User Guide and Caveats for the
1992/93, 1993/94, 1996/97, 1998/99, 2000/01 and 2001/02
Land Use of Australia, Version 3

Introduction

The 1992/93, 1993/94, 1996/97, 1998/99, 2000/01 and 2001/02 Land Use of Australia, Version 3, is a series of land use maps of Australia for the years 1992/93, 1993/94, 1996/97, 1998/99, 2000/01 and 2001/02. These are the first digital national land use maps at regional scale to be published since the release of the 1996/97 Land Use of Australia, Version 2 data set of the National Land and Water Resources Audit (the Version 2 Audit map). The maps are supplied as a set of ARC/INFO grids with geographical coordinates referred to GDA94 and 0.01 degree cell size. For each year there is a set of probability maps, one for each agricultural land use, and a single summary map made from the probability maps using some simple rules to make an approximation to a maximum likelihood land use map. As supplied the probability maps are floating point grids with cell value between 0 and 1 and no value attribute table while the summary map is an integer grid with a value attribute table with attributes defining the agricultural commodity group, irrigation status and land use according to the Australian Land Use and Management Classification (ALUMC), Version 5.

Methodology

Background

The 1992/93, 1993/94, 1996/97, 1998/99, 2000/01 and 2001/02 Land Use of Australia, Version 3, was constructed using the SPREAD II algorithm, developed by Simon Barry of BRS. SPREAD II, like the SPREAD (SPatial REallocation of Aggregated Data) algorithm of Walker and Mallawaarachchi (1998), uses time series normalized difference vegetation index (NDVI) data with control sites (ground control data comprising records of the agricultural land uses that existed at specific geographic locations in specific years) to spatially disaggregate agricultural census or survey data. The SPREAD algorithm was used previously to construct the Version 2 Audit map.

SPREAD and SPREAD II both use the time series NDVI data to characterize agricultural land pixels – those with unknown land use and control site pixels with known land use. They then relate the unknown pixels to the known pixels based on similarities in the NDVI time series. The SPREAD methodology uses a nearest neighbour approach and generates a single interpretive map and some qualitative reliability data. The SPREAD II methodology, however, is statistically based, using a Bayesian technique – a Markov chain Monte Carlo (MCMC) algorithm implemented in R – and generates outputs of the kind described above. There are, in theory, 42 probability maps comprising a dryland and an irrigated probability map for each of 21 commodity groups covering all agricultural commodities reported in the agricultural census and survey data. (In practice, it was not possible to construct all 42 maps, for reasons discussed below.) For a given cell, the sum of the cell values for all of the probability maps is 1. The summary grid was made from the probability grids using the following algorithm applied to each SLA in turn:

1. Allocate land use of rarest commodity to the cells with highest probability for the commodity until the agricultural census or survey constraint is satisfied.

2. Allocate land use of next rarest commodity to the remaining cells with highest probability for the commodity until the agricultural census or survey constraint is satisfied.

3. Continue until all land uses allocated.

The area allocated is close to the constraint, but note that the agricultural census or survey data are manipulated during processing so that, for most SLAs, the total area to be allocated agrees with the space available according to the map. This is discussed further below. A land use with less than 110 ha in a given SLA is treated as though the area were zero – the probability surface for that land use is set to zero for all agricultural cells in the SLA and there is no allocation in the SLA to that land use in the summary grid.

Another major difference between the new maps and the Version 2 Audit map is that an irrigation constraint and a horticulture constraint were used in the construction of the new maps. This is also discussed further below.

Determination of non-agricultural land uses and the distribution of agricultural land
For each year mapped, four thematic layers were constructed in raster form with 0.01 degree pixel size and overlain to determine the non-agricultural land uses and the distribution of agricultural land. The layers were a topographic features layer, a protected areas layer, a tenure layer and a forest type layer. They were constructed as follows:

1. The topographic features layer was constructed from:
   - A 1999 update of TOPO-250K (Series 1), a 1:250,000 scale vector topographic data set published by Geoscience Australia (GA)
   - A 2005 update of TOPO-250K (Series 2), a 1:250,000 scale vector topographic data set published by GA
   - Catchment scale land use map data at scales ranging from 1:25,000 to 1:100,000 from the collaborative 'Land Use Mapping at Catchment Scale' project managed by BRS (Bureau of Rural Sciences, 2002)

Water body polygons, built-up area polygons and licensed airport points were taken from the TOPO-250K, Series 1, data set. The point features representing licensed airports were buffered before conversion to raster format. Mine area polygons were taken from the TOPO-250K, Series 2, data set. Rural residential polygons were taken from the catchment scale land use map data.

