User Guide and Caveats for the
Land Use of Australia, Version 4, 2005-06

Introduction

The *Land Use of Australia, Version 4, 2005-06* (the 'Version 4 map'), is a national scale land use map of Australia for the year 2005-06. It was constructed by the Australian Bureau of Agricultural and Resource Economics – Bureau of Rural Sciences (ABARE–BRS), within the Australian Government Department of Agriculture, Fisheries and Forestry, as a product of the Australian Collaborative Land Use and Management Program (ACLUMP). It is the latest to be completed in a series of digital national land use maps at national scale that have been constructed by ABARE–BRS. The previous ones were the:

- *Land Use of Australia, Version 2, 1996-97* (the 'Version 2 map') – previously called the *1996/97 Land Use of Australia, Version 2* – constructed for and published by the National Land and Water Resources Audit (NLWRA) as described by Stewart et al. (2001)

- *Land Use of Australia, Version 3, 1992-93, 1993-94, 1996-97, 1998-99, 2000-01 and 2001-02* (the 'Version 3 maps') – previously called the *1992/93, 1993/94, 1996/97, 1998/99, 2000/01 and 2001/02 Land Use of Australia, Version 3* – constructed for the Australian Greenhouse Office and the NLWRA and published by BRS (Smart et al., 2006)

In the Version 4 map, the non-agricultural land uses are drawn from existing digital maps covering six themes: topographic features, catchment scale land use, protected areas, world heritage areas, tenure and forest type. Time series data at relatively high temporal resolution are available for the protected areas and forest type themes. Only intensive land uses (such as built-up areas and mining) and plantation forestry are drawn from the catchment scale land use data.

The types of agricultural land use and their abundances are based on 2005-06 agricultural census data collected by the Australian Bureau of Statistics (ABS) – product codes, 7125.0 (*Agricultural Commodities: Small Area Data, Australia, 2005-06*) and 4618.0 (*Water Use on Australian Farms, 2005-06*). The spatial distribution of the agricultural land uses is modelled and has largely been determined using Advanced Very High Resolution Radiometer (AVHRR) satellite imagery with training data. Irrigation status has also been mapped using AVHRR data. Existing digital maps contributed to the classification of grazing land as native or modified pastures.

The Version 4 map is supplied as a set of ArcInfo™ grids with geographic coordinates referred to GDA94 and 0.01 degree cell size. These comprise a set of floating point grids with cell values between 0 and 1 and several versions of a single integer grid. The floating point grids are continuous probability surfaces that describe the distribution and abundance, within the zone of non-timbered agricultural land, of each of the agricultural commodity groups mapped. (The term 'non-timbered' will be used, throughout this document, to mean 'no trees' or 'lightly treed' up to a crown

cover of 20%.) The integer grid is a categorical summary land use map, which has a value attribute table (VAT) with columns defining input layers and an output layer.

The output layer specifies land use in terms of the Australian Land Use and Management Classification (ALUMC), Version 6 (http://www.daff.gov.au – search site for ALUM). The spatial distribution of agricultural commodity groups shown in the summary land use map within the zone of non-timbered agricultural land is based on the probability surfaces and is an approximation to a maximum likelihood map.

Prospective users of the data should note that page 0 metadata is included in a document entitled *Page 0 Metadata: Land Use of Australia, Version 4, 2005-06* (ABARE–BRS, 2010) and that the Version 4 map differs significantly from the Version 3 maps.

Construction methodology

Background

Agricultural land uses were mapped, within the zone of non-timbered agricultural land, ignoring irrigation status, using an algorithm called SPREAD II, which was developed by Simon Barry, formerly of BRS (Smart et al., 2006). SPREAD II, like the SPREAD algorithm of Walker and Mallawaarachchi (1998), uses time series Normalised Difference Vegetation Index (NDVI) data with training data to spatially disaggregate agricultural census data, processing the census reporting areas one at a time. The SPREAD II methodology is statistically based, using a Bayesian technique – a Markov Chain Monte Carlo (MCMC) algorithm. Training data were collected for the NLWRA, during the construction of the Version 2 map, and relate to the four years, 1996-97 to 1999-00 (Stewart et al., 2001).

To increase its discriminating power, SPREAD II can be run using not only the census based area constraints but also additional spatial constraints. Each spatial constraint relates to certain agricultural commodities and takes the form of a digital map which identifies the pixels where those commodities are more likely to occur (the inside pixels) and where they are less likely to occur (the outside pixels). Thus, each spatial constraint controls how SPREAD II allocates the agricultural commodities to which the constraint relates.

