NATIONAL RESEARCH FLAGSHIPS

Water for a Healthy Country

Spatial prioritisation of NRM investment in the West Hume area (Murray CMA region)

Patricia Hill, Hamish Cresswell and Lisa Hubbard

June, 2006

Water for a Healthy Country

Spatial prioritisation of NRM investment in the West Hume area (Murray CMA region)

Patricia Hill, Hamish Cresswell and Lisa Hubbard

Water for a Healthy Country is one of six National Research Flagships established by CSIRO in 2003 as part of the National Research Flagship Initiative. Flagships are partnerships of leading Australian scientists, research institutions, commercial companies and selected international partners. Their scale, long time-frames and clear focus on delivery and adoption of research outputs are designed to maximise their impact in key areas of economic and community need. Flagships address six major national challenges; health, energy, light metals, oceans, food and water.

The Water for a Healthy Country Flagship is a research partnership between CSIRO, state and Australian governments, private and public industry and other research providers. The Flagship aims to achieve a tenfold increase in the economic, social and environmental benefits from water by 2025.

The work contained in this report is collaboration between CSIRO Land and Water, CSIRO Sustainable Ecosystems and the Murray Catchment Management Authority (NSW).

Citation: Patricia Hill, Hamish Cresswell and Lisa Hubbard (2006). ***Spatial prioritisation of NRM investment in the West Hume area (Murray CMA region)***. Technical Report,CSIRO Water for a Healthy Country National Research Flagship Canberra.

For further information contact:

Dr Hamish Cresswell
Ph: 02 6246 5933
Fax: 02 6246 5965

www.csiro.au

Acknowledgements

We thank the staff at the Murray Catchment Management Authority for expert input into the project through discussion of guidelines and contributing weightings for themes and guidelines, specifically Jack Chubb, David Costello, Alexandra Knight, Dale Stringer, Liz Symes, Robyn Walker, Emmo Willinck and Helen Wilson.

We thank the Bureau of Rural Sciences, specifically, Michael Hill, Rob Lesslie, Steve Dawson and Simon Barry for access to MCAS-S and support for the product.

Thanks also to CSIRO staff who have contributed technical input including Trevor Dowling, John Gallant, David Freudenberger, Geoff Barrett, Neil McKenzie and Mark Glover.

We gratefully acknowledge funding from the Australian Government National Action Plan for Salinity and Water Quality and from CSIRO through the Water for a Healthy Country National Research Flagship.

Table of Contents

1. Executive Summary

A land use planning process was undertaken for the West Hume area in south-eastern NSW – within the Murray Catchment Management Authority (CMA) jurisdiction. The purpose was to support the prioritisation of investment in land use change aimed at achieving multiple environmental benefits. That is, helping to decide where to target revegetation. Spatial multiple criteria analysis was used as part of a method designed to make good use of existing data sets and the knowledge of participants. The method used a set of logical and transparent guidelines (management principles), together with an evaluation of the importance of each expressed as a weighting. Exploratory land use allocations were generated for biodiversity objectives and for salinity objectives, before these were combined into a single integrated land use scenario where different locations were given a level of priority for land use change. The indicative high priority zones for revegetation were based on the likelihood of multiple environmental benefits being achieved and also reflected likely opportunity costs of changing land use. Areas suggested as high priority for revegetation activity are in a wide band to the west of Burrumbuttock, a more concentrated area to the north-east of Burrumbuttock, smaller concentrated areas of dry foothill forest on the hill at Goombargana West, and in riverine woodland in the south-west corner of the study area adjacent to the River Murray. The land use planning process appeared successful in integrating various management principles and underlying data sets to produce a logical land use allocation map. This approach could form a basis for use of differential financial incentives or mechanisms of targeting revegetation. There appears to be value in being able to clearly express priority areas for natural resource management investment in the form of maps, accompanied by a set of logical and transparent management principles that underlie the prioritisation process. This type of land use planning could be completed over larger areas of the Murray CMA region at very low cost relative to the size of ongoing NRM investment.

2. Introduction

This report documents a project to identify potential priority areas for NRM investment (land use change) on the basis of maximising (multiple) environmental outcomes and minimising the costs of change. The project represents collaboration between CSIRO and the Murray Catchment Management Authority (NSW). The outputs are to assist Catchment Management Authority (CMA) implementation staff in contracting landholders to undertake land use change using differential rates of financial incentive (or other targeted approaches) based on likely (multiple) public good environmental outcomes.

The land use planning process was designed to distinguish locations where land use change will give multiple environmental benefits as well as production benefits – synergistic actions are highlighted and choices made on the basis of likely overall benefits that will result. Thus it helps decide ‘what needs to be planted where’. It is to help recognise multiple benefits from land use change and to ensure that multiple benefits are obtained from the investment wherever possible. The planning process sought to explore and balance land use options, as informed by underlying analysis of land resources, salinity and groundwater processes, biodiversity and commodity production. The planning integrates available knowledge and datasets at catchment level but at a resolution that allows individual properties to be recognised. Within the zones identified to prioritise on-ground works investment, the expectation is that whole-farm planning would guide specific site selection for on-ground works at the within-property scale.

An objective was to make best possible use of existing data sets and the technical expertise of participants, integrating the knowledge in a transparent and objective way. The method sought is suited to dynamic incremental improvements over time - a step-by-step (starting off simply) process that can use many types of information (soil survey, topography, simulation modelling, land use mapping, groundwater system mapping etc.), bringing it together to enable prioritisation of NRM investment. As better information becomes available (eg. new modelling, monitoring) it can be progressively incorporated into effective NRM planning and implementation.

Catchment planning should not be approached from the basis of any single issue (*e.g.* environmental flows or salinity or biodiversity) but should recognise multiple issues and possible interactions between them. Land use options for any particular part of a catchment must be evaluated in a way that recognises synergies, multiple benefits, resource competition and tradeoffs. Management decisions made on the basis of single issues run the risk of negative unintended outcomes, some of which might not become apparent for many years.

The project aimed to enhance, simplify and extend the land use planning prototype developed in the southern NSW Billabong Creek catchment (the Heartlands Initiative and Water for a Healthy Country) to the West Hume area, which is between Billabong Creek and the River Murray.

The current project is within the scope of existing spatial data sets and did not set out to undertake:

- New measurement or data collection
- New process modelling
- Assessment of environmental impacts from different land use scenarios (either in terms of spatial location or extent of land use change)

The project does not aim to generate a highly specific 'optimal' pattern of land use change to meet prescribed environmental targets - rather indicative zones for investment in land use change, consistent with maximising multiple environmental outcomes. In addition the project is an evaluation of the practicality of expressing the CMAs investment strategy as clear spatial (mapped) priorities which can be justified to landholders hence providing support for the prioritisation of NRM investment.

3. Methods

3.1. Study area

The study area, proposed by the Murray CMA, is the West Hume area between Walbundrie to the north, the River Murray to the south, Balldale to the west and WallaWalla to the east as shown in Figure 1. The area is approximately 86,000 ha, including the Majors Creek, Burrumbuttock Creek, and Long Plain areas. The study area has previously been identified by the Murray CMA as within a salinity and biodiversity management priority area (Murray CMA Catchment Blueprint).

A hillshade image of the study area is shown as Figure 2 to show topography and drainage lines.

Features of the study area include:

- predominantly mixed cropping agricultural landuse
- mainly class II, III and IV land capability (from Emery, 1986)
- local soils include: texture contrast Chromosols in lower landscape positions, red and yellow chromosols on the slopes, free draining red Kandosols on some slopes and crests, and some yellow or grey Sodosols in poorly drained locations (McKenzie and Gallant, 2006)
- mean annual rainfall gradient from 500 mm/year in the west to 670 mm/year in the east.

Figure 1. The West Hume study area.