The same topographic features layer was used for all years mapped.

2. The protected areas layer was constructed from:
   - The Collaborative Australian Protected Areas Database – CAPAD97 – Version 2 (1997), a 1:250,000 scale vector protected areas data set with currency end date 31 December 1997 published by the Department of Environment and Heritage (DEH)
   - The Collaborative Australian Protected Areas Database – CAPAD – 2000, a 1:250,000 scale vector protected areas data set with currency end date 1 February 2000 published by DEH

- The Collaborative Australian Protected Areas Database – CAPAD – 2002, a 1:250,000 scale vector protected areas data set with currency end date 16 October 2002 published by DEH

The 1997 data set was used to construct the 1992/93, 1993/94 and 1996/97 maps. The 2000 data set was used to construct the 1998/99 map. The 2002 data set was used to construct the 2000/01 and 2001/02 maps. Protected area polygons were taken from the data sets according to their gazettal date. Where the gazettal date was null, the latest gazettal date was used as a surrogate. For the 1992/93 map, protected areas with gazettal dates (or surrogate gazettal dates) falling in 1993 and more recent years were excluded from the map; a similar scheme was used for the other five maps.

3. Two versions of the tenure layer, an 'early' tenure layer and a 'late' tenure layer, were constructed using Australian Tenure, a 250m raster tenure data set compiled by BRS's National Forest Inventory section in 1997. To make the 'early' tenure layer, additional attribute information compiled by state and territory agencies in 1997 was incorporated, providing a classification of the land use for aboriginal freehold and aboriginal leasehold land as agricultural or non-agricultural. Defence reserves missing from the BRS tenure map but shown in the GA 1993 tenure map were then incorporated to complete the 'early' tenure layer. The boundaries were taken from the GA 1993 tenure map but were edited so that no sliver polygons would be formed. The result of these updates was the final form of the 'early' tenure layer, which was used to make the 1992/93, 1993/94 and 1996/97 maps. To make the 'late' tenure layer, a recently created, large defence reserve, the Bradshaw Military Reserve in the Northern Territory, which is missing from both the BRS tenure map and the GA 1993 tenure map, was incorporated in a copy of the 'early' tenure layer. The boundaries were taken from the catchment scale land use map data (detailed above in the topographic features layer section) and, again, were edited so that no sliver polygons would be formed. The result of incorporating the Bradshaw Military Reserve in the 'early' tenure layer was the final form of the 'late' tenure layer, which was used to make the 1998/99, 2000/01 and 2001/02 maps.

4. Five different forest type layers were constructed, based respectively on the five Kyoto Forest data sets for 1992, 1995, 1998, 2000 and 2002. The Kyoto Forest data sets are in 25m raster format; they were compiled by DEH and show presence or absence of forest. Each forest type layer was constructed from its precursor Kyoto Forest data set using the following steps.

Firstly, the Kyoto Forest data set was resampled to 0.01 degree pixel size. To do this, each output pixel was classed as forest if more than 50% covered by input forest pixels.

Secondly, forest pixels in the resampled Kyoto Forest data set were allocated a crown cover attribute by overlaying the data sets, Vegetation: Present (1988) and Vegetation: Pre-European Settlement (1788) published by GA.

Thirdly, plantation forestry areas were identified in the resampled Kyoto Forest data set by overlaying existing plantation forest data. A single plantation forest layer was constructed for this purpose by taking plantation forestry polygons, where available, from the catchment scale land use map data (detailed above in the topographic features layer section). The plantation forest layer was completed by taking plantation forestry polygons, where not available from the catchment scale land use map data, from BRS's Plantations 2001 data set.

Finally, horticulture areas, particularly orchards and plantation fruit, that had been classed as forest in the resampled Kyoto Forest data set were reclassed as non-forest. A horticulture mask was constructed for this purpose containing all horticulture areas – vegetables and grapes as well as orchards and plantation fruit – using: (i) data collected in the course of the collaborative 'Land Use Mapping at Catchment Scale' project managed by BRS (Bureau of Rural Sciences, 2002) – final data covering most of the agricultural land in Australia with currency 1997-2005 and draft data covering some of the agricultural land in NSW with currency 2000-2005; (ii) data collected in the course of the collaborative 'Land Use Data Integration Case Study – Lower Murray NAP Region' project managed by BRS – currency 2000 to 2005; and (iii) Agricultural Land Cover Change: 1995 Land Cover data set – currency c. 1995 – compiled by BRS.