For the Version 4 map, a minor modification was made to the algorithm within SPREAD II that partitions the areas to be allocated between the 'inside' and 'outside' regions defined by each spatial constraint. In the new version of this algorithm, for each spatial constraint, a default proportion, or density, is set for the commodities to which the spatial constraint relates. This setting gives the default proportion of the controlled commodities inside the spatial constraint. (For each constraint, the same defaults applied to all census reporting areas but the potential exists to set specific defaults for specific census reporting areas or groups of census reporting areas.) For example, one of the spatial constraints used in the construction of the Version 4 map was a horticulture constraint, or mask. This is a digital map that identifies the pixels where horticulture is more likely to occur (the inside pixels) and where horticulture is less likely to occur (the outside pixels). The controlled commodities comprise all of the horticultural land uses to be mapped. Setting the default proportion to 90% would mean that, by default, 90% of the area inside the horticulture mask should be occupied by horticultural land uses and only 10% by non-horticultural land uses. In the old version of the partitioning algorithm, it was necessary to set a default proportion specifying the proportion to be allocated inside the spatial constraint of the total area of the controlled commodities (the rest of the controlled commodities then, of necessity, needing to be allocated outside the spatial constraint).

In both the new and the old versions of the partitioning algorithm, the default setting is overridden with an alternative value calculated on the fly if the default proves to be inconsistent with the agricultural census based area constraints. The reason for the change is that the actual proportions modelled by the new default are more likely to be constant from census reporting area to census reporting area than those modelled by the old default.

As discussed earlier, the Version 4 map consists of a set of ArcInfo™ grids comprising continuous probability surfaces and a categorical summary land use map. The continuous probability surfaces describe the distribution and abundance, within the zone of non-timbered agricultural land, of each of the agricultural commodity groups mapped and are SPREAD II outputs. They are 23 in number. The relationship between the probability grids is the following: for a given cell with a SPREAD II allocation, the sum of the cell values for all of the probability grids is 1.

The categorical summary land use map is a grid with layers defined by VAT columns. There is an output land use layer, which is constructed from a series of input layers. Most of the input layers are existing digital maps showing themes such as protected areas and tenure, but one is a SPREAD II output, a categorical summary agricultural land use grid for the zone of non-timbered agricultural land. The relationship between the summary agricultural land use grid and the probability grids is that the former is derived from the latter using the following algorithm, applied to each census reporting area in turn:

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

3. Continue until all land uses allocated.

In the resulting summary agricultural land use grid, the area allocated is close to the census based area constraint, but note that the agricultural census data need to be modified in a number of ways to generate the area constraints, as discussed below. Note, too, that a land use with less than 110 ha in a given census reporting area is treated by SPREAD II as though the area were zero – the probability surface for that land use is set to zero for all agricultural cells in the census reporting area and there is no allocation in the census reporting area to that land use in the summary grid.

In the Version 4 map, mapping of irrigation status was undertaken outside SPREAD II. The use of a spatial constraint and the default density concept defined above in relation to their use with SPREAD II was extended to the mapping of irrigation status outside SPREAD II.

Determination of non-agricultural land uses

Six thematic layers were constructed in raster form with 0.01 degree pixel size and overlain to determine the non-agricultural land uses and, therefore, also, the distribution of agricultural land. The themes were topographic features, catchment scale land use, protected areas, world heritage areas, tenure and forest type. These layers were constructed as follows:

1. The topographic features layer was constructed from a June 2006 release of *GEODATA TOPO 250K, Series 3*, a 1:250 000 scale vector topographic data set published by Geoscience Australia (GA). Polygon features representing built-up areas, mines, water bodies and watercourses were used.

2. The catchment scale land use layer was constructed from the latest catchment scale land use data available as at February 2009 from the collaborative catchment scale land use mapping project coordinated by ABARE–BRS (BRS, 2006). The currency of these data ranges from 1997 to February 2009 and they cover nearly the whole of Australia with areas of missing data filled using land use information from the *Mesh Blocks (2006) Digital Boundaries, Australia* data set published by the ABS. (The area of missing data was 0.30% of the area of the country, the areas of missing data being mainly confined to small areas around Sydney, Melbourne, Adelaide, Darwin and Canberra.) Only intensive land uses and plantation forestry were retained in the layer.

3. The protected areas layer was constructed to store the World Conservation Union (IUCN) categories of protected areas from the *Collaborative Australian Protected Areas Database – CAPAD 2006*, a 1:250 000 scale vector protected areas data set with currency July 2006 to January 2007 published by the Department of the Environment, Water, Heritage and the Arts (DEWHA). Only protected areas gazetted prior to 1 April 2006 were included in the layer. Where overlaps between protected areas occur, the IUCN category of the protected area with the highest level of protection applying to the area of overlap was written to the layer.