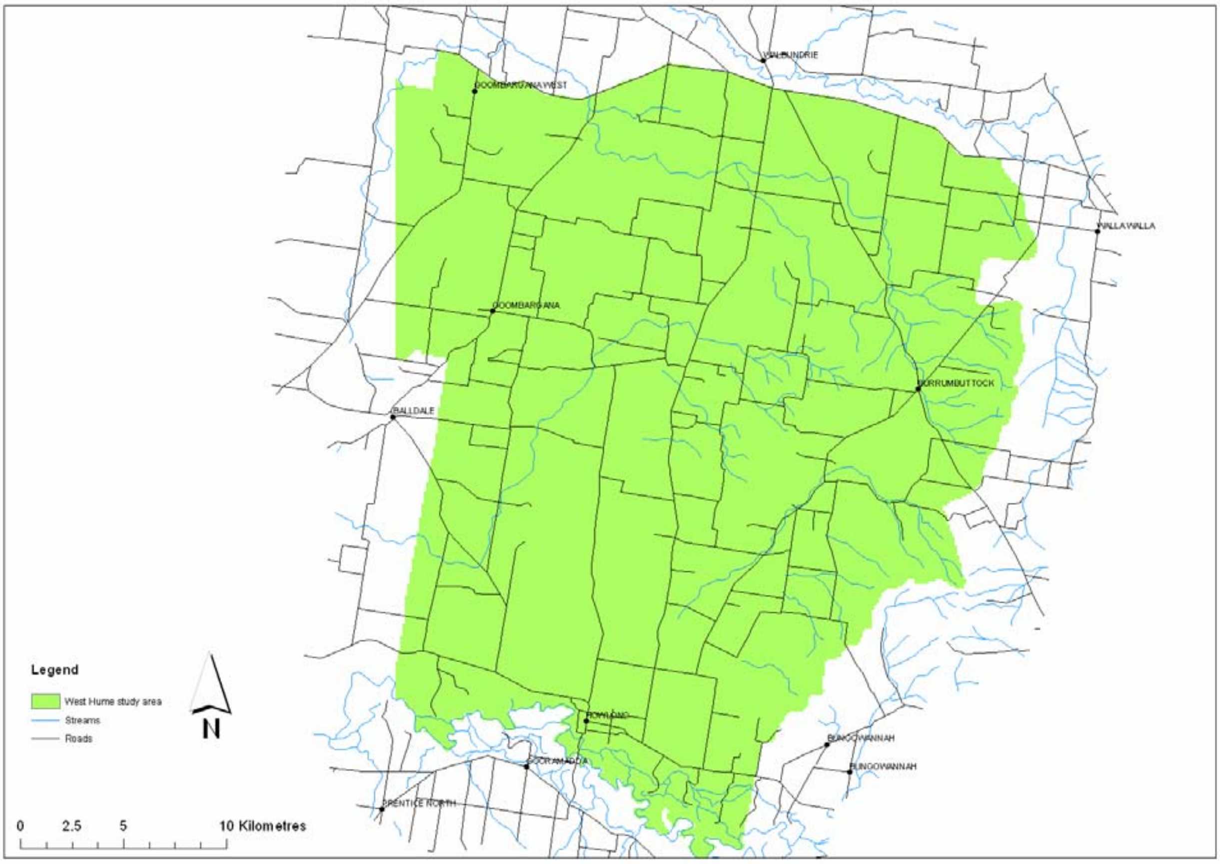
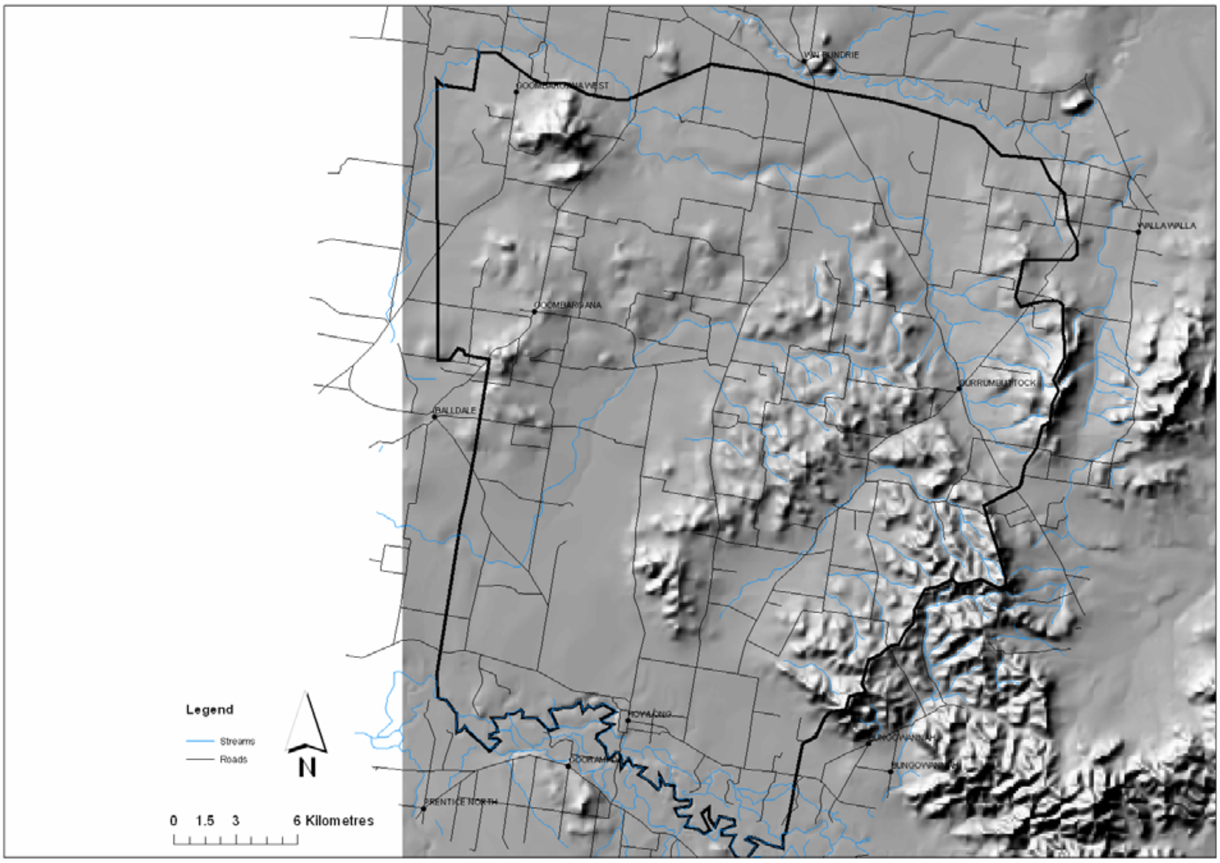


Figure 2. Hillshade image of the West Hume study area.



3.2. Procedure

The goal of the land use planning process is to identify a land use pattern that integrates a number of landscape ‘themes’ (*e.g.* biodiversity, salinity, commodity production) and to explore the opportunities such patterns offer for achieving multiple benefits (increasing the net benefit to society). This process involved identifying areas within the landscape where trees or perennial pastures could be planted to efficiently achieve environmental targets. A key aspect is where within the landscape perennials should be planted.

Given the need to appraise new land use options for catchments, we sought an analytical approach with the following features:

- Process that can support a wide range of land use options
- Transparency of process
- Enables stakeholder participation
- Ability to incorporate both quantitative and qualitative knowledge
- Value driven approach (not necessarily measured in economic terms)
- Capacity to incorporate an understanding of the impacts of specific land use change (including predictive modelling)
- Robust allocation of appropriate land use to spatial units.

We adopt an approach along the lines of the SIRO-MED mediation process (Ive and Cocks, 1999; CSIRO, 2001) designed to include the knowledge and values of farmers, Catchment Management Authorities, scientists and other stakeholders. The process is a value-driven one, where land allocation is driven by guidelines written or reviewed by participants, who also ascribe the relative importance of each guideline. The approach is designed for the exploration of options and examination of trade-offs, in a quest for a pattern of land use that satisfies multiple goals efficiently – that is, with the lowest cost in terms of opportunities foregone.

The methodological procedure used was as follows:

1. Identify the preferred study area through discussions with Murray CMA staff.
   The West Hume area as shown above was selected.
2. Confirm the set of NRM issues we seek to address (‘themes’) and have adequate supporting spatial data to do so.
   The decision was to focus on where to plant trees/shrubs or perennial pastures to address salinity and biodiversity whilst cognisant of commodity production potential. Soil acidity was of interest but there is inadequate spatial soil pH data to include explicitly into the land use allocations and so it is recommended that acidity related benefits be assessed at site level in consultation with local landholders. Soil acidity could be explicitly incorporated at a later date should adequate data become available.
3. Decide spatial units.
   A grid with 1 ha pixels was preferred due to its practicality although this resolution of spatial allocation is finer than many of the contributing data sets. The mapped output should be interpreted in light of the resolution of the input data.
4. Develop a set of spatial guidelines (or rules) that reflect management principles with which to drive the land use planning process. This step involves utilising past research and the knowledge of local experts and project staff.
5. Identify the required data surfaces to implement the guidelines.
6. Collate all necessary datasets unifying projections and generally conforming to standard data protocols.
7. Convert the guidelines into spatial datasets where necessary.

8. Decide weightings for each guideline for each theme i.e., determine relative importance of the different themes and guidelines as part of spatial prioritisation.
   This was achieved by CSIRO and Murray CMA staff working together as a small focus group.
9. Develop and run a spatial multiple-criteria analysis to generate spatial allocations of landuse for each theme (i.e. for salinity and for biodiversity outcomes).
10. Develop and run a spatial multiple-criteria analysis to generate spatial allocations of landuse for the combined themes (i.e. the integrated landuse allocation process).
11. Create mapped output.
12. Document and communicate the analysis (brief final report (this report); feedback meeting with Murray CMA staff; presentation to Murray CMA board.

In essence, the multiple criteria analysis combines the spatial attractiveness patterns associated with each individual guideline into a single pattern. Each cell (land unit) receives a value reflecting its overall suitability for the theme and its attractiveness from the perspective of each individual guideline pattern. The cells gaining the highest suitability ranking are progressively allocated to revegetation identifying the preferred location for the particular theme until the nominated aerial target is reached. The remainder of the grid cells are available for alternative land uses.

At this point the sub set of grid cells identified for revegetation for each theme, reflect the revegetation pattern that offers the greatest potential gain from the perspective of that theme only. The sets of guidelines developed to drive the development of the land use patterns for the individual themes were subsequently used to develop a multiple theme revegetation allocation. The multiple theme revegetation allocation seeks to identify the revegetation pattern, that best meets the requirements of all guidelines from all themes. The aim is to reach an effective and logical compromise between the requirements for each theme.

The land use planning process can be applied at any scale from paddock to continent providing supporting information is available. Here we chose an application that was relevant at the scale of the individual farm property, as is needed for the allocation of financial grants to individual landholders for completion of on-ground works. At the same time, the size of area considered here (approximately 86, 000 ha) is relevant to local groundwater flow systems for salinity management, is acceptable for looking at land use mosaics from a biodiversity perspective, and is broadly consistent with the local community social networks such as Landcare groups.