The forest type layer based on the 1992 Kyoto Forest data set was used to make the 1992 and 1993 maps; that based on the 1995 Kyoto Forest data set was used to make the 1996 map; that based on the 1998 Kyoto Forest data set was used to make the 1998 map; that based on the 2000 Kyoto Forest data set was used to make the 2000 map; and that based on the 2002 Kyoto Forest data set was used to make the 2001 map.

Determination of distribution of agricultural land uses

The spatial distribution of agricultural land uses for each of the six years was determined using SPREAD II. (See above for a general discussion of SPREAD II.)

NDVI images were obtained from Advanced Very High Resolution Radiometer (AVHRR) data processed to correct for cloud cover by DEH. Control site data were collected by State and Territory agencies for the National Land and Water Resources Audit (NLWRA) – project BRR5 – and relate to the years 1996, 1997 and 1998. The irrigation status of most control sites is known and the method was used to determine the distribution, not only of commodity groups, but also of their irrigation status. Agricultural census and survey data reported on Statistical Local Areas (SLAs) were obtained from the Australian Bureau of Statistics – AgStats data. Modifications made to the AgStats data are the same as carried out during the construction of the Version 2 Audit map (Stewart et al, 2001) except that the AgStats scaling regime was changed and some edits were made to the AgStats data for a small number of SLAs with gross under-reporting of commodities.

AgStats scaling was used in the construction of the Version 2 Audit map and also in the construction of the current maps to render the total of the scaled AgStats commodity areas equal to the area of agricultural land in each SLA. The AgStats scaling regime used in the construction of the Version 2 Audit map was based on the assumption that in SLAs where the AgStats data needed to be multiplied by a large scale factor, it was very likely that some of the potentially agricultural land was used for land uses other than agriculture, principally rural residential and mining; and that, for such SLAs, it would be better not to scale the AgStats data and to allocate agricultural land uses only up to the areas reported, leaving some of the potentially agricultural land pixels unallocated. For the Version 2 Audit map, these assumptions were implemented using a nationally applied rule that the AgStats data were not scaled if the scale factor was greater than or equal to 4.2. The pixels of potentially agricultural land in such SLAs that received no agricultural land use allocations were given the land use classification ‘undifferentiated intensive uses’. For the current maps, mining polygons were incorporated nationally and rural residential polygons were incorporated where they were available from catchment scale land use map data

(i.e. for most of the country). Consequently, the AgStats scaling regime was changed for the current maps in the following way: for SLAs wholly contained in the area in which rural residential polygons were obtained from catchment scale land use map data, scaling of the AgStats data was undertaken regardless of the size of the scale factor. For the remaining SLAs, the scaling regime was the same as that used in the construction of the Version 2 Audit map. For each of the six maps, gross under-reporting in the AgStats data, leading to spurious results from scaling, was identified in a small number of SLAs. In these cases, the AgStats data were edited in accordance with information supplied by reviewers and obtained from other data sets.

There are no berry fruit control sites and consequently this commodity has not been mapped – berry fruit areas, which are small, were set to zero and the areas of all other commodity groups to be mapped were multiplied by SLA-specific scale factors chosen to make the total area of commodities to be mapped in each SLA the same as it had been before setting berry fruit areas equal to zero. There are no dryland apples control sites and consequently this commodity has been combined with and mapped as irrigated apples.

Agroforestry is incompletely covered by the AgStats data, and variably so from year to year. The AgStats data for the 1992 and 1993 maps have no agroforestry data. For these two years, agroforestry is expected to have been mapped as remnant native cover (ALUMC, Version 5, code 1.3.3) where the height of the trees is 2 m or more and the crown cover exceeds 50% and to have been mapped as grazing natural vegetation (ALUMC, Version 5, code 2.1.0) otherwise. The AgStats data for the 1996, 1998, 2000 and 2001 maps only includes areas for agroforestry plantations that were established in the year of the census or survey ('seed sown' or 'seedlings planted' or both) and these areas cannot be disaggregated into dryland and irrigated components. For these four years, agroforestry is expected to have been mapped as remnant native cover (ALUMC, Version 5, code 1.3.3) where the height of the trees is 2 m or more and the crown cover exceeds 50% and to have been mapped as plantation forestry (ALUMC, Version 5, code 3.1.0) where the agroforestry plantations were established in the year of the census or survey and to have been mapped as grazing natural vegetation (ALUMC, Version 5, code 2.1.0) otherwise.