4. The world heritage areas layer was constructed from the October 2007 version of the *Australia, World Heritage Areas* data set, a 1:250 000 scale Australian world heritage areas vector data set with currency end date October 2007. This layer flags, with value 1, all pixels within the extent of the Version 4 map that represent a terrestrial world heritage area polygon in the *Australia, World Heritage Areas* data set with the *iucn_mgt* attribute indicating an assigned management level (such as '1a' or '1a, 1b, 2'); and flags, with value 0, all pixels within the extent of the Version 4 map that represent a terrestrial polygon in the *Australia, World Heritage Areas* data set with the *iucn_mgt* attribute indicating no assigned management level (i.e. equal to the empty string or 'Unassigned'); and flags, with value 0, all pixels within the extent of the Version 4 map that are non-terrestrial. Users should note that the *Australia, World Heritage Areas* data set has a caveat stating that the coastal boundary for the Great Barrier Reef World Heritage Area is interim and that the boundary shown should indicate 'mean low tide', as stated in the World Heritage inscription, but is actually only indicative of this.

5. The tenure layer, which shows land tenure classified into 16 categories, is the same as the later currency tenure layer of the two tenure layers used in the construction of the Version 3 maps. It is based on *Australian Tenure*, a 250m raster tenure data set compiled by BRS in 1997, but the data content was updated for the construction of the Version 2 map (Stewart et al., 2001) and was further updated for the construction of the Version 3 maps (Smart et al., 2006).

6. The forest type layer was constructed from the BRS 2007 forest data set, a 100 m raster data set with nominal scale 1:250 000 and with currency end date 2007. This data set defines forest as treed areas with crown cover greater than 20% and tree height greater than 2 m. The forest type layer only retains basic forest type attributes from its source data set; it categorises forest pixels as plantation forest (further broken down into hardwood, softwood and unknown or mixed), native forest (further broken down into closed forest with crown cover greater than 80%, open forest with crown cover between 50% and 80% and woodland with crown

cover between 20% and 50%), and non-forest (crown cover less than 20%) or no data. Forest pixels which were also classified as horticulture in the horticulture mask (discussed below) were reclassified as non-forest.

Construction of horticulture, cultivated and irrigation masks

A horticulture mask identifying all (or at least most) horticulture pixels – vegetables and grapes as well as orchards and plantation fruit – was constructed using the following steps: (i) Pixels representing horticulture were identified according to the latest catchment scale land use data available as at February 2009 – the same source data as used in the construction of the catchment scale land use layer and discussed earlier. (ii) Additional pixels representing horticulture were identified using data from the collaborative *Land Use Data Integration Case Study – Lower Murray NAP Region* project managed by BRS – currency 2000 to 2005. (iii) Additional pixels representing horticulture were identified using the *Agricultural Land Cover Change: 1995 Land Cover* data set – currency c. 1995 – compiled by BRS. (iv) Additional pixels representing horticulture were identified using polygons representing orchards from a June 2006 release of the *GEODATA TOPO 250K, Series 3* data set published by GA. (v) A presence absence data set for horticulture (other than grapevines) compiled by the ABS at mesh block level based on the 2005-06 agricultural census data was used to remove spurious pixels and thereby sharpen the temporal focus on the 2005-06 year. (vi) Unpublished digital boundaries for the Ord River Irrigation Area obtained from the Western Australia Department of Agriculture and Food were used to remove, from the set of horticulture pixels, any in the east Kimberley district of Western Australia, which did not fall inside the Ord River Irrigation Area.

A cultivation mask identifying all (or at least most) pixels representing cultivated land – sown pasture, fallow land associated with crop-pasture rotations, grains, sugar cane, pastures and crops for hay, cotton, other non-cereal crops, vegetables and other horticulture – was constructed using the following steps: (i) The NLWRA native vegetation data set, entitled *Native Vegetation Baseline 2004 VERSION 1*, was used to identify pixels representing modified vegetation in all states and territories except Queensland. In these areas, modified vegetation, as defined by this data set, where it coincides with agricultural land, was assumed to be largely composed of cultivated land and plantation forestry, with native-exotic pasture mosaics excluded. (ii) An unpublished Queensland vegetation map, entitled *VAST Map for Queensland*, compiled by the Queensland Department of Environment and Resource Management in May 2009, was used to identify pixels representing modified vegetation in Queensland, with native-exotic mosaics treated as native vegetation for the purpose of constructing the cultivation mask. (iii) The horticulture mask, already described, was used to identify additional pixels representing modified vegetation throughout Australia; horticulture was viewed as modified vegetation for the purpose. (iv) The forest type layer, already discussed, was used to exclude pixels representing plantation forestry from the set of pixels representing cultivated land and to ensure exclusion of all pixels representing native forest (crown cover greater than 20%). (v) The digital boundaries representing the Ord River Irrigation Area, already mentioned, were used to remove, from the cultivated set, pixels in the east Kimberley district of Western Australia, which did not fall inside the Ord River Irrigation Area.