The adoption of a grid-based approach conferred some advantages in terms of computational efficiency and removed the necessity for negotiation of a set of polygon boundaries for each theme and the associated set of guidelines. The grid-based approach also has some disadvantages. There is an increased risk of misinterpretation of the precision of the maps and how they should be used, because the small grids can make the maps appear more precise than the reality of the underlying data. With this choice of spatial unit only remnant vegetation patches of greater than one hectare could be considered. It is noted that areas less than one hectare provide benefits within agricultural landscapes and warrant protection.

3.3. Guidelines

The guidelines that were constructed, the rationale for each, the way in which they were implemented and the data sets that were used are described below. The starting point was a set of guidelines developed as part of the Heartlands Initiative for Simmons Creek catchment, which is immediately to the north of the West Hume study area (Cresswell, 2004). This set of guidelines was modified after the CSIRO and Murray CMA focus group worked through them in Albury in May 2006. Some of the original guidelines were omitted and some remaining guidelines improved.

Note that with each of the guidelines the allocation assumes plant species used for revegetation are consistent with the pre-European broad vegetation type (BVT) for that location.

Detailed descriptions of each of the data sets used, including the data custodians, is given in Appendix One.

3.3.1. Biodiversity guidelines

Rule 1 Revegetate for Geographical Dispersal

'As far as possible disperse the allocation across the study area'

Rationale

A geographically dispersed representation provides insurance against threatening processes impacting upon a single site and also provides subtle variation in habitat conditions due to climatic variation across the area.

Implementation

To ensure a geographic dispersal across the landscape, cells were randomly allocated a value between 1 and 255 using the ArcGIS "rand" function. This dataset was then reclassified from 100 (255) to 0.

Rule 2 Revegetate Biophysically Heterogeneous Areas

'As far as possible allocate to areas with the greatest biophysical heterogeneity'

Rationale

The aim is to identify areas where the greatest variation occurs in a small area, as this is likely to offer increased biodiversity opportunities because of the diverse range of habitat possibilities in a restricted area. There may also be benefits from this concentration under climatic change conditions, as it may offer opportunities for vegetation communities and the fauna they support to adjust by moving to counter climatic change impacts.

Implementation

Aspect and slope were calculated from the DEM. Biophysical heterogeneity was then calculated using neighbourhood statistics, variety function on each of the aspect, slope, and soil profile class layers and summing the normalised results for each layer. The final layer was then reclassified from 100 (the most variety) through to 0 (the least variety).

Data sets used

Digital Elevation Model; soil profile classes

Rule 3 Revegetate Rare BVT's

'As far as possible allocate to areas of BVT that are rare within the broader bioregion'

Rationale

This rule considers the broader context within which the study area sits by reflecting regional rarity of vegetation types that might be locally common.

Implementation

Vegetation types which are regionally rare (i.e. rare in the broader bioregion) are considered a revegetation priority. Hence the proportion of each BVT remaining as compared with pre-European extent was calculated for the (IBRA) bioregion:

Grassy Box Woodland = 8% remaining

Dry Foothill Forest = 52% remaining

Riverine Forest Woodland = 60% remaining

Wetland = 7% remaining

Priority was then calculated as (100 – % BVT remaining).

Data sets used

Pre-European vegetation mapping

Rule 4 Revegetate Areas with Rare Species

'As far as possible allocate to areas that include rare and threatened species'.

Rationale

Rare and threatened species are often the focus of programmes to prevent their extinction. Therefore attempts to increase the natural habitat requirements for rare and threatened species provides an opportunity for reducing the risk to such species and the species with which they are associated.

Implementation

Base dataset showed presence of just one rare or threatened species, which was the brolga (*Grus rubicunda*). One kilometre buffers of sighting locations were given a value of 100, and other areas given a value of 0.

Data sets used

Threatened species

Rule 5 Revegetate In Areas with Dense Patch Distribution

'As far as possible to allocate areas of higher remnant patch density'.

Rationale

This guideline seeks to identify areas that have the greatest potential to increase habitat hectare assessment by encouraging revegetation in areas with a high number of existing remnants per unit area. Protecting and enhancing existing remnants is regarded as a beneficial strategy.

Implementation

The base dataset was converted to a raster "[remnants]" with all remnants given a value of 1. The ArcGIS "regiongroup" command was used, and then neighbourhood statistics, "variety" function using a 1km circle to determine the number of patches in 1km. This dataset was then reclassified so that the maximum number of patches = 100, and the minimum number of patches = 0.

Data sets used

Remnant vegetation

Rule 6 Revegetate Close to Large Patches

'As far as possible allocate to areas close to larger remnants'.

Rationale

This guideline seeks to identify areas that have the greatest potential to increase habitat hectare assessment by encouraging allocation close to large existing remnants (enlarging and enhancing them).

Implementation

ArcGIS “regiongroup”, followed by “zonalarea” and then “distance allocation” functions were used to determine the size of the nearest patch for each cell. This data was then reclassified so that for cells whose nearest patch was the largest in the layer = 100, and the cells for which their nearest patch was the smallest in the layer = 0.

Data sets used

Remnant vegetation

Rule 7 Revegetate Close to Streams

‘As far as possible allocate to areas close to streams’.

Rationale

Stream bank plantings are seen as providing particularly high ecological opportunity for a number of reasons. Firstly, streamlines in agricultural areas often occupy some of the more productive land and have therefore been largely cleared of native vegetation. These areas are frequently the only watering points for domestic stock and therefore any remaining native vegetation is at continual risk, as these points regularly become high-density congregation points. As a consequence, stream banks become unprotected and vulnerable to erosion, further impacting upon stream water quality. Secondly, the combination of water and native vegetation provides highly valued habitat conditions for most native fauna. Thirdly, stream bank plantings (assuming domestic stock is excluded) stabilise the banks and provide a filter strip, reducing sediment and nutrient inflow to the stream. The filter strips also serve to reduce the inflow rate and therefore moderate the peak flows and erosive capacity of the stream, improving in-stream habitat conditions for the stream’s biota. Stream bank plantings may also intercept sub-surface groundwater moving laterally to the stream, should this groundwater be saline then the plantings may reduce entry of saline water to the stream furthering adding to improvement in water quality.

Implementation

The ArcGIS “distance” function was used to determine distance from all streams in the base dataset. Highest priority for revegetation is closest to the streams, so the distance for each cell was subtracted from the maximum distance value for the whole study area, to give an “inverse” value. This “inverse” dataset was then reclassified from 100 (ie closest to the stream) to 0 (furthest from the stream).

Data sets used

Drainage

Rule 8 Revegetate enclosed areas

‘As far as possible allocate to areas enclosed by remnant vegetation’.

Rationale

Infill plantings allow existing disparate plantings to be coalesced into a larger area by a block planting filling the void between the disparate plantings. Because of the viable area requirements of some species, infill plantings may transform two non-viable areas into a single viable area.

Implementation

ArcGIS “neighbourhood statistics”, using a 3*1 and then a 1*3 moving filter to sum the values of the surrounding cells, such that each cell had a value depending on the number of adjacent cells which are classified as remnants. This dataset was then reclassified so that cells surrounded by remnants = 100, and cells with no adjacent remnant cells = 0.

Data sets used

Remnant vegetation

Rule 9 Revegetate to Form Corridors

'As far as possible allocate to areas that provide short linkages between remnant vegetation'.

Rationale

Corridors provide a link between isolated patches, enabling species movement up and down the corridor to the terminal patches. (However, corridors have also been criticised as providing conditions easily exploited by feral predators preying upon native fauna as they attempt to move along the corridor).

Implementation

ArcGIS "flowdirection" followed by ArcGIS "basin" function to create basins, the boundaries of which are the corridors between remnant patches. This was converted to a polyline, and the length of each "corridor" calculated. Priority is given to shorter corridors, so priority layer values were calculated using (max distance – distance). These values were then reclassified so that the shortest corridors = 100, and the longest corridors = 1.

Data sets used

Remnant vegetation

Rule 10 Revegetate Land with Low Production Potential

'As far as possible allocate to areas away from land of high value for commodity production'.

Rationale

This rule seeks to identify areas that are currently (or foreseeably) used for alternative high value land uses. By recognizing this aspect, the likelihood that areas will come under threat from competing land uses in the future can be minimized and therefore areas selected for management for biodiversity should be at lower risk in the future.

Implementation

The landcapability values were used to determine the priority for revegetation such that low value land (ie higher land classes) were given a high priority while high value land (ie lower land classes) were given a lower value. The layer was then reclassified so that land class = 7 was given a value of 100, and 1 was given a value of 0.

Data sets used

Land capability classes

3.3.2. Salinity guidelines

Rule 11 Revegetate Areas with Responsive Groundwater Flow Systems

'As far as possible establish revegetation with perennials for salinity control on areas overlying priority (responsive) groundwater flow systems'.

Rationale

The groundwater flow systems classification incorporates knowledge on likely responsiveness of groundwater to reductions in recharge, e.g. the likely lag time between revegetation activity and any reduction in saline discharge. The economics of revegetating unresponsive groundwater systems for salinity management appear poor and point towards other interventions such as groundwater pumping. It is in the smaller quicker responding systems where revegetation is likely to have more impact.