An irrigation mask was constructed and used as an irrigation constraint to refine the prior probabilities used in the MCMC algorithm. The irrigation boundaries data set published by the NLWRA, the Australian Irrigation Areas, Version 1a, served as the basis for the irrigation mask. All designated and actual irrigation areas in the NLWRA data set were included in the mask. A small number of additional irrigation pixels were added, representing irrigation areas in Victoria, most notably in the Maffra district. The operating parameters for the irrigation constraint were set so that SPREAD II allocated approximately 70% of irrigated land uses within the irrigation areas (to the extent that the area inside the irrigation areas was sufficient to accommodate them).

The horticulture mask discussed above in the forest type layers section was used as a horticulture constraint to refine the prior probabilities used in the MCMC algorithm. The operating parameters for the horticulture constraint were set so that SPREAD II allocated approximately 90% of horticultural land uses within the horticulture areas (to the extent that the area inside the horticulture areas was sufficient to accommodate them).

For each of the six years, SPREAD II generated outputs comprising probability maps as described above in the Introduction and a summary agricultural

land use map (the agricultural component of the summary map described in the Introduction).

Determination of land uses according to the Australian Land Use and Management Classification, Version5

Land uses were assigned to pixels in the summary grids with the aid of a macro, which assigns land use categories from the Australian Land Use Management Classification, Version 5 (http://www.daff.gov.au/ – search site for ALUM) according to the attributes of the four layers overlaid to determine the non-agricultural land uses and of the summary agricultural land use map made by SPREAD II.

Caveats

1. The purpose of these maps is to provide nation-wide representations of major commodity types for mapping and display, and spatial input to numerical models.

2. Finer resolution land use data are available for many areas of Australia and, when appropriate, should be used in preference to these maps.

3. The land use maps should be used at an appropriate scale (nominally 1:2,000,000). For the agricultural land uses, the summary maps cannot be expected to have high attribute accuracy on a pixel-by-pixel basis (each pixel is ~ 1.1km).

4. Attribute accuracy is likely to be particularly low for pixels in the summary maps representing agricultural land used for more than one commodity group. This can occur where different commodity groups are close in space (strip cropping in particular and small scale planting in general) or in time (multiple cropping). Attribute accuracy is generally dependant on how distinct the commodity appears in the satellite image. The most distinct commodities include primary level classifications and some homogeneous irrigated agricultural types.

5. Agricultural census data and, in the case of the 1998 and 2001 maps, agricultural survey data supplied by the Australian Bureau of Statistics (ABS) provide the areas of each commodity group in each Statistical Local Area (SLA) that were built into the maps. It should be noted that the ABS data were processed on the basis of various assumptions during construction of the maps, as discussed in the project report entitled 'Final Report: 1992/93, 1993/94, 1996/97, 1998/99, 2000/01 and 2001/02 Land Use of Australia, Version 3' compiled by BRS in 2006. The maps should therefore be used with appropriate caution. In relation to the 1998 and 2001 maps, it should, further, be noted that the agricultural survey data include many records with large relative standard error, which may exceed 50%. This is because the ABS designs its agricultural surveys to be reported on larger areas than SLAs and only releases agricultural survey data at SLA level by special request. The 1998 and 2001 maps should therefore be used with additional caution.

6. The ABS agricultural census and survey data provide a clear distinction between grazing of highly modified pastures, such as sown pastures, and grazing of pastures that are not highly modified. The highly modified pastures can be subdivided into dryland and irrigated types. The data do not, however, provide a clear distinction between grazing of moderately modified pastures, whose

composition deviates significantly from native pasture, and grazing of minimally modified pastures, whose composition does not deviate significantly from native pasture. It is likely that the satellite imagery would not provide a clear discrimination between moderately modified and minimally modified pasture in any case. Consequently, in the construction of the maps, pastures were mapped using three map units: dryland highly modified pastures, irrigated highly modified pastures and all other pastures. In terms of the Australian Land Use and Management Classification (ALUMC), Version 5, these three map units were classified, respectively, as 3.2.0 (grazing modified pastures), 4.2.0 (irrigated modified pastures) and 2.1.0 (grazing natural vegetation). Users of the maps should be aware that a significant proportion of the area classified as 2.1.0 comprises pastures whose composition deviates from native pasture more than it should according to ALUMC guidelines.

7. In the construction of the maps it has been assumed that farmland, as defined by tenure, with native forest cover will be used for agricultural pursuits if the crown cover is less than 50% and will not be used for agricultural pursuits if the crown cover exceeds 50%. Reality, however, does not conform to this rigid demarcation. Some forest areas with crown covers as high as 80% are grazed and, on the other hand, some woodland with crown cover between 20% and 50% is not used for agricultural pursuits, nor for any other purposes. Users of the maps should be aware that for some land classified, in terms of the ALUMC, Version 5, as 1.3.3 (remnant native cover), the prime use from time to time should be classified as 2.1.0 (grazing natural vegetation); and that for some land with classifications such as 2.1.0 (grazing natural vegetation) or 3.2.0 (grazing modified pastures) the prime use should actually be classified as 1.3.3 (remnant native cover).