An irrigation mask identifying all (or at least most) pixels in designated and private irrigation areas was constructed from an augmented version of the irrigation areas

data set published by the NLWRA, the *Australian Irrigation Areas, Version 1a.* The augmented source data set was completed by BRS in (and has currency end date) October 2008 and incorporates new data from various stakeholders.

These masks were used as spatial constraints to improve the accuracy of the mapping of specific agricultural land uses. For the horticulture and cultivation masks, default densities were taken to be 100%. For the irrigation mask, default densities were tailored to each unique combination of statistical division (SD) and commodity group, as discussed further, below.

Determination of distribution of agricultural land uses

The spatial distribution of specific agricultural land uses was modelled using area constraints based on the 2005-06 agricultural census data collected by the ABS and reported at statistical local area (SLA) level. The agricultural census data must be processed in various ways to generate suitable area constraint data: adjustments need to be made for double cropping (and for multiple cropping of vegetables), orchard tree numbers need to be converted to areas, areas need to be scaled to fit the existing digital maps and irrigated areas for broad commodity groups need to be disaggregated into the more specific commodity groups to be mapped. The processing undertaken for the Version 4 map is similar to that described by Stewart et al. (2001). Discrimination between land uses was provided by monthly NDVI images covering the period 1 April 2005 to 31 March 2006, a total biomass image, crown cover data and slope data. NDVI images were from AVHRR data processed to correct for cloud cover by DEWHA. The pixel by pixel sum of the twelve NDVI images served as a surrogate total biomass image. Crown cover data were from the forest type layer discussed above. Slope data were from the *GEODATA 9 Second Digital Elevation Model (DEM-9S) Version 3*, published by GA in 2008.

Two aspects of the 2005-06 agricultural census data presented difficulties. One was the fact that the areas of fallow land reported were significantly larger than in previous years. This appears to be partly due to drought conditions and partly to the inclusion of non-stocked rangelands as fallow land. The proportions of fallow land attributable to rangelands and to crop-pasture rotations, however, were not reported. The other was the fact that total areas of sown pastures were not reported.

These difficulties were circumvented using the following steps, applied independently to the data for each SLA: (i) Using the cultivation mask and the horticulture mask discussed earlier, it was possible to estimate the ratio of cultivated land, excluding horticulture, to non-cultivated land. The fallow land area reported in the census data was split in these proportions into a crop-pasture rotation associated component and a rangelands associated component. Where the crop-pasture rotation associated component plus the areas of all other cultivated commodities excluding horticulture was too large to fit into the area available according to the cultivation and horticulture masks, the crop-pasture rotation associated component of fallow land was reduced as much as necessary, or as much as possible, to avoid or minimise the discrepancy and the rangelands associated component was increased accordingly. (ii) The area of sown pasture for grazing was taken to be the area of cultivated land excluding horticulture, according to the cultivation and horticulture masks, minus the total area reported for cultivated commodities excluding horticulture (but including newly planted agroforestry). Where this gave a negative area, the area of sown pasture for grazing

was taken to be zero. (iii) The rangelands associated component of fallow land was reclassified as grazing of native or naturalised pasture or of native-exotic pasture mosaic for allocation by SPREAD II. (iv) The crop-pasture rotation associated component of fallow land was, similarly, reclassified for allocation by SPREAD II – as a mixture of sown pasture and all reported cultivated commodities excluding horticulture and newly planted agroforestry, in the same proportions as these commodities were reported.

The reclassification of fallow land in the manner described has two advantages. First, it deals with fallow land in the manner advocated by the ALUMC. Second, it means the Version 4 map will be more readily comparable with the Version 3 maps and with the Version 2 map – the earlier maps ignored fallow land since the earlier agricultural censuses and surveys on which they were based either did not report fallow land at all or the areas reported were negligible. The reclassification of fallow land in the manner described also has a disadvantage – it means that SPREAD II was asked to allocate a land use other than fallow land to pixels that, in reality, do represent fallow land and the outcome for any given pixel may not be the most sensible outcome for that pixel – but this disadvantage is, to some extent, mitigated by the fact that incorrectly allocated pixels generally receive low probabilities for all land uses and, in this way, are differentiated from correctly allocated pixels.

The agricultural land uses were mapped (ignoring irrigation status) in the zone of non-timbered agricultural land using the SPREAD II algorithm. SPREAD II was run using two spatial constraints, the horticulture mask and the cultivation mask. The default densities for both the horticulture and the cultivation constraints were set to 100%.

