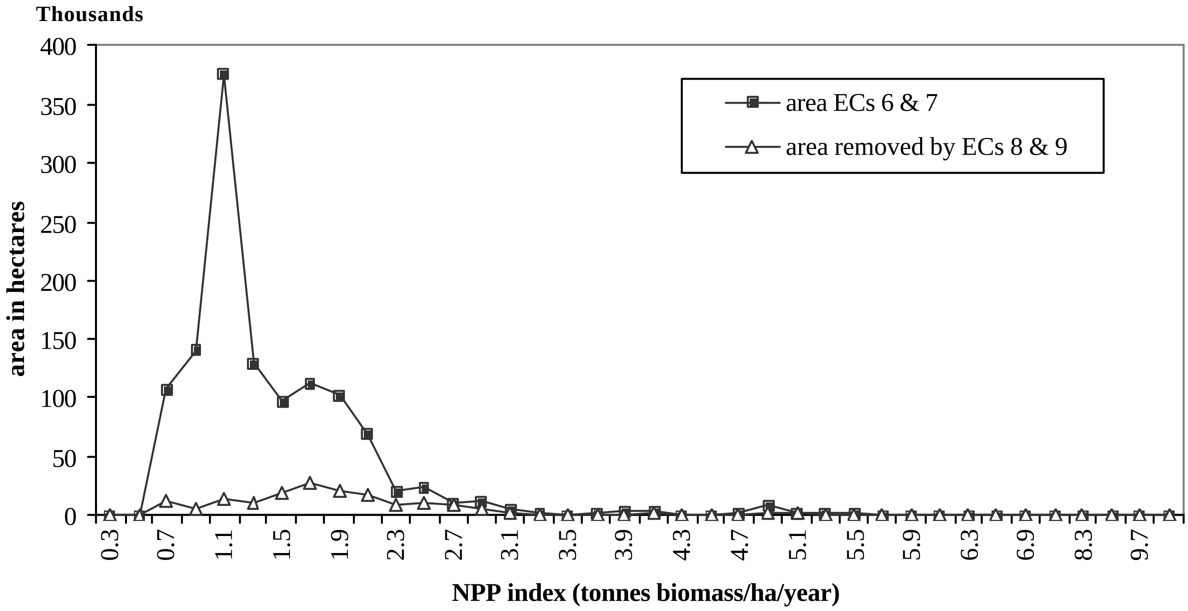

Figure 4.10 Area of mallee forest type removed by exploitation criteria 8-9 stratified by net primary productivity index.

The distribution of the area of the non-mallee forest type excluded by exploitation criteria 8 and 9, stratified by net primary productivity index is shown in Figure 4.11. From Figure 4.11 it can be seen that the non-mallee forest type is much more widely distributed than the mallee forest type, occupying the entire range of net primary productivity i.e. between 0.2 and 14.0 t ha^{-1} yr^{-1} (net primary productivity classes 1 - 69). What remains of the non-mallee forest type peaks in the net primary productivity index range 2.2 - 4.8 t ha^{-1} yr^{-1} (net primary productivity classes 11 - 23) with a long diminishing tail towards the higher productivity values. The majority of the area of non-mallee excluded by exploitation criteria 8 and 9 fell in the net primary productivity index range 2.2 - 4.8 t ha^{-1} yr^{-1}, a pattern comparable to the distribution of the entire area of the MDB (see Figure 4.1).