8. In the construction of the maps, the distribution of native forest was determined using the Kyoto Forest data sets for 1992, 1995, 1998, 2000 and 2002 (NCAS data, Department of Environment and Heritage). These data sets provide a methodologically consistent time series of native forest extent mapping; and, further, that they enable accurate determination of change in forest extent. However this data will not be consistent with the official national forest extents as per the National Forest Inventory (NFI) datasets, which includes a wider range of woody vegetation types. Users of the maps should be aware that the resulting distribution of some land uses could be affected, such as remnant native cover.

9. In the construction of the maps, the native forest crown cover was determined using the Carnahan Vegetation data sets representing present and pre-European vegetation in Australia (Geoscience Australia). These data sets show data captured from low resolution (1:5 million scale) source material. Users of the maps should be aware that this is expected to contribute to errors in the distribution of some land uses such as remnant native cover.

10. Non-perennial and perennial hydrographic features have not been distinguished. Users of the maps should be aware that grazing might have been the dominant land use, from time to time, in some areas classified as 'lake', 'river' or 'marsh/wetland'.

11. In the construction of the maps, areas of crown land (other than defence reserves) not in protected areas and with no woody vegetation (i.e. the crown cover is less than 20% or the height is less than 2 m) have been shown as ALUMC, Version 5, class 1.3.0 (other minimal use), but it is likely that many of these areas have remnant native vegetation that may or may not have been burnt and should be classed as 1.3.3 (remnant native cover).

12. Some known errors and omissions in the maps are the following:
    - Areas of institutional crown land have been misclassified. They have been shown as ALUMC, Version 5, class 1.3.0 (other minimal use) rather than class 5.5.0 (services) or 5.0.0 (intensive uses).
    - The Wahgunyah Conservation Reserve (a small protected area in South Australia classed as a 'natural monument' and, as such, falling in ALUMC, Version 5, class 1.1.4) has been omitted from the 2000 map due to an error in one of the input data sets.
    - The eastern extent of the Pitjantjatjara Lands near Marla, South Australia, the southern extent of the Maralinga Tjarutja Aboriginal Land in South Australia and the eastern section of the Yalata Lands in South Australia are not classified as ALUMC, Version 5, class 1.2.5, due to errors in one of the input data sets.
    - Some small defence reserves and facilities have been omitted from the maps due to errors in one of the input data sets.
    - Estuaries are classified as ALUMC, Version 5, class 6.1 (lake) or class 6.3 (river) rather than as class 6.6 (estuary/coastal waters). Only mangroves and saline coastal flats are classed as 6.6. This reflects the classification structure of the input data.

Grid naming conventions and data dictionary

The data and metadata for the six maps are supplied on three DVDs. DVD 1 contains data for the 1992 and 1993 maps and metadata documents that cover all six maps. DVD 2 contains data for the 1996 and 1998 maps and copies of the metadata documents that are on DVD 1. DVD 3 contains data for the 2000 and 2001 maps and copies of the metadata documents that are on DVD 1. The grids for each year mapped are stored, on the appropriate DVD, in their own subdirectory, called gridsYY, where *YY* indicates the map year and is one of 92, 93, 96, 98, 00 or 01.

The probability grids are floating point grids. They have been named *pYYv3ANN* where:

- *YY* indicates the map year and is one of 92, 93, 96, 98, 00 or 01;
- *v3* indicates Version 3;
- *A* is a one letter code for the irrigation status of the mapped land use with values being either d (dryland) or i (irrigated); and
- *NN* is a two digit integer code for the modelled land use with values ranging from 01 (ie 1) to 21.

The meanings of the land use codes (*NN*) can be read from the *spread_desc* column of Table 2, reading from the row of the table that has the appropriate land use code in the *spread* column of the table. The probability grids have cell values that are either equal to 0, for residual potentially agricultural land pixels in SLAs where the total of the area constraints is less than the area of potentially agricultural land, or to a number between 0 and 1, which is the probability that the land use for the pixel concerned was the mapped land use. There are no probability grids for commodities which, for

reasons discussed above, have not been mapped. Thus, there are no probability grids for any of the years mapped for dryland or irrigated berry fruit (*spread* = 19 in Table 2), dryland apples (*spread* = 15), and irrigated agroforestry (*spread* = 2); and there are no probability grids for 1992 and 1993 for dryland agroforestry (*spread* = 2).