Additional grazing land allocations were then made, outside SPREAD II, up to the area reported in the agricultural census. Allocations were to agricultural land pixels with crown cover up to 80%, prioritised, first, by crown cover (lowest crown cover classes given highest priority) and, second, by slope (smallest slope values given highest priority).

Finally, irrigation status was mapped outside SPREAD II. Irrigated area data by commodity group from the 2005-06 agricultural census – only available at SD level – served as area constraints. (Note that SDs are much larger than SLAs – each SD comprises about 20 SLAs.) The irrigation mask was used as a spatial constraint. The area constraints were partitioned between the irrigation area pixels and other pixels using an implementation outside SPREAD II of the partitioning algorithm newly introduced into SPREAD II and described above. The default densities were tailored to each unique SD and commodity group combination, choosing values that gave results consistent with irrigation densities reported in the Australian Natural Resources Atlas irrigation extent web pages (under http://www.anra.gov.au/topics/irrigation/extent/index.html) and in the Murray Irrigated Limited annual report for 2005-06. ‘Irrigated’ status was then allocated to pixels to which agricultural land uses (other than newly planted agroforestry) had already been allocated by SPREAD II, prioritised by total biomass (largest total biomass values given highest priority).

There are no ground control points for berry fruit. Further, the area of berry fruit is probably sufficiently small and the berry fruit farms are probably sufficiently scattered that the representation of berry fruit farms in a map with 0.01 degree pixels

should amount to a negligible number of pixels in any case. Consequently this commodity has not been mapped and there is no probability grid.

Agroforestry is incompletely covered in the 2005-06 agricultural census – areas for agroforestry plantations that were established in the census reference year ('seed sown' or 'seedlings planted' or both) are reported but areas for previously established agroforestry are not. Therefore the agroforestry mapped as such by SPREAD II is only newly established agroforestry. Previously established agroforestry is likely to have been mapped in the categorical summary land use map as 'Residual native cover' (ALUMC, Version 6, code 1.3.3), 'Grazing natural vegetation' (ALUMC, Version 6, code 2.1.0) or 'Plantation forestry' (ALUMC, Version 6, codes 3.1.0 to 3.1.2 or 4.1.0). Also, area irrigated is not reported for agroforestry and, for this reason, all mapped agroforestry has been classified as dryland.

A single categorical grid was constructed to store all the agricultural land use allocations (ignoring irrigation status), both those made inside SPREAD II and the additional grazing allocations made outside it. A second categorical grid was constructed to store the irrigation status allocations. These layers were incorporated in the categorical summary land use map; they are preserved as columns in its VAT.

Classification of land uses according to the ALUMC, Version 6

An additional layer was incorporated in the categorical summary land use map to enable grazing land to be classified as 'Grazing natural vegetation' (ALUMC, Version 6, code 2.1.0) or 'Grazing modified pastures' and 'Irrigated modified pastures' (ALUMC, Version 6, codes 3.2.0 and 4.2.0) using an ACLUMP approved method. This grazing split layer provides a binary classification for each pixel as potentially natural (more likely to be grazing of natural vegetation, if grazed at all) or as potentially modified (more likely to be grazing of modified pasture, if grazed at all). For all states except Queensland, the binary classification was derived from the latest catchment scale land use data available as at February 2009 – the same source data as used in the construction of the catchment scale land use layer and discussed earlier – except that all pixels in the Ord River Irrigation Area were classified as potentially modified using the boundaries representing the Ord River Irrigation Area, already mentioned in connection with the construction of the horticulture and cultivation masks. For Queensland, the catchment scale land use data are inadequate for this task and the binary classification was derived from the unpublished Queensland vegetation map, entitled *VAST Map for Queensland*, compiled by the Queensland Department of Environment and Resource Management in May 2009 (already mentioned previously) with native-exotic mosaics treated as modified vegetation for the purpose of constructing the grazing split layer.

Land uses were assigned to pixels in the final categorical summary land use map with the aid of a macro, which assigns land use categories from the ALUMC, Version 6 according to the attributes of all the input layers, i.e. of the six layers overlain to determine the non-agricultural land uses (the topographic features, catchment scale land use, protected areas, world heritage areas, tenure and forest type layers) and of the commodities, irrigation and grazing split layers. The land use assignments were stored in a number of VAT columns, which store codes and descriptions from different levels of the hierarchically structured ALUMC.