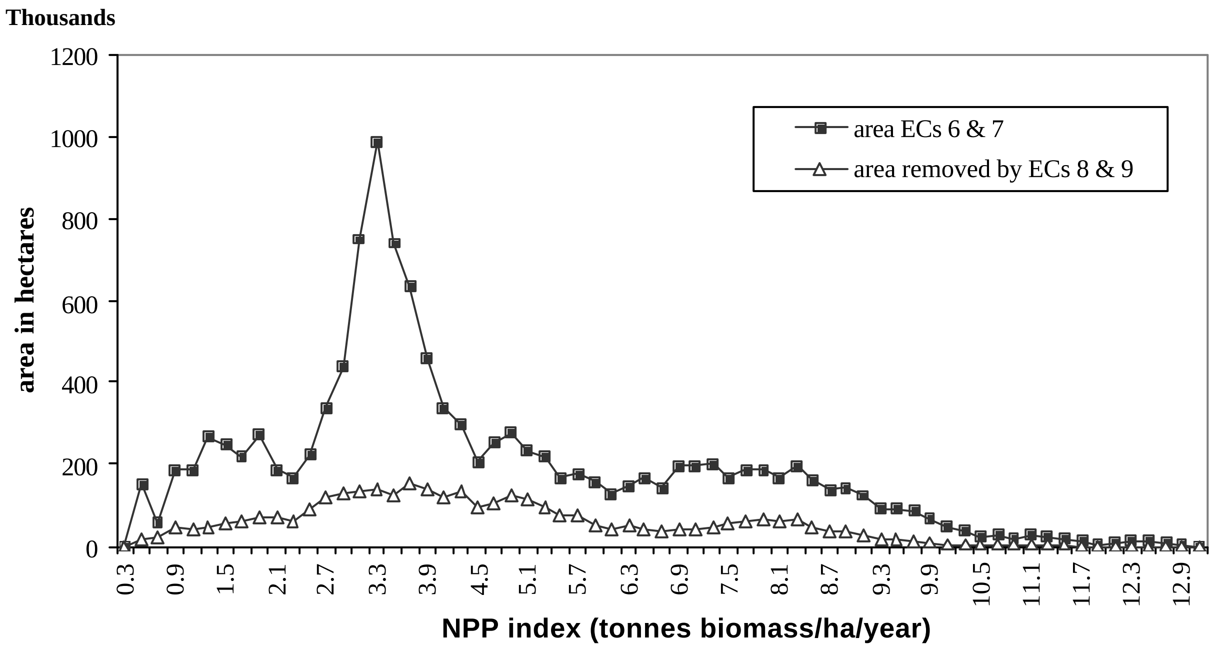

Figure 4.11 Area of non-mallee forest type removed by exploitation criteria 8-9 stratified by net primary productivity index.

The stratified data for the green-wood scenario can be found in Appendix 6, Table 9, which shows the net primary productivity class. The net primary productivity class can be related to the net primary productivity index value through Appendix 6, Table 7, Dataset 16.

4.3.7 The plantation scenario; methods

The plantation scenario focused on the areas of the MDB assessed as having non-native vegetation, i.e. on those parts of the landscape which were not addressed by Scenarios 1 and 2. It also employed exploitation criteria 1,2, 3 (Section 3.1) and exploitation criteria 6 and 7 (Section 3.3) and 2 new exploitation criteria, exploitation criteria 10-11 (Section 3.4).

The datasets for exploitation criteria 1, 2, 3, 6 and 7 were already available (Datasets 12, 14, 15 and interim dataset *ftenure*, Section 4.3.1, exploitation criterion 3, and Appendix 3 Table 1 Dataset 10, point 4).

Exploitation criterion 10 required the urban areas dataset (Dataset 4) and the *mdbften* dataset (interim dataset Section 4.3.2 from exploitation criterion 4). Exploitation criterion 11 required the dataset *basedemlam* (interim dataset Section 4.3.5, exploitation criterion 7). The processing methods for the datasets for exploitation criteria 10 and 11 are described below.

EC 10 The *mdbften* dataset was reclassified on the basis of the forest type attribute to produce a non-native vegetation grid, which held data on the “non-forest” and “no data” forest types for all land tenures (Table 4.4). The urban area Shapefile (Dataset 4) was processed to exclude all urban areas from the non-native vegetation grid.

EC 11 Dataset 13 (*elt650*) was calculated from the *basedemlam* dataset such that all areas ≥ 650 metres were classified to “NoData”, and all areas < 650m were = “1”. This excluded high water-yield areas from plantation development.