The summary grids are integer grids called *luYYv3* where *YY* indicates the map year and is one of 92, 93, 96, 98, 00 or 01 and the suffix, v3, indicates Version 3. The summary grids all have the same structure. Each summary grid has a value attribute table (VAT) and comprises three layers, each layer being defined by a group of attributes in the VAT. The summary grids all have their VAT attributes defined and named the same way, as set out in the following tables 1, 2, 3 and 4. Table 1 lists the summary grid VAT attributes and shows how they define the layers.

Table 1. VAT attributes of the summary grid showing their meanings and how they define the three layers.

Attribute	Meaning	Layer
value	Cell value	Not applicable
count	Number of cells with given value	"
spread	Agricultural commodity code: SPREAD output	Agricultural commodities layer
spread_desc	Agricultural commodity description: SPREAD output	"
irrigation	Irrigation status code: SPREAD output	Irrigation layer
irrigation_desc	Irrigation status description: SPREAD output	"
lu_code	Land use code: ALUMC Version 4	Land use layer
lu_desc	Land use description: ALUMC Version 4, primary land use	"
lu_desc2	Land use description: ALUMC Version 4, secondary land use	"
lu_desc3	Land use description: ALUMC Version 4, tertiary land use	"
t-code	Land use code: ALUMC Version 4, tertiary code	"

The agricultural commodities layer is defined by the attributes *spread* (a numerical code) and *spread_desc* (a brief description). The values of these attributes and their meanings are listed in Table 2.

Table 2. Attributes of the agricultural commodities layer showing values and meanings.

spread	spread_desc	Meaning
-1	Non-agricultural land or no data	Non-agricultural land or no data.
0	Unallocated potentially ag. land	Potentially agricultural land for which no agricultural land use was allocated by SPREAD. The total area submitted to SPREAD exceeds the total commodity area available, for the SLA concerned. The land is non-forested and non-public. It is probably mainly non-agricultural. Intensive uses may be prominent, especially rural residential ('hobby farms') in periurban areas.
1	Residual/Native pastures	Native pasture of variable quality and miscellaneous residual land
2	Agroforestry	Agroforestry
3	Sown pastures	Sown pastures
4	Cereals excluding rice	Cereals excluding rice (eg wheat, oats, barley, grain sorghum, maize, millet)
5	Rice	Rice
6	Legumes	Legumes (eg soybeans, peanuts, lupins)
7	Oilseeds	Oilseeds (eg canola, sunflower)
8	Sugar cane	Sugar cane
9	Non-cereal forage crops	Non-cereal forage crops
10	Cotton	Cotton
11	Other non-cereal crops	Other non-cereal crops (eg tea, coffee, turf, herbs)
12	Other vegetables	Other vegetables
13	Potatoes	Potatoes
14	Citrus fruit	Citrus fruit (eg oranges, lemons)
15	Apples	Apples
16	Pears	Pears (includes quinces and nashi)
17	Stone fruit	Stone fruit (eg apricots, figs, olives, peaches, avocados)
18	Nuts	Nuts (eg macadamia, almonds)
19	Berry fruit	Berry fruit (eg strawberries, raspberries, blackcurrants)
20	Plantation fruit	Plantation fruit (eg bananas, kiwifruit, pineapples)
21	Grapes	Grapes

The irrigation layer is defined by the attributes *irrigation* (a numerical code) and *irrigation_desc* (a brief description). The values of these attributes and their meanings are listed in Table 3.

Table 3. Attributes of the irrigation layer showing values and meanings.

irrigation	irrigation_desc	Meaning
-999	Non-ag or unalloc pot ag land or no data	Non-agricultural land or no data; unallocated potentially agricultural land.
0	Dryland agriculture	Dryland agriculture
1	Irrigated agriculture	Irrigated agriculture

The land use layer is defined by the attributes *lu_code* (a numerical code), *lu_desc* (the primary classification), *lu_desc2* (the secondary classification), *lu_desc3* (the tertiary classification) and *t-code* (the tertiary code). The tertiary code is a string of three numbers separated by periods indicating, respectively, the primary, secondary and tertiary classifications. These attributes, and their values, use the ALUMC, Version 5, described in the next section. The values of *lu_code* are three digit integers. The three digits indicate the primary, secondary and tertiary classes in the ALUMC, Version 5. The three digits are the same as the three numbers forming the t-code, and are in the same order. For example, *lu_code* = 500 indicates primary class 5 Intensive uses (t-code 5.0.0), *lu_code* = 540 indicates secondary class 5.4 Residential (t-code 5.4.0) and *lu_code* = 542 indicates tertiary class 5.4.2 Rural residential (t-code 5.4.2). The values of *lu_desc* (the primary classification in words) and their meanings and corresponding ranges of values for *lu_code* are listed in Table 4.