Statements pertaining to input data provided under licence

The *Land Use of Australia, Version 4, 2005-06* incorporates derivatives of data provided by various agencies under licence and is made publicly available subject to the following provisions:

1. The topographic features layer is based on a June 2006 release of the *GEODATA TOPO 250K, Series 3* data set, which was compiled by the Australian Government agency, Geoscience Australia (GA), and is copyright, Commonwealth of Australia, 2006. The *GEODATA TOPO 250K, Series 3* data set has been used in the *Land Use of Australia, Version 4, 2005-06* with the permission of GA. GA has not evaluated the *GEODATA TOPO 250K, Series 3* data set as altered and incorporated within the *Land Use of Australia, Version 4, 2005-06* and therefore gives no warranty regarding the accuracy, completeness, currency or suitability for any particular purpose of this use and representation of their data.

2. The world heritage areas layer is based on the *Australia, World Heritage Areas* data set, which was compiled by DEWHA and is copyright, Commonwealth of Australia, 2007. The Australia, *World Heritage Areas* data set has been used in the *Land Use of Australia, Version 4, 2005-06* with the permission of DEWHA. DEWHA has not evaluated the *Australia, World Heritage Areas* data set as altered and incorporated within the *Land Use of Australia, Version 4, 2005-06* and therefore gives no warranty regarding the accuracy, completeness, currency or suitability for any particular purpose of this use and representation of their data.

Comparison with previous maps

The Version 4 map differs from the Version 3 maps and the Version 2 map in a number of ways. Many of the differences relate to changes in the agricultural census data, some of which have created opportunities for improving the map and some of which have created difficulties needing to be surmounted. The main differences are as follows:

1. In the Version 4 map, two additional thematic layers are used explicitly in the determination of the non-agricultural land uses. They are the catchment scale land use layer and the world heritage areas layer. The former, with the topographic features layer, enables the determination of intensive land uses; and with the forest type layer, enables the determination of plantation forestry land uses. The latter, with the protected areas layer, enables the determination of protected areas land uses. As discussed previously, the catchment scale land use data set, on which the catchment scale land use layer is based, now has very nearly complete national coverage whereas at the time the Version 3 maps were constructed it had some large areas of incomplete coverage in south-east Australia and, therefore, could not be used as extensively. One aspect of the catchment scale land use layer which is particularly useful in the Version 4 map is that it enables mapping of the land use categories, rural residential and rural living; another is that it gives a more complete picture of the extent of plantation forestry than the forest type theme since the latter is limited to showing the location of actual stands of plantation forestry but does not show non-timbered areas that are used for plantation forestry. World heritage areas data have never been used in previous national scale land use maps; their incorporation enables certain areas of forest in the Wet Tropics of Queensland World Heritage Area to be correctly classified as nature conservation rather than as production forestry.

2. Non-trivial areas of fallow land are reported in the 2005-06 agricultural census data. This did not occur in the agricultural census and survey data on which the Version 3 maps and the Version 2 map were based. The areas were so large that they could not be ignored. They needed to be dealt with either by mapping fallow land or by reclassifying the areas reported as fallow land as the land uses temporarily replaced by the fallow land. The second option was adopted. The methodology used and its advantages and disadvantages have been discussed previously.

3. In a significant departure from the methodology used in the construction both of the Version 3 maps and of the Version 2 map, irrigation status was ignored in the mapping of agricultural commodities using SPREAD II. This was because the 2005-06 agricultural census only reports irrigated areas broken down by commodity at SD level.

4. Because SPREAD II was not required to map irrigation status in the Version 4 map, dryland and irrigated ground control points for each commodity could be combined and ground control points whose irrigation status is unknown could also be used, greatly increasing the number of ground control points for many map units and enabling some rationalisation of map units as follows:

- Cereals excluding rice split into summer cereals excluding rice and winter cereals

- Legumes split into summer legumes and winter legumes

- Oilseeds split into summer oilseeds and winter oilseeds

- Non-cereal forage crops dropped; pastures and crops for hay (a new unit that includes cereals for hay) introduced in its place

- Stone fruit split into tropical stone fruit and stone fruit excluding tropical

5. Total area of grazing is reported in the 2005-06 agricultural census. The assumption used in previous national scale land use maps, that grazing stops when the crown cover increases to 50% was therefore not needed in the Version 4 map, in which the mapping of the extent of grazing is more likely to agree with reality.

6. In contradistinction with the agricultural census and survey data on which previous national scale land use maps have been based, the 2005-06 agricultural census data do not include reporting of area of sown pastures. It was therefore considered advisable to run SPREAD II using an estimated split of non-timbered grazing into (i) grazing of native or naturalised pasture or of native-exotic pasture mosaic and (ii) grazing of modified pastures. The estimation methodology, described in detail previously, made use of the cultivation and horticulture masks.

7. In the Version 4 map, the method of partitioning area constraints between the inside and the outside of spatial constraint masks has been rationalised.