The stratified data for the plantation scenario were then produced. Firstly exploitation criteria 1 and 2 (within the MDB and within 500km of Capital Cities) were applied (Appendix 2, Box 3 Step 1). Next exploitation criterion 6 (distance from rivers, Appendix 2, Box 3, Step 3), then exploitation criterion 7 (slope, Appendix 2, Box 3, Step 3) followed by exploitation criterion 11 (elevation, Appendix 2, Box 3, Step 4, producing the dataset (*cs3layer*).

Option 1 Plantations established in the most productive regions of the MDB

The *cs3layer* dataset was then stratified by net primary productivity class, giving the dataset *scen3op1* (Appendix 2, Box 3, Step 5). The stratification method is similar to that illustrated by Table 4.6, except there was only one “forest type” class i.e. non-native vegetation cover, which made things much simpler because the resulting value was the net primary productivity class value. The value attribute table for the stratified grid was imported into a relational database and the stratified dataset produced. The stratified data gave the area of non-native vegetation by net primary productivity class.

The *scen3op1* dataset represents the baseline for all data for the plantation scenario. the plantation scenario was considered under four “Options”. Additional constraints were applied to Options 2 -4.

EC 12 The stratified dataset was limited by excluding all data with an net primary productivity index of at < 5 t ha^{-1} yr^{-1} (sub-economic productivity).

Option 2 Plantations established in the most productive regions of the MDB where annual rainfall averages < 900mm

The DEM (Dataset 4, *basedem*) was used to produce a grid of annual mean rainfall values though ANUCLIM module ESOCLIM (Hutchinson et al.1999). The annual mean rainfall grid was projected to the project coordinate system, clipped to the extent of Dataset 14 (*citymdb*), and reclassified to give Dataset 19 (*rainclass*) with three rainfall classes: 1. < 600 mm; 2. 600 - 900 mm; and 3. > 900 mm. The range of annual mean rainfall values for this grid was from 196mm to 2792 mm.

The reclassified rainfall dataset was then used to stratify the data for the plantation scenario, giving the dataset *scen3op2* (Appendix 2, Box 3, Step 6). The stratification method is illustrated by Table 4.6. The value attribute table for the stratified grid (*scen3op2*) was imported into a relational database, where the stratified grid value was broken down into the separate net primary productivity and rainfall class and the stratified dataset produced.

EC 12 The stratified dataset was limited by excluding all data with a net primary productivity index of < 5 t ha^{-1} yr^{-1} (sub-economic productivity).

Option 3 Plantations established in regions of the MDB where native woody cover is <30% (priority areas for revegetation).

This option required the ability to determine all non-native vegetation cover gridcells which occurred in areas of the MDB with a percent woody cover of < 30%. The interim dataset *precov30*, a by-product in the production of Dataset 17 for exploitation criterion 8 (Section 4.3.5, exploitation criterion 8) provided a starting point for this, as it identified all gridcells (woody or non-woody) which had a percent cover ≥ 30%. The value attributes for this dataset were reclassified so that all gridcells with > 30% cover became “NoData” and all “NoData” gridcells i.e. gridcells which either had a percent cover < 30% or were true “NoData” gridcells, became “1”, giving Dataset 18 (*covlt3op*).

The stratified data for the plantation scenario Option 3 (*scen3op3*) were produced by multiplying the baseline plantation scenario dataset (*scen3op1*) by Dataset 18 (Appendix 2, Box 3, Step 7), simultaneously eliminating all non-native vegetation cover gridcells with a percent cover ≥ 30% and true “NoData” gridcells.

The value attribute table for the grid (*scen3op3*) was imported into a relational database and the stratified dataset produced. The stratified data gave the area of non-native vegetation by net primary productivity class.

EC 12 The stratified dataset was limited by excluding all data with a net primary productivity index of < 5 t ha^{-1} yr^{-1} (sub-economic productivity).