Table 4. Values and meanings for the attributes, *lu_code* and *lu_desc,* of the land use layer.

lu_code	lu_desc	Meaning
0	NO DATA	No data.
100 to less than 200	CONSERVATION AND NATURAL ENVIRONMENTS	Land used primarily for conservation purposes, based on the maintenance of the essentially natural ecosystems present.
200 to less than 300	PRODUCTION FROM RELATIVELY NATURAL ENVIRONMENTS	Land used primarily for primary production based on limited change to the native vegetation.
300 to less than 400	PRODUCTION FROM DRYLAND AGRICULTURE AND PLANTATIONS	Land used mainly for primary production, based on dryland farming systems.
400 to less than 500	PRODUCTION FROM IRRIGATED AGRICULTURE AND PLANTATIONS	Land used mostly for primary production, based on irrigated farming.
500 to less than 600	INTENSIVE USES	Land subject to extensive modification, generally in association with closer residential settlement, commercial or industrial uses.
600 to less than 700	WATER	Water features. Water is regarded as an essential aspect of the classification, but it is primarily a cover type.

The values of *lu_desc2*, *lu_desc3* and *t-code* follow the ALUMC, Version 5. See the following section for more information or visit http://www.daff.gov.au/ and search the site for ALUM.

Australian Land Use and Management Classification (Version 5)

Minimum expected level of attribution

s-code	Secondary class	t-code	Tertiary class
I Conservation and Natural Environments			
1.1	Nature conservation		
		1.1.1	Strict nature reserves
		1.1.2	Wilderness area
		1.1.3	National park
		1.1.4	Natural feature protection
		1.1.5	Habitat/species management area
		1.1.6	Protected landscape
		1.1.7	Other conserved area
1.2	Managed resource protection		
		1.2.1	Biodiversity
		1.2.2	Surface water supply
		1.2.3	Groundwater
		1.2.4	Landscape
		1.2.5	Traditional indigenous uses
1.3	Other minimal use		
		1.3.1	Defence
		1.3.2	Stock route
		1.3.3	Remnant native cover
		1.3.4	Rehabilitation
2 Production from Relatively Natural Environments			
2.1	Grazing natural vegetation		
2.2	Production forestry		
		2.2.2	Other forest production
2.2	Production forestry	2.2.1	Wood production
		2.2.2	Other forest production
3 Production from Dryland Agriculture and Plantations			
3.1	Plantation forestry		
		3.1.1	Hardwood production
		3.1.2	Softwood production
		3.1.3	Other forest production
		3.1.4	Environmental
3.2	Grazing modified pastures		
		3.2.1	Native/exotic pasture mosaic
		3.2.2	Woody fodder plants
		3.2.3	Pasture legumes
		3.2.4	Pasture legume/grass mixtures
		3.2.5	Sown grasses
3.3	Cropping		
		3.3.1	Cereals
		3.3.2	Beverage & spice crops
		3.3.3	Hay & silage
		3.3.4	Oil seeds
		3.3.5	Sugar
		3.3.6	Cotton
		3.3.7	Tobacco
		3.3.8	Legumes
3.4	Perennial horticulture		
		3.4.1	Tree fruits
		3.4.2	Oleaginous fruits
		3.4.3	Tree nuts
		3.4.4	Vine fruits
		3.4.5	Shrub nuts fruits & berries
		3.4.6	Flowers & bulbs