8. In the Version 4 map, land uses have been classified according to Version 6 of the ALUMC; the Version 3 maps were classified according to ALUMC, Version 5; and the Version 2 map was classified according to ALUMC, Version 4.

9. In the Version 4 map, an ACLUMP approved method for distinguishing grazing of natural vegetation from grazing of modified pastures has been introduced. This should mean that, in the Version 4 map, the classification of grazing land comes closer to the spirit of the ALUMC than it did in previous maps.

Caveats

Users of the Version 4 map should note the following caveats.

1. The purpose of this data set is to provide a nation-wide representation of major commodity types for mapping and display, and as spatial input to numerical models.

2. Finer resolution land use data are available for most of Australia and, when appropriate, should be used in preference to this data set.

3. The land use data set should be used at an appropriate scale (nominally 1:2 000 000). For the agricultural land uses, the categorical summary land use map cannot be expected to have high attribute accuracy on a pixel-by-pixel basis; each pixel is about 1 km in size. Further, if the data set is compared with other national scale land use maps constructed by BRS using SPREAD or SPREAD II, it should be borne in mind that the method used to construct the maps does not impose temporal stability and temporal changes observed in the land use allocations to individual pixels should not be used to infer that real land use transitions have affected those specific pixels.

4. Attribute accuracy is likely to be particularly low for pixels in the categorical summary land use map 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 commodity categories are those based on SPREAD II map units that are phenologically homogeneous, for example, cotton or sugar cane. The least distinct commodity categories are those based on SPREAD II map units that are phenologically inhomogeneous, for example, other non-cereal crops or plantation fruit.

5. The 2005-06 agricultural census data published by the ABS provide the commodity areas built into the categorical summary land use map: the area of each map unit in each SLA and the area irrigated for each map unit in each SD. It should be noted that the ABS data were processed using various assumptions during construction of the data set, as discussed in the methodology section, above, using similar procedures to those described by Stewart et al. (2001). It should, further, be noted that even the unprocessed agricultural census data are estimates with relative standard errors, which, in some cases, are quite large. The data set should, therefore, be used with appropriate caution.

6. It is difficult to classify grazing land in terms of the ALUMC guidelines without examining the pastures at first hand. The use of the grazing split layer should improve the results in this area but the classification of grazing land into ‘natural’ and ‘modified’ categories should nevertheless still be used with caution.

7. In the categorical summary land use map, the assignment of land uses to agricultural land pixels that did not receive a SPREAD II allocation was subject to simplifying assumptions as discussed in the data dictionary section, below (where

it will also be seen that pixels that did not receive a SPREAD II allocation in the categorical summary land use map have value zero in the *commodities* column in the VAT of the grid).

8. In constructing the Version 3 maps, the distribution of woody vegetation was modelled using data sets for the years 1992, 1995, 1998, 2000 and 2002 compiled by DEWHA in 2004 for greenhouse accounting purposes. These data sets provide an internally consistent time series of woody vegetation extent mapping; they therefore provide for a precise determination of change in extent. These data are not the same as the nationally agreed forest extent data compiled from State and Territory data by the National Forest Inventory (NFI) group within BRS, which includes a wider range of forest types for the purpose of broader forest assessment and reporting. In constructing the Version 4 map, the NFI forest extent data were used. Users, not only of the Version 4 map, but also of the Version 3 maps, should be aware of these methodological details since they may affect the distribution of some land uses, and, further, since they may affect the outcomes of comparisons between the Version 4 map and any of the Version 3 maps.

9. Non-perennial and perennial hydrographic features have not been distinguished. Users of the data set 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'.

10. In the construction of the data set, 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 6, 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).

11. Much, if not all, of the land shown as ALUMC, Version 6, class 2.2.0 (production forestry) would probably be better classified as a tertiary class under ALUMC, Version 6, class 1.2.0 (managed resource protection). This has not been done for two reasons. First, the *Collaborative Australian Protected Areas Database – CAPAD 2006*, on which the protected areas layer is based, and earlier editions of this data set, do not support this approach. Second, ALUMC, as at Version 6, does not yet have a tertiary class under class 2.2.0 for managed resource protection applying to forestry. Similar caveats apply to the Version 3 maps and to the Version 2 map.

12. The mapping of irrigation status is based on 2005-06 agricultural census data that are available at SD level only, not at SLA level; further, the mapping of irrigation status was done outside SPREAD II using a less sophisticated methodology. Similarly, the mapping of grazing of timbered agricultural land (with woodland and open forest cover, i.e. with crown cover between 20% and 80%) was also done outside SPREAD II, though in this case the underlying agricultural census data were reported at SLA level. Therefore the attribute accuracy of the mapping of irrigation status and of grazing of timbered agricultural land is likely to be at a significantly lower level than that of the mapping, for all commodities across the zone of non-timbered agricultural land with irrigation status ignored, that was done using SPREAD II.