Implementation

Groundwater flow systems were ranked according to their perceived responsiveness, from 0 (least-responsive) to 100 (most responsive):

High relief granite = 100

High relief non-granite = 83

Low relief granite = 67

Low relief non-granite = 50

Upland alluvium = 33

Murray basin = 17

Data sets used

Groundwater flow systems

Rule 12 Protect High Value Water Resources

'As far as possible establish revegetation with perennials for salinity control in locations (corridors) close to water ways receiving (or potentially receiving) saline water (e.g. close to the Murray River)'.

Rationale

Revegetation is obviously expensive and so best undertaken first in locations where the potential economic benefits are greatest (in the areas where salinisation constitutes a large economic threat). Protection of high value infrastructure, such as water supplies, are therefore a priority. A significant direct threat in the study area is salt transport to the Murray River, vegetation within a few km of the river is likely to have a more direct impact on reducing saline fluxes into the Murray.

Implementation

The Murray River arcs were selected from the base dataset. The ArcGIS "distance" function, with a maximum distance of 5km, was then used. This was then reclassified so that 5km = 0, and minimum distance = 100.

Data sets used

Drainage

Rule 13 Protect High Value Biodiversity Assets

'As far as possible establish revegetation with perennials for salinity control in the catchments of high value biodiversity assets'.

Rationale

Same principle as above rule. High value biodiversity assets such as important wetlands should be prioritised for salinity mitigation over other areas.

Implementation

The catchment for each high value biodiversity asset was calculated using ArcGIS "watershed" command. Watersheds were given a value of 100, all other areas = 0.

Data sets used

Crown Reserves

Rule 14 Protect High Value Built Assets

'As far as possible establish revegetation with perennials for salinity control in subcatchments containing high-value built assets (towns and significant roads)'.

Rationale

Same principle as above. High value built assets such as buildings and highways should be prioritised for salinity mitigation over other areas.

Implementation

Towns - the "snappourpoints" command was used to determine the highest flow accumulation cell within 1km of each town. The catchment of each pourpoint was then calculated using ArcGIS "watershed" function and given a value of 100. All other areas = 0.

Roads - ArcGIS "basin" command was used to determine 5 main subcatchments to cover the West Hume study area. The length of class 2 and 3 roads (ie paved highways) for each subcatchment was calculated, and then reclassified so that the subcatchment with the greatest length of road = 100, and the subcatchment with the least length of road = 0.

Data sets used

Towns; roads; digital elevation model.

Rule 15 Revegetate Soils with High Salt Stores

'Where possible establish revegetation with perennials for salinity control on soil materials known to contain large qualities of salt (i.e. parna)'.

Rationale

Soil material that blew into the study area from the salt lakes of inland Australia depositing on the slopes and crests is known as Parna. The Parna is known to have had a high salt content and there is some evidence of salinity outbreaks being on parna-derived soils or downslope. Also, Parna derived soils that have developed in well drained landscape positions tend to be highly permeable. Accordingly areas with Parna deposits constitute priority locations for revegetation on the basis of likely effectiveness for salinity management.

Implementation

Soils were given a value between 0 and 100 depending on their salt stores:

SPC 3 = 100

SPC 4 = 70

SPC other = 0

Data sets used

Soil profile classes

Rule 16 Revegetate High Recharge Potential Areas

'As far as possible establish revegetation with perennials for salinity control in areas with high recharge potential as defined as where soils are shallow and coarse textured'.

Rationale

Soils with low water holding capacity tend to contribute more drainage than deeper finer textured materials and hence revegetation in these locations is favoured on the basis of likely effectiveness for salinity management (note that where soils are shallow, trees might be of little hydrological gain as compared to perennial pastures).

Implementation

Soils were given a value between 0 and 100 depending on their recharge potential:

Soil profile class 1 = 100

Soil profile class 3 = 67

Soil profile class 7 = 33

Soil profile class other = 0

Data sets used

Soil profile classes

Rule 17 Revegetate in Areas with High Rainfall

'As far as possible establish revegetation with perennials for salinity control in areas of higher rainfall'.

Rationale

In low rainfall areas, annual species might use the majority of the available water and investment in species with higher water use capability won't give much hydrological benefit. Perennials are advantageous in higher rainfall areas, where there is a larger discrepancy between the amount of water available and the capacity of the plants to use that water.

Implementation

The base dataset was converted to UTM. It was then reclassified so that maximum rainfall = 100 and minimum rainfall = 0.

Data sets used

Rainfall

Rule 18 Revegetate Away From Saline Discharge Zones

'As far as possible do not establish revegetation with perennials for salinity control in potential saline discharge zones (wet areas as indicated by FLAG fuzzy wetness index, especially where known to coincide with shallow saline groundwater)'.

Rationale

Planting perennials in saline discharge areas is likely to result in a concentration of salt in the rootzone and eventual death of the vegetation – not a good return on investment. (Different local strategies would be adopted to treat saline discharge areas – here the objective would be stabilising surface soil and minimising salt wash-off using vegetation especially suited for this purpose).

Implementation

The FLAG tool was used to create a "lowness and upness" (low_up) surface. Scalds were identified as [low_up] values >0.1, and these areas were reclassified from 0 – 100. Areas where [low_up] < 0.1 were reclassified = 100.

Data sets used

Digital elevation model

Rule 19 Revegetate Low Value Agricultural Land

'As far as possible do not establish revegetation with perennials for salinity control on high value, high production cropping land'.

Rationale

The opportunity costs of revegetating high quality farm land are high and adoption is unlikely.

Implementation

The land capability values were used to determine the priority for revegetation; low value land was given a high priority while high value land was given a lower value. The layer was then reclassified:

Land class 0 – 3 = 0

Land class 4 = 70

Land class 5 = 80

Land class 6 = 90

Land class 7 = 100

Data sets used

Land capability mapping

Rule 20 Revegetate Areas with High Forest Production Potential

‘As far as possible establish revegetation with perennials (trees) for salinity control in areas of highest forest production potential (highest rainfall, greatest soil depth)’.

Rationale

Where trees are being planted for salinity control and with a view to an income stream from forestry, then the intervention is going to be more economically viable in areas where potential tree productivity is high.

Implementation

The base dataset was converted to UTM. It was then reclassified so that maximum rainfall = 100 and minimum rainfall = 0.

The soil depth was calculated by summing [athick] and [bthick]. This datset was then reclassified so that maximum depth = 100 and minum depth = 0.

The two datasets were then added together and then reclassified from 0 (min depth, min rainfall) to 100 (max depth, max rainfall).

Data sets used

Rainfall; Soil depth (a horizon thickness and b horizon thickness)

3.4. Weightings

Guidelines differ in importance, necessitating an importance value to be attributed to each guideline to reflect its significance in the overall theme pattern. The relative importance of each guideline in the theme is the relative importance with respect to achieving the theme’s objective (*e.g.* revegetation to salinity mitigation and prevention). Weightings were attributed by use of a survey on the importance of each of the guidelines. The survey was completed by selected CSIRO staff and by the Murray CMA staff focus group. A pair-wise statistical comparison technique was used. The weightings were discussed and refined by the focus group in a May 2006 workshop in Albury and then finalised after some guideline modifications. It was not the intention that the theme focus groups would represent a general community perspective. It was decided to test the planning approach with the staff focus group as a first step, and then involve local communities later. It is recognised that a community process would be a logical next step and beneficial in terms of learning and achieving community ownership of the planning process (postscript: a first meeting with the West Hume Landcare group has since been held). The normalised weightings arrived at for each of the guidelines are given below in Table 1 and 2.

Table 1. Final weightings for the biodiversity guidelines.

Rule		Weighting (Rank; 1=most important)
1	Revegetate for Geographical Dispersal	0.09740 (6)
2	Revegetate Biophysically Heterogeneous Areas	0.05406 (9)
3	Revegetate Rare BVT's	0.10381 (5)
4	Revegetate Areas with Rare Species	0.09354 (7)
5	Revegetate In Areas with Dense Patch Distribution	0.15022 (1)
6	Revegetate Close to Large Patches	0.13015 (4)
7	Revegetate Close to Streams	0.14919 (2)
8	Revegetate enclosed areas	0.07316 (8)
9	Revegetate to Form Corridors	0.13054 (3)
10	Revegetate Land with Low Production Potential	0.01788 (10)
Total		1.000

Table 2. Final weightings for the salinity guidelines.

Rule		Weighting (Rank; 1=most important)
11	Revegetate Areas with Responsive GFS	0.16777 (1)
12	Protect High Value Water Resources	0.09387 (6)
13	Protect High Value Biodiversity Assets	0.10390 (5)
14	Protect High Value Built Assets	0.07297 (7)
15	Revegetate Soils with High Salt Stores	0.12618 (3)
16	Revegetate High Recharge Potential Areas	0.15505 (2)
17	Revegetate in Areas with High Rainfall	0.06829 (8)
18	Revegetate Away From Saline Discharge Zones	0.06407 (9)
19	Revegetate Low Value Agricultural Land	0.11794 (4)
20	Revegetate Areas with High Forest Production Potential	0.02994 (10)
Total		1.000

To develop the multiple theme revegetation allocation, the focus group assessed the relative importance of each theme in meeting the objectives (targets) set by the Murray Catchment Management Authority. In this case the relative importance of two themes (biodiversity and salinity) was determined as 60% salinity to 40% biodiversity as reflecting investor preferences and consensus from the Albury workshop participants.