Option 4 Plantations established only in regions of the MDB which are at higher risk of degradation through soil salinisation.

The projection of the Land and Water Audit Salinity Assessment coverage (Dataset 7) was defined as a GDA94 geographic projection (from the metadata see Appendix 3 Section 1.7). This dataset was re-projected to the project coordinate system. We selected all polygons from the coverage where the assessment of salinity risk for the year 2000, that is the attribute ASSESS_2000, was set to "high hazard or risk" and saved the result to a Shapefile. The Shapefile was clipped to the extent of the MDB using the Shapefile version of Dataset 1 (*mdblam*), and converted to a grid of 100m resolution. This grid was reclassified such that all values (which were the polygon identifiers) were set = “1”, identifying all gridcells where the salinity risk was assessed as high, giving Dataset 20 (*sasshigh*).

The stratified data for plantation scenario Option 4 were produced by multiplying the baseline plantation scenario data (*scen3op1*) with Dataset 20 (Appendix 2, Box 3, Step 8), leaving only non-native vegetation cover gridcells which had been assessed with high salinity risk (*scen3op4*).

The value attribute table for the grid (*scen3op4*) was imported into a relational database and the stratified dataset produced. The stratified data gave the area of non-native vegetation by net primary productivity class.

EC 12 The stratified dataset was limited by excluding all data with a net primary productivity index of < 5 t ha^{-1} yr^{-1} (sub-economic productivity).

4.3.8 The plantation scenario; results

The results of the plantation scenario are described in sequence, showing the cumulative changes of area available to the scenario as each exploitation criterion is applied, and as the 4 Options are applied thereafter.

Map 15 (Appendix 4) shows the geographical distribution of the data for exploitation criterion 10 (gridcells with non-native vegetation cover) on private tenure (exploitation criterion 3) for the whole of the MDB (exploitation criterion 1). Table 4.13 shows the effects of exploitation criterion 10 on the available area of non-native vegetation cover.

Table 4.13 Areas of non-native forest cover in the MDB.

Cover type	**Area (ha)**	**%Area**
Private non-native	66,706,502	89.49%
Public non-native	7,835,196	10.51%
Total non-native cover	74,541,698	100.00%

Map 16 (Appendix 4) shows the geographical distribution of elevation classes in the MDB (exploitation criterion 11). About 7.8 million hectares of the MDB have elevations ≥ 650m.

The results of applying the exploitation criteria for the plantation scenario (Steps 1-8, Appendix 2, Box 3) can be seen in the following sequence of tables.

Table 4.14 shows the results of Step 1, which culminates in the application of exploitation criteria 1-3 and exploitation criterion 10. Map 17 illustrates the resulting geographical distribution of the non-native vegetation cover gridcells.

Table 4.14 Area of non-native vegetation cover after the application of exploitation criteria 1-3 and exploitation criterion 10.

Cover type	**Area (ha)**	**%Area**
Private non-native within 500km of capital cities	51,248,291	76.83%
Beyond 500km	**15,458,211**	**23.17%**
Total private non-native in the MDB	**66,706,502**	

Table 4.15 shows the results of Step 2, i.e. the effects of exploitation criterion 6 (exclusion of areas within 50m of rivers). The effect is difficult to see at the scale of the map because of the very small area removed.

Table 4.15 Area of non-native vegetation cover after exclusion of areas < 50m from rivers (exploitation criterion 6).

Cover type	Area (ha)	%Area
Private non-native within 500km of capital cities and ≥ 50m from rivers	51,210,235	76.77%
Within 50m of rivers	**38,056**	[a] **0.06%**
Total private non-native within 500km of capital cities	**51,248,291**	[a] **76.83%**
Total private non-native in the MDB	**66,706,502**	

[a] Expressed as a percentage of the total area of private non-native vegetation in the MDB (see last row of this Table and Table 4.14).