3.4.7 Vegetables & herbs

s-code	Secondary class	t-code	Tertiary class
3.5	Seasonal horticulture		
		3.5.1	Fruits
		3.5.2	Nuts
		3.5.3	Flowers & bulbs
		3.5.4	Vegetables & herbs
4 Production from Irrigated Agriculture and Plantations			
4.1	Irrigated plantation forestry		
		4.1.1	Irrigated hardwood production
		4.1.2	Irrigated softwood production
		4.1.3	Irrigated other forest production
		4.1.4	Irrigated environmental
4.2	Irrigated modified pastures		
		4.2.1	Irrigated woody fodder plants
		4.2.2	Irrigated pasture legumes
		4.2.3	Irrigated legume/grass mixtures
		4.2.4	Irrigated sown grasses
4.3	Irrigated cropping		
		4.3.1	Irrigated cereals
		4.3.2	Irrigated beverage & spice crops
		4.3.3	Irrigated hay & silage
		4.3.4	Irrigated oil seeds
		4.3.5	Irrigated sugar
		4.3.6	Irrigated cotton
		4.3.7	Irrigated tobacco
		4.3.8	Irrigated legumes
4.4	Irrigated perennial horticulture		
		4.4.1	Irrigated tree fruits
		4.4.2	Irrigated oleaginous fruits
		4.4.3	Irrigated tree nuts
		4.4.4	Irrigated vine fruits
		4.4.5	Irrigated shrub nuts fruits & berries
		4.4.6	Irrigated flowers & bulbs
		4.4.7	Irrigated vegetables & herbs
4.5	Irrigated seasonal horticulture		
		4.5.1	Irrigated fruits
		4.5.2	Irrigated nuts
		4.5.3	Irrigated flowers & bulbs
		4.5.4	Irrigated vegetables & herbs
5 Intensive Uses			
5.1	Intensive horticulture		
		5.1.1	Shadehouses
		5.1.2	Glasshouses
		5.1.3	Glasshouses (hydroponic)
5.2	Intensive animal production		
		5.2.1	Dairy
		5.2.2	Cattle
		5.2.3	Sheep
		5.2.4	Poultry
		5.2.5	Pigs
		5.2.6	Aquaculture
5.3	Manufacturing and industrial		
5.4	Residential		
		5.4.1	Urban residential
		5.4.2	Rural residential
5.5	Services		
		5.5.1	Commercial services
		5.5.2	Public services
		5.5.3	Recreation and culture
		5.5.4	Defence facilities
		5.5.5	Research facilities
5.6	Utilities		
		5.6.1	Electricity generation/transmission
		5.6.2	Gas treatment, storage and transmission

	s-code	Secondary class	t-code	Tertiary class
	5.7	Transport and communication		
			5.7.1	Airports/aerodromes
			5.7.2	Roads
			5.7.3	Railways
			5.7.4	Ports and water transport
			5.7.5	Navigation and communication
	5.8	Mining		
			5.8.1	Mines
			5.8.2	Quarries
			5.8.3	Tailings
	5.9	Waste treatment and disposal		
			5.9.1	Stormwater
			5.9.2	Landfill
			5.9.3	Solid garbage
			5.9.4	Incinerators
			5.9.5	Sewage
6 Water				
	6.1	Lake		
			6.1.1	Lake - conservation
			6.1.2	Lake - production
			6.1.3	Lake - intensive use
	6.2	Reservoir/dam		
			6.2.1	Water storage and treatment
			6.2.2	Reservoir - intensive use
			6.2.3	Evaporation basin
			6.2.4	Effluent pond
	6.3	River		
			6.3.1	River - conservation
			6.3.2	River - production
			6.3.3	River - intensive use
	6.4	Channel/aqueduct		
			6.4.1	Supply channel/aqueduct
			6.4.2	Drainage channel/aqueduct
	6.5	Marsh/wetland		
			6.5.1	Marsh/wetland - conservation
			6.5.2	Marsh/wetland - production
			6.5.3	Marsh/wetland - intensive use
	6.6	Estuary/coastal waters		
			6.6.1	Estuary/coastal waters - conservation
			6.6.2	Estuary/coastal waters - production
			6.6.3	Estuary/coastal waters - intensive use

References

Bureau of Rural Sciences, 2002, *Land use mapping at catchment scale: principles, procedures and definitions*, Edition 2, Bureau of Rural Sciences, Canberra.

Bureau of Rural Sciences, 2006, *Final report: 1992/93, 1993/94, 1996/97, 1998/99, 2000/01 and 2001/02 land use of Australia, version 3*, Bureau of Rural Sciences, Canberra.

Bureau of Rural Sciences, 2006, *Page 0 metadata: 1992/93, 1993/94, 1996/97, 1998/99, 2000/01 and 2001/02 land use of Australia, version 3*, Bureau of Rural Sciences, Canberra.

Stewart, J.B., Smart, R.V., Barry, S.C. and Veitch S.M. 2001, *1996/97 Land Use of Australia: final report for project BRR5*, National Land and Water Resources Audit, Canberra, available online http://audit.ea.gov.au/ANRA/atlas_home.cfm

Walker, P.A. and Mallawaarachchi, T. 1998, 'Disaggregating agricultural statistics using NOAA-AVHRR NDVI', *Remote Sens. Environ.*, vol. 63, pp. 112-125.

Bureau of Rural Sciences
June 2006