3.5. Input data

Key spatial data requirements for this implementation include: historical rainfall and temperature; elevation data; soil landscapes and profile classes; soil water holding capacity; current (or recent) land use; pre-European vegetation; threatened species (point) data; groundwater pressure and quality data; groundwater flow systems mapping; stream flow and water quality; location of important assets or infrastructure such as towns, highways and rivers; and cadastral including drainage networks and roads. Data requirements are dependent on the particular themes to be addressed in each application. The relative importance of each data set is dependent on the mix of themes and guidelines in the analysis and on their relative importance. However, good quality basic climate, soil, land use, and hydrological data will usually be important. Good land use planning requires the capability to relate land use change and catchment response. The limitation to this is often lack of local data and inadequate process understanding.

Specifically in this study the following data sets were used:

- Rainfall
- Digital elevation model
- Soil profile class
- Land capability
- Groundwater flow systems
- FLAG wetness
- Current (or recent) land use
- Remnant vegetation
- pre-European vegetation
- Threatened species (point)
- Drainage networks
- Roads
- Towns

Refer to Appendix one for more details.

These spatial data layers that have been used directly in the guideline implementation constitute a minimum data set for land use planning (as limited by the scope of themes addressed). All of these data layers need consistent catchment boundary and projections.

Where appropriate, methods were utilized to at least partially account for properties and processes outside of the study area boundary. Specifically, the groundwater management analysis took into account the regional hydrology, and a six kilometre buffer around the catchment boundaries was included in the biodiversity analysis in recognition of the impact adjoining areas might have upon biodiversity priorities. It is recognized that these types of analysis should be undertaken at a whole-of-landscape scale.

3.6. Implementation

At commencement of the project the intention was to implement the land use allocations using spatial multi-criteria functionality in the proprietary GIS package IDRISI and supplementary programming. However, during the project a new alternative became available in the form of MCAS-S, a multi-criteria analysis shell for spatial decision support constructed in C and C++ by the Bureau of Rural Sciences (BRS) (Hill et al., 2006). MCAS-S provided some significant functional advantages:

- reads grid data in several formats;
- calculates histograms and enables grid classification in a variety of ways;
- provides for two-way comparisons;
- allows creation of scaled (0 – 1) floating point multi-way summary index using various methods of combination.
- MCAS-S provides the capacity to quickly explore the effects of changing the way in which various guidelines are combined on the allocation outcome.
- Additional guidelines can readily be added and removed to the Multiple Criteria Analysis
- The allocation outcome can be exported to any mapping or GIS software
- Is user-friendly and doesn't require GIS knowledge to run a Multiple Criteria Analysis

The shell requires basic GIS pre-processing of data to the same grid resolution, spatial extent and projection. It does however substantially increase the efficiency in completing this type of analysis.

MCAS-S also provides good data visualisation for working with clients (Figure 3), it enables projects to be easily distributed to clients, and it allows easy updating and re-working of projects with alternative map assessments – a process that can be completed as a participatory analysis. In all this the tool enables visualization of the relationship between the decision, the science, the spatial data and other constraints.

GIS software was used to process the identified data layers to create a spatial pattern (map) of the attractiveness of the catchment from the perspective of each guideline.

Each of the twenty spatial suitability surfaces for each of the guidelines (created using the processes described above in section 3.3) was imported into MCAS-S as a raster file. A new project was created and the rasters for each guideline were added. Three new composite files were added to the project: “Salinity”, “Biodiversity” and “Combined”. The ten biodiversity guidelines were used to create the composite “Biodiversity” map, using the weightings from section 3.4. The same process was repeated for the composite “Salinity” map using the 10 salinity guidelines and their associated weightings. The “Salinity” and “Biodiversity” composites were then combined to create the “Combined” composite map, with the biodiversity layer receiving a 0.4 weighting and the salinity layer receiving 0.6 weighting. The three output composites were then exported into ArcGIS for mapping.

4. Results and Discussion

4.1. Results

4.1.1. Single theme outputs

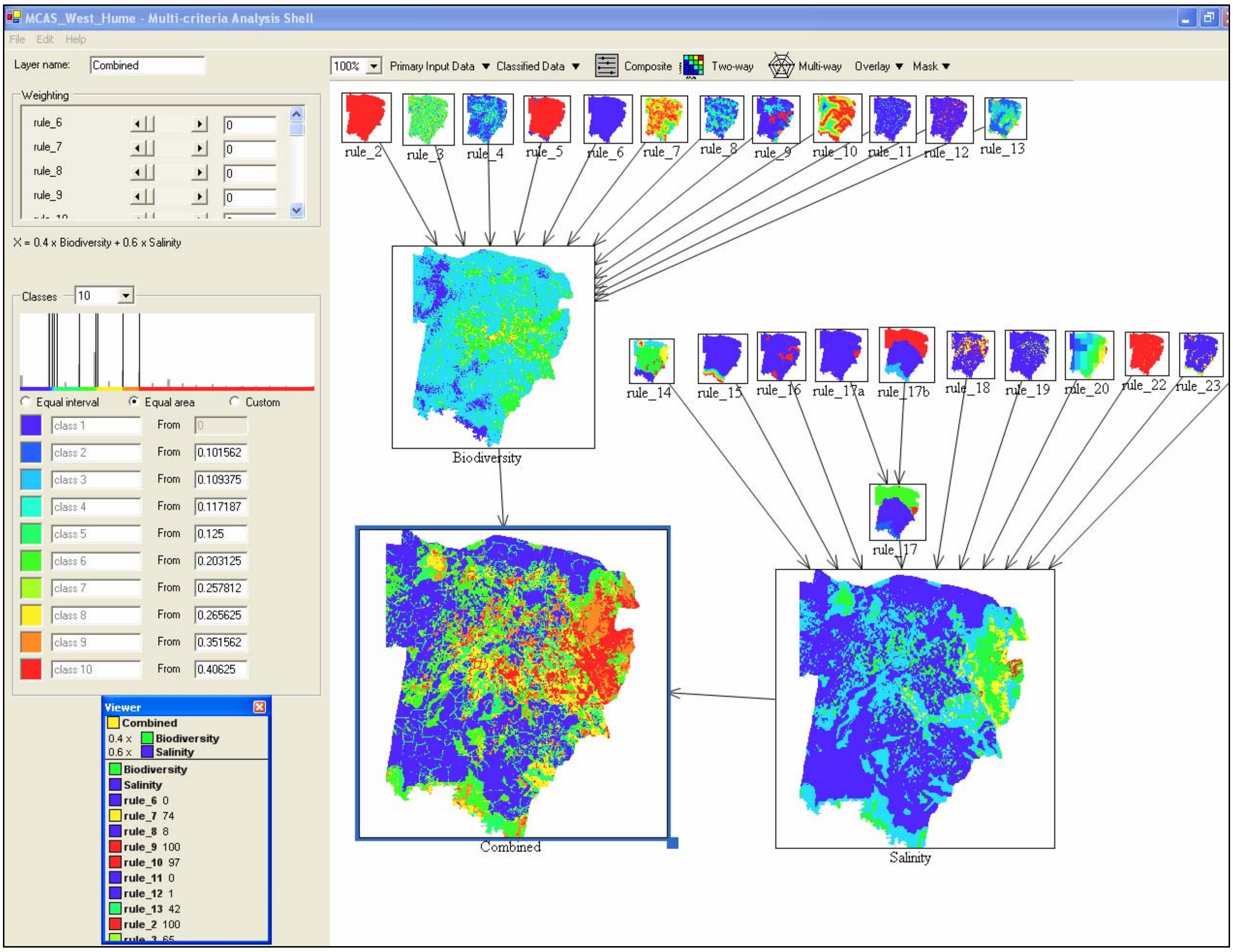
The result of applying the biodiversity guidelines using the relevant input datasets for the study area and with the guideline weightings summarised above is shown in Figure 4. The colours enable priorities to be evident by BVT. Note that this single theme output is generated only as a check that the land use allocation is consistent with the intent of our biodiversity guidelines and weightings.

The following features are evident:

- Grassy box woodland plantings to the west and south west (following the hills) of Burrumbuttock being seen as a priority, enlarging and linking existing remnants, particularly where patch distribution is dense and remnants are large
- Corridors connecting remnants being suggested
- Dry foothill forest on the hill at Goombargana West suggested as high priority
- Areas of riverine woodland in the south west corner of the study area adjacent to the River Murray suggested as high priority
- Grassy box woodland revegetation is being suggested across areas of high value agricultural land (reflecting the low weighting ascribed to guideline 10)

The effects of the guidelines and weightings are clearly evident in the spatial land use allocation, as they must be.

Figure 3. Example screen window from MCAS-S.



The salinity revegetation allocation (Figure 5) looks to have a high degree of complementarity with the biodiversity prioritisation, i.e. there is plenty of area that is high priority from both a biodiversity and salinity perspective. In part this is helped by having a salinity objective to protect high value biodiversity assets. The following features are evident in the salinity allocation:

- Prioritisation towards responsive groundwater flow systems in the north east of the study area
- Complementarity in this north eastern area with higher rainfall and soils featuring high salt stores and high recharge potential
- The general influence of high salt stores and high recharge potential in driving the allocation elsewhere in the study area (as per our weightings).

4.1.2. Integrated (combined theme) outputs

A primary project output is the combined land use allocation in Figure 6. This allocation reflects the guidelines and weightings for both the biodiversity and salinity themes and the relative weighting of these two themes. Areas suggested as high priority for revegetation activity are in a wide band to the west of Burrumbuttock, a more concentrated area to the north east of Burrumbuttock, and smaller concentrated areas of dry foothill forest on the hill at Goombargana West, and in riverine woodland in the south west corner of the study area adjacent to the River Murray.