Table 4.16 shows the results of Step 3, i.e. the effects of exploitation criterion 7 (exclusion of areas of the MDB where slope ≥ 15°). Map 18 (Appendix 4) shows the combined effects of exploitation criterion 6 (excluding land < 50 metres from a river) and exploitation criterion 7 on the geographic distribution of the non-native vegetation cover.

Table 4.16 Area of non-native vegetation cover after exclusion of areas where slope ≥ 15° (exploitation criterion 7).

Cover type	area (ha)	%area
Private non-native within 500km of capital cities and ≥ 50m from rivers and slope < 15°	51,155,036	76.69%
Slope ≥ 15°	**55,199**	**0.08%** [a]
Private non-native within 500km of capital cities and ≥ 50m from rivers	**51,210,235**	**76.77%** [a]
Total private non-native in the MDB	**66,706,502**	

[a] Expressed as a percentage of the total area of private non-native vegetation in the MDB (see last row of this Table and Table 4.14).

Table 4.17 shows the results of Step 4, i.e. the effects of exploitation criterion 11, i.e. exclusion of areas where elevation ≥ 650m. Map 19 (Appendix 4) shows the effects of exploitation criterion 11, which is also the final geographic distribution of all potential eligible areas for the plantation scenario, i.e. the areas of privately owned non-native vegetation cover deemed potentially suitable for the establishment of plantations.

Table 4.17 Area of non-native vegetation cover after exclusion of areas where elevation ≥ 650m (exclude high water-yield areas: exploitation criterion 11).

Cover type	area (ha)	%area
Private non-native within 500km of capital cities and ≥ 50m from rivers and slope < 15° and elevation < 650m	48,139,840	72.17%
Elevation ≥ 650m	**3,015,196**	[a] **4.52%**
Private non-native within 500km of capital cities and ≥ 50m from rivers and slope < 15°	**51,155,036**	[a] **76.69%**
Total private non-native in the MDB	**66,706,502**	

[a] Expressed as a percentage of the total area of private non-native vegetation in the MDB (see last row of this Table and Table 4.14).

The data for the plantation scenario, stratified by net primary productivity class, can be found in Appendix 6, Table 10.

Option 1 Plantations established in the most productive regions of the MDB

The stratified data for the plantation scenario Option 1 can be seen in Appendix 6, Table 11, which shows the net primary productivity class. The net primary productivity class can be related to the net primary productivity index value through Appendix 6, Table 7, Dataset 16.

The application of exploitation criterion 12 meant that only the high productivity areas falling into a net primary productivity class of 52 and above (10.4 - 14 t ha^{-1} yr^{-1}) were considered for the plantation scenario Option 1 (see Section 10.5). Map 20 shows the geographic distribution of the privately owned non-native vegetation cover deemed suitable for plantation under the plantation scenario Option 1. The map classifies the area into the four productivity classes used for the modelling (Section 10.5). Table 4.18 shows the available area in hectares for Option 1 for each productivity class.

Table 4.18 The area of land in hectares for Option 1 by productivity class.

Productivity class	Area (ha)
5 - 6.8 t ha^{-1} yr^{-1}	9,969,348
6.8 - 8.2 t ha^{-1} yr^{-1}	3,769,333
8.2 - 10.4 t ha^{-1} yr^{-1}	1,787,664
10.4 - 14 t ha^{-1} yr^{-1}	277,781
Total area for Option 1	**15,804,126**

Option 2 Plantations established in the most productive regions of the MDB where annual rainfall averages < 900mm (avoiding areas with the highest water yield)

Map 21 (Appendix 4) shows the distribution of the rainfall classes in the area of the MDB defined by exploitation criterion 2 (within 500km of capital cities). Appendix 6, Table 7, Dataset 19 shows the areas (from Map 21) of each rainfall class. Only 3,551,091 hectares, or 4.57% of the area of the MDB within 500km of capital cities, have an annual mean rainfall > 900mm. This area was excluded from consideration in the plantation scenario Option 2.