Figure 4. Biodiversity allocation.

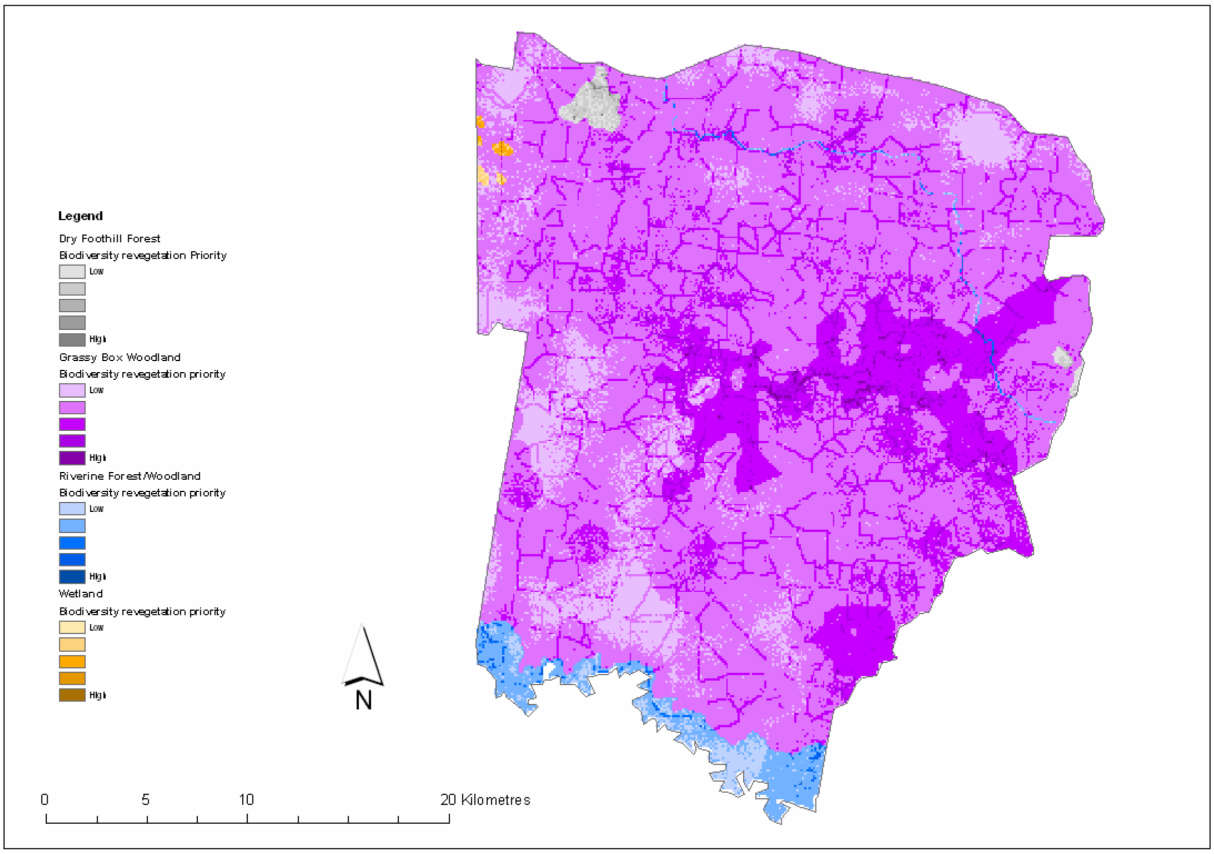
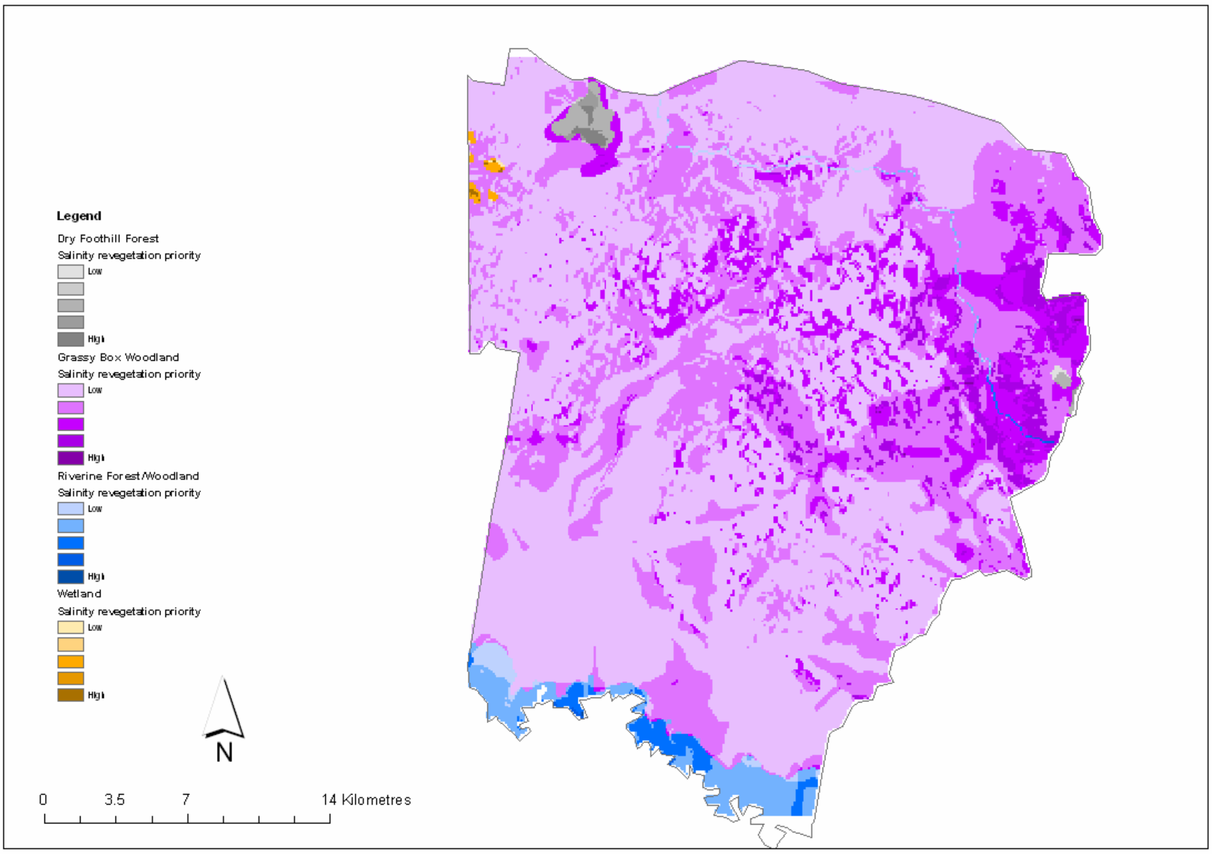


Figure 5. Salinity allocation.

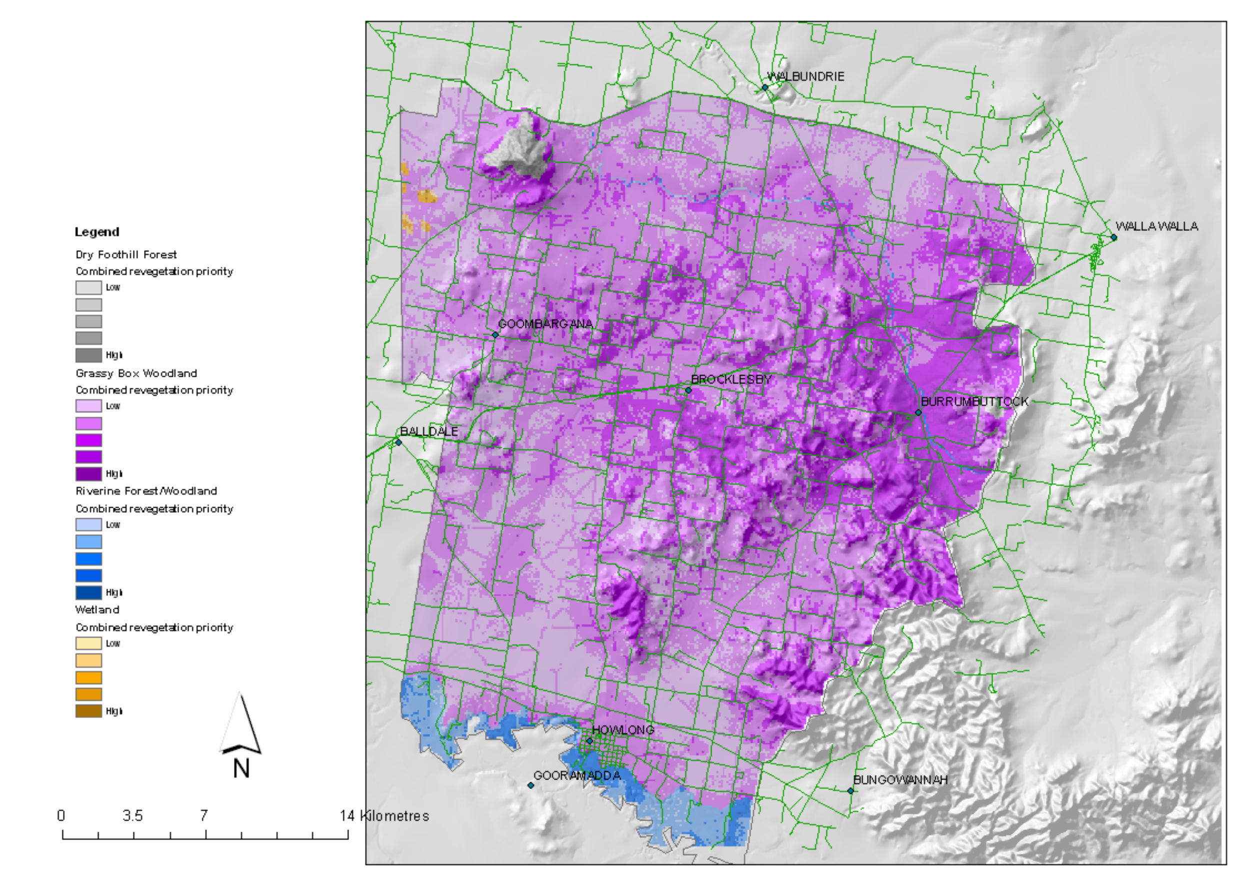


4.2. Critical assessment

It is appropriate to point out some of the limitations of the analysis described in the report.

- The analysis has been limited to using readily available input data, in some cases that means making less robust assumptions in guideline implementation. For example, here we use land capability data and assume a relative ‘productive value of the land’ for each land class. More specific data on land productive capacity or market value would lead to a more precise implementation.
- The analysis is limited by the available accuracy and resolution of the input data; higher accuracy and resolution would obviously lead to a more robust allocation.
- Approximations and assumptions are inevitable in guideline formulation and implementation. There is a risk of the guideline formulation and implementation not adequately reflecting available knowledge on the relevant themes, i.e. knowledge is omitted through simplification and assumption to the point where robustness of the overall analysis is not preserved.
- A limited range of themes was considered in this analysis. This was partly due to the lack of available spatial datasets to support implementation of extra guidelines. Other issues could be considered (e.g. soil erosion, soil acidity, risk of bushfire) and that would make the analysis more complete. Breadth of the analysis is a trade-off against the complexity and cost.

Figure 6. Combined prioritisation.



- In this project guidelines were reviewed and weightings ascribed by a small focus group of CSIRO and Murray CMA staff. This process might have been improved had there been wider participation and more time spent analysing and questioning guidelines and weightings.
- The method used here for the allocation is essentially an 'additive model', the more guidelines are satisfied and the greater their importance then the higher the priority for revegetation. However, this model as used is not strong in reflecting situations where multiple conditions need to be met and the absence of one condition leads to a low or zero priority. In such circumstances if-then-else logical rules are probably more appropriate. Note however that the approach here could be used with a greater number of forced exclusion or inclusion rules to create a similar outcome.
- This analysis does not explicitly include any sort of economic optimisation or specific economic analysis. There is however an underlying 'value based' pretext. It is reasonable to argue for a stronger economic focus, although the underlying economic data needs would have to be met.

Ideally this land use planning would be a first step in an adaptive process. Guidelines and weightings would be modified as discussion and evaluation of the allocations deepens, then the allocations would be used as scenarios and tested using methods of predicting environmental response for land use change. Subsequently the allocations would be updated, and a plan agreed by all participants. As land use change proceeds, then the planning would again be revisited as the priority allocation will change in accordance with where land use change has actually occurred.

4.3. Appropriate use of the results

This spatial multiple-criteria analysis indicates locations that may be appropriate for revegetation (with either woody species or in some cases perennial pasture) based on the number of desirable principles for siting revegetation (guidelines) that are met and their importance (weighting). We assume that in locations where multiple important revegetation guidelines are met, then the likely environmental benefits from revegetation at those locations will be greater than from other locations where guidelines are not as well satisfied. In essence the analysis provides a straightforward and logical means of prioritising areas for revegetation using simple first-principle criteria with available spatial data.

We believe that interpreting the areas where multiple important principles for siting revegetation are met as 'high priority for revegetation investment' (in relative terms to other locations in the study area) is appropriate. Decisions on any revegetation investment should however only be made following field site inspections and in the context of local farm plans and farmer land management objectives. In designing specific management actions at property level care should be taken to ensure preservation of multiple environmental benefits (e.g. actions focussed on salinity outcomes should not compromise potential concurrent biodiversity outcomes).

Although the land use allocation and presentation of mapped output is completed on a 1 ha grid no attempt should be made to use the output at this scale. Much of the underlying input data is uneven in resolution, much of it not being reliable at 1 ha. The mapped output should be used to indicate general areas that may be high priority for revegetation works relative to other locations in the study area. Specific decisions on revegetation investment will follow negotiations with local landholders and will be dependent on their willingness to participate – for this reason highly precise spatial prioritisation is often not useful.

The results of this analysis could be used as a basis for implementing differential financial incentives to better target revegetation works. For example, locations identified as high priority from this analysis could attract a greater share of government investment to offset costs of land use change given the expected larger environmental benefit relative to low priority locations.

Where implementation officers are approaching individual farmers with financial incentives for land use change, the outcomes are likely to be better if properties within the high priority areas are targeted.

Usually there is no integrated spatial analysis to guide investment prioritisation and so in the absence of better information the distribution of NRM investment tends to follow the most interested landholders. Targeting revegetation using the spatial analysis provided here will be a significant improvement. So although the analysis undertaken here has various limitations its use is strongly recommended until a better basis for prioritisation become available.

4.4. Feasibility and cost of undertaking the analysis elsewhere

Some observations on this process to support the prioritisation of land use change for environmental outcomes are that:

- The data sets that have been used are readily available for much of the Murray CMA area (at least the eastern parts) (exceptions are the FLAG wetness index and soil profile class mapping)
- The guidelines that have been used are quite generic and could be applied to other areas in the Murray CMA with minimal changes
- The availability of MCAS-S has made this multiple-criteria analysis more straightforward, reducing the cost of implementation elsewhere
- Analysing additional or larger areas on the same grid resolution is proportionally cheaper (cost per unit area falls)

- The process, again enhanced by the functionality of MCAS-S, can leave a flexible analysis in the form of a GIS 'project' which can be incrementally updated or improved, and is transparent to users
- We assert that the cost of such land use planning analysis is very small in comparison to the potential advantages from improved prioritisation of millions of dollars of NRM investment
- Our assessment is that completing a similar analysis on other (larger) areas within the Murray CMA region would require the following resources:
    - 4 - 6 days supervision/management by a project leader
    - 15 – 20 days from a project officer (requires GIS skills, awareness of multi-criteria analysis procedures, and technical understanding of relevant land management principles and their formulation into guidelines)
    - 6 days aggregate input from CMA technical staff (biodiversity, salinity, soil etc.)

  This assumes efficiencies from multiple-applications, is very dependent on the project officer having the skills indicated, and does not include running a local community participation process or extensive reporting/communication.

This case study has not been taken through a full stakeholder participation process. This was a deliberate choice reflecting the need to first complete underlying theme analyses and data generation, to ensure that the process of spatial integration was successful, and to incorporate priorities and expertise from the Murray CMA staff together with CSIRO researchers. The obvious next steps are expanding the direct stakeholder involvement in the process, and bringing in other component analyses and themes including greater emphasis on economics. Note that there has been recent research on designing participatory stakeholder input into processes such as this (Eggins et al., 2005).

One of the benefits of applying the land use planning process demonstrated here to other catchments is the opportunity for much better use of existing data and local knowledge. Local agency and CMA staff can do most of the data preparation, guideline formulation, and guideline weighting processes with only minimal support needed from CSIRO or other agencies. Technical input is required from multiple scientific disciplines and so infers a technical reference group being preferred to one or two individuals. The advent of tools like MCAS-S have moved the programming and computations for multiple objective land use allocation process from mainly the domain of technical specialists to being readily accessible to CMA staff.

Catchments that lack basic soil, land use and hydrological understanding would likely need more substantial investment before on-ground works could be well targeted. That said, even in catchments that are very data-poor, the process of developing and applying very simple guidelines with existing (sparse) data is likely to improve land use planning and provide a basis for sound targeting of research investment. Research focussed on providing the data sets and understanding to formulate and apply guidelines for use in an integrated planning process is likely to be much more cost effective than projects scattered across different general issues.

5. Conclusions and Recommendations

The land use planning process demonstrated here has been successful in a number of ways:

1. It is shown to be an effective means of spatial integration that has produced plausible land use allocations given the limited number of themes considered. It is important to emphasise here that spatial integration is not just a process of overlays within a GIS as seems to be a commonly held view.
2. It is shown to be a workable approach to drive current and future land use planning.
3. It has succeeded as a means to bring together a range of research disciplines and types of knowledge within a spatial context and in a way that directly informs on-ground investment in land use change.
4. The guideline based approach is transparent, the guidelines are readily understandable and their influence on the land use pattern is apparent. Such transparency is important in stakeholder process where a ‘black box’ model or process which is not easily understood will not encourage participation and will end up being treated with suspicion.
5. The discipline of setting guidelines from current knowledge sets out testable hypothesis and can provide focus for future research and investigation investment. Note that the guideline based approach has utility of operating at any scale providing supporting information is available.
6. Many of the sets of guidelines used here are transferable. This methodology is just based on established general principles and basic local data. As local knowledge and data sets develop then the land use allocation process can continue to be improved.