The plantation scenario Option 2 data can be seen in Appendix 6, Table 12.

The stratified data for the plantation scenario Option 2 can be seen in Appendix 6, Table 13, which shows the net primary productivity class. The net primary productivity class can be related to the net primary productivity index value through Appendix 6, Table 7, Dataset 16.

The application of exploitation criterion 12 meant that only areas falling into net primary productivity class 25 and above (5 - 13 t ha^{-1} yr^{-1}) and into rainfall classes 1 and 2 (i.e. < 900mm/year) were considered for the plantation scenario Option 2 (see Section 10.5). Map 22 shows the geographic distribution of the privately owned non-native vegetation cover deemed suitable for plantation under the plantation scenario Option 2. The map classifies the area into the four productivity classes used for the modelling (Section 10.5). Table 4.19 shows the available area in hectares for the Option 2 for each productivity class.

Table 4.19 The area of land in hectares for Option 2 by productivity class.

Productivity class	Area (ha)
5 - 6.8 t ha^{-1} yr^{-1}	9969,348
6.8 - 8.2 t ha^{-1} yr^{-1}	3769,333
8.2 - 9.4 t ha^{-1} yr^{-1}	1468,953
9.4 - 13 t ha^{-1} yr^{-1}	588,972
Total area for Option 2	**15,796,606**

Option 3 Plantations established in regions of the MDB where native woody cover is <30%.

The area for the plantation scenario Option 3 for all net primary productivity classes can be seen in Appendix 6 Table 14, which shows the net primary productivity class. The net primary productivity class can be related to the net primary productivity index value through Appendix 6, Table 7, Dataset 16. The stratified data for the plantation scenario Option 3 can be seen in Appendix 6 Table 15.

The application of exploitation criterion 12 meant that only areas falling into net primary productivity classes 25 and above (5 - 12.6 t ha^{-1} yr^{-1}) were considered for the plantation scenario Option 3 (see Section 10.5). Map 23 shows the geographic distribution of the privately owned non-native vegetation cover deemed suitable for plantation under Scenario3 Option 2. The map classifies the area into the three productivity classes used for the modelling (Section 10.5). Table 4.20 shows the available area in hectares for Option 3 for each productivity class.

Table 4.20 The area of land in hectares for Option 3 by productivity class.

Productivity class	Area (ha)
5 - 6.8 t ha^{-1} yr^{-1}	8,953,580
6.8 - 9.0 t ha^{-1} yr^{-1}	4,139,947
9 - 12.6 t ha^{-1} yr^{-1}	433,872
total area for Option 3	**13,527,399**

Option 4 Plantations established only in regions of the MDB which are at higher risk of degradation through soil salinisation.

Appendix 6, Table 7, Dataset 20 shows the areas assessed with high salinity risk in the entire MDB. 1,309,766 hectares, or 1.68% of the area of the MDB, have been assessed with high salinity risk or hazard in the year 2000.

The plantation scenario Option 4 data can be seen in Appendix 6, Table 16.

The stratified data for the plantation scenario Option 2 can be seen in Appendix 6, Table 17, which shows the net primary productivity class. The net primary productivity class can be related to the net primary productivity index value through Appendix 6, Table 7, Dataset 16.

The application of exploitation criterion 12 meant that only areas falling into net primary productivity class 25 and above (5 - 13.4 t ha^{-1} yr^{-1}) were considered for the plantation scenario Option 4 (see Section 10.5). Map 24 shows the geographic distribution of the privately owned non-native vegetation cover deemed suitable for plantation under the plantation scenario Option 4. The map classifies the area into the two productivity classes used for the modelling (Section 10.5). Table 4.21 shows the available area in hectares for Option 4 for each productivity class.

Table 4.21 The area of land in hectares for Option 4 by productivity class.

Productivity class	Area (ha)
5 - 6 t ha^{-1} yr^{-1}	114,927
6 - 13.4 t ha^{-1} yr^{-1}	763,179
Total area for Option 4	**878,106**