The adoption of the planning processes used here could substantially improve the effectiveness of current investment in natural resource management (NRM) through much better targeting of on-ground works expenditure. The procedure for the combining of diverse biophysical and ecological knowledge and data sets with social and economic considerations addresses a common deficiency in NRM planning. Even formulating and applying simpler guidelines in locations where data is limited would improve on many current approaches to prioritising investment in land use change.

It is important that the analysis undertaken here is understood as being an exploration of future revegetation patterns, as opposed to being a prescription for land use change. Rather than seeking to develop the ‘final’ land use pattern, this should be seen as a first stage in an adaptive process. In integrated catchment management it is the adaptive change process that is most important, rather than the current proposed pattern of high priority areas for revegetation.

Overall the land use scenarios generated are only as good as the underlying data, the process understanding in the catchments, and the veracity of reflecting these in guidelines and weightings. In most of the theme areas considered, the capability to relate land use change and catchment response needs continued development.

The results of this project, plus experience from other applications, suggests strongly that this land use planning process should be more widely applied. Particularly given the needs of many CMA’s to better prioritise financial incentives for environmental works.

References

Commonwealth Scientific and Industrial Research Organisation (2001) Sustainable use of rangelands in the 21st Century; on the road to a better future for the Western Division of NSW, www.cse.csiro.au/nsw_rangelands, CSIRO, Canberra.

Cresswell HP (editor) (2004). *Heartlands* – Planning for Sustainable Land Use and Catchment Health. *Heartlands* Technical report, Publication HL9-04, CSIRO.

Eggins R, Reynolds K, Cresswell HP, and Reid P. (2005). A Participative Negotiation and Planning Model for Improved Catchment Management. Report to the Murray Darling Basin Commission. Australian National University, CSIRO Land and Water, and Coraki Consulting.

Emery, K.A. (1986). Rural Land Capability Mapping 1:100,000 Scale. New South Wales Department of Land and Water Conservation Report. See http://www.dnr.nsw.gov.au/care/soil/soil_pubs/

Ive J, and Cocks D. (1999) SIRO-MED: bringing information based mediation support to natural resource allocation. Australian Dispute Resolution Journal 10(3), 165-72.

Michael J. Hill, Robert Lesslie, Andrew Barry and Simon Barry (2006). A Simple, Portable, Spatial Multi-Criteria Analysis Shell – MCAS-S. Bureau of Rural Sciences, Australia.

McKenzie NJ, Gallant JC (2006) Digital soil mapping with improved environmental predictors and models of pedogenesis. In 'Advances in digital soil mapping.' Developments in Soil Science Series (Eds P Lagacherie, AB McBratney, M Voltz) (Elsevier).

Appendix One Datasets

Rainfall

Dataset name: whume_rain_ma.

Dataset custodian: CSIRO, Land and Water.

Description: A grid dataset of mean annual rainfall (mm) for the period 1980-1999.

Metadata link:

http://www.indexgeo.net/asdd/anrdl/summary/mamf_r9cl__03311a.html

Digital elevation model

Dataset name: New South Wales DTDB Landform Theme 50k Digital Terrain Models

Dataset custodian: NSW Department of Information Technology and Management (LPI), Bathurst

Description: Topographic 3 dimensional 25 metre grid data derived from contour and drainage data sourced from the New South Wales Topographic Map Archive (pre 1995). Predominantly 10 metre and 20 metre contours used as source data. Sydney basin data was supplemented by integrating 2 metre contours as a 3 dimensional 5 metre grid where they were available.

Metadata: dtdb_25mdtm notepad file

Soil profile class

Dataset name: whume5km_soils.shp

Dataset custodian: Department of Natural Resources, Soils Decision Support Unit, Parramatta.

Description: Dataset of 84 types of soil and land system combinations for the lower Lachlan, Murray and Murrumbidgee flood plains. Each unit contains a summary of the land surface, geomorphology and vegetation. Australian Soil Classification is used to list the soil types in each unit and their proportion and location in the landscape

Metadata: Riverine_Soils_Metadata.doc, Riverine_Soils_Attributes.xls, Planning_Constraints.xls

Land capability

Dataset name: whume5km_landcap.shp

Dataset custodian: DNR

Description: This dataset is a merge of individual 1:100k mapsheets, classifying areas according to their land capability based on erosion risk (as at 2001). Capability is defined from class 1 (Land suitable for a wide variety of uses. Includes "prime agricultural land") through to class 8 (land unusable for agricultural or pastoral uses). Metadata for the individual sheets can be found at http://canri.nsw.gov.au/nrdd/records/ANZNS0359000808.html

Groundwater flow systems

Dataset name: whume5km_gwfs.shp

Description: A process for defining Groundwater Flow Systems was applied within the Murray catchment, to describe the sub-surface landscape, as it relates to salinity development and management. Eight groundwater flow systems were defined by DNR for the NSW Murray Catchment. A summary of each system is provided in the report, detailing their geological and geomorpological characteristics. The description also includes a summary of the effectiveness of a range of management options used for salinity control as relevant to each groundwater system.

Metadata: Gwfs_mry_metadata.doc

FLAG Wetness

Dataset name: whume5km_wetness.shp

Dataset custodian: DNR

Description: Dataset is the product of using the FLAG model to determine areas at risk of waterlogging. Created in February 2002 for ***NSW Murray Catchment Salinity Report – Salt Loads, Salinity Risk And A Focus For Actions*** by Anthony Watson.

Data is based on LPI 10m DEM. Areas designated as "wet" are potential dryland salinity sites. Comparison to known salinity sites proved the model to be quite reliable in predicting salt scalds.

Metadata: wetness_metadata.doc

Current/recent land use

Dataset name: whume5km_landuse_ALUM

Dataset custodian: DNR

Description:

A data set of recent land use as at November 1999 for the Upper Billabong Creek Catchment, in southern New South Wales. Created by interpreting satellite imagery. The land use classification is based upon the modified Baxter & Russell classification and presented according to the specifications contained in www.LUCs.gov.au/land&water/landuse.

This classification is referred to as the Australian Land Use and Management (ALUM) Classification.

Classifications used in the dataset include both agricultural and non-production land uses.

Metadata: Landuse – Upper Billabong Creek Catchment.doc

Remnant vegetation

Dataset name: whume5km_tree_cover_bvc.shp

Dataset custodian: DNR

The remnant vegetation data layer shows patches of remnant vegetation as identified using tree density mapping data combined with Broad Vegetation Type (BVT) communities data.

Metadata: murr_tree_cover_bvc_metadata.doc, murr_tree_cover_metadata.doc

Pre-European vegetation

Dataset name: whume5km_pre_euro_veg.shp

Dataset custodian: DNR

Description: The New South Wales Murray Catchment Pre-European Broad Vegetation Types dataset shows modelled pre-European Vegetation Types reclassified and grouped into Broad Vegetation Types (BVTs) to produce a seamless NSW Murray Catchment data set. Three existing datasets were used in the reclassification.

Metadata: murr_pre_euro_veg_metadata.doc

Threatened species

Dataset name: whume5km_thr_fauna.shp, whume5km_threat_sp.shp

Dataset custodian: DEC

The threatened species dataset was created from a list of sightings of rare and threatened fauna only (NOT FLORA) which contained co-ordinate information. This list was obtained from the NSW Wildlife Atlas Database maintained by DEC.

Metadata: http://canri.nsw.gov.au/nrdd/records/ANZNS0208000020.html

Drainage

Dataset name: whume5km_50k_drainage.shp

Dataset custodian: LPI

Description: Drainage Information from LPI's Digital Topographic Database (DTDB) showing drainage lines as represented at 1:50,000 scale

Metadata: http://canri.nsw.gov.au/nrdd/records/ANZNS0404001262.html

Roads

Dataset name:whume5km_50k_roads.shp

Dataset custodian: LPI

Description: Cultural Information from LPI's Digital Topographic Database (DTDB) showing roads as represented at 1:50,000 scale

Metatdata: http://canri.nsw.gov.au/nrdd/records/ANZNS0404001262.html

Towns

Dataset name: whume5km_localities.shp (AND/OR whume5km_towns_pts.shp???)

Dataset custodian: Geoscience Australia

The towns data layer is subset of the locality dataset as created by Geoscience Australia as part of the *GEODATA TOPO 250K Series 3.* We included only the localities which were comprised of at least several buildings.

250k Locality GIS Data – Internet Link

http://www.ga.gov.au/nmd/products/digidat/250k.htm

Other datasets used in the analysis

Study Area Boundary

Dataset name: West_Hume_Landcare.shp

Dataset custodian: DNR

Description: The Study Area Boundary was the West Hume Landcare administrative boundary.

Metadata: Landcare_groups_metadata.doc

Salinity (used for correlation with FLAG wetness dataset)

Dataset name: whume5km_salinity.shp

Dataset custodian: DNR

Description: Spatial mapping of where dryland salinity outbreaks occur in the Murray Valley and assessments of treated saline sites. The data source is an existing series of dryland salinity maps prepared by DNR for the MCMB area, combined with updating of new and treated areas of salinity not previously mapped.

Metadata: e_murr_2002_salt_metadata.doc

Crown Reserves

Dataset name: whume5km_crown_reserves.shp

Dataset custodian: DNR

Description: Crown Estate data was obtained from that currently held in the DNR Enterprise Database (EDB) which has been extracted from CLID spatial and textual data

Metadata: Mm_crown_reserves_additional.pdf

Ends.