Grid naming conventions

The floating point probability grids have been named *p05v4_NN* where *p* indicates probability grid, *05* indicates the data set currency (i.e. 2005-06), *v4* indicates the data set version (i.e. Version 4) and *NN* is a two digit integer code for the modelled land use with values ranging from 01 (i.e. 1) to 25, excluding 4 and 23 (which represent, respectively, fallow land and berry fruit, which were not mapped for reasons explained above and for which there are, consequently, no probability grids). The meanings of the land use codes (*NN*) can be read from the right-hand column of Table 8, reading from the row of the table that has the appropriate land use code in the left-hand column.

The categorical summary land use map is available as four different integer grids comprising an abridged and a non-abridged version in each of two different coordinate systems, referred to briefly as geographical coordinates and Albers coordinates. The abridged grids have many of the columns dropped from the VAT. The unabridged grids have all columns retained in the VAT. The geographical coordinates are latitude and longitude referred to horizontal coordinate datum, GDA94. The Albers coordinates are Albers equal-area conic referred to horizontal coordinate datum, GDA94. The grids are called *lu05v4ug*, *lu05v4ua*, *lu05v4ag* and *lu05v4aa* where the prefix, *lu*, indicates categorical summary land use grid, *05* indicates the data set currency (i.e. 2005-06), *v4* indicates the data set version (i.e. Version 4), the second last letter indicates unabridged or abridged (*u* or *a*, respectively) and the last letter indicates geographical coordinates or Albers coordinates (*g* or *a*, respectively). The four grids all have VATs and, except in respect of the number of columns in the VAT, the same structure. Each grid has layers defined by groups of columns in the VAT. The naming of the VAT columns and the way they are grouped into layers and which columns are dropped and which retained in the abridged grids is described in the next section.

Data dictionary

Categorical summary land use grid

Table 1 shows the columns in the VAT of the categorical summary land use grid.

Table 1. Columns in the VAT of the categorical summary land use grid showing their meanings and how they define the layers. Only those marked with an asterisk are present in the abridged version.

Column	Meaning	Layer
*value**	Cell value	Not applicable
*count**	Number of cells with given value	"
topo_features	Topographic feature code	Topographic features
topo_feat_desc	Topographic feature description	"
clum_data	Catchment scale land use code	Catchment scale land use
clum_data_desc	Catchment scale land use description	"
prot_areas	Protected areas code	Protected areas
prot_areas_desc	Protected areas description	"
wh_areas	World heritage areas code	World heritage areas
wh_areas_desc	World heritage areas description	"
tenure	Tenure code	Tenure
tenure_desc	Tenure description	"
forest_type	Forest type code	Forest type
forest_type_desc	Forest type description	"
*commodities**	Agricultural commodity code: output from SPREAD II and mapping of grazing outside SPREAD II	Agricultural commodities
*commodities_desc**	Agricultural commodity description: output from SPREAD II and mapping of grazing outside SPREAD II	"
*irrigation**	Irrigation status code: output from mapping of irrigation status outside SPREAD II	Irrigation
*irrigation_desc**	Irrigation status description: output from mapping irrigation status outside SPREAD II	"
graz_split	Grazing split code (for assigning native or modified status to pixels representing grazing land)	Grazing split
graz_split_desc	Grazing split description (for assigning native or modified status to pixels representing grazing land)	"
*lu_code**	Land use code: ALUMC Version 6 land use tertiary code as three digit integer	Land use
*lu_desc**	Land use description: ALUMC Version 6, primary land use	"
*lu_desc2**	Land use description: ALUMC Version 6, secondary land use	"
*lu_desc3**	Land use description: ALUMC Version 6, tertiary land use	"
*t-code**	Land use code: ALUMC Version 6, land use tertiary code as string	"

The topographic features layer is defined by the columns *topo_features* and *topo_feat_desc*. The values of these attributes and their meanings are listed in Table 2.

Table 2. Columns representing the topographic features layer showing values and meanings.

topo_ features	***topo_feat_desc***	**Meaning**
0	Not a topographic feature	Not classified as a topographic feature
1	Lake - perennial	A naturally occurring body of mainly static water surrounded by land; normally contains water for the whole year, except during unusually dry periods, in at least nine years out of ten
2	Lake - non-perennial	A naturally occurring body of mainly static water surrounded by land; contains water for several months of each year or only contains water intermittently.
3	Watercourse - perennial	A natural channel along which water may flow from time to time; normally contains water for the whole year, except during unusually dry periods, in at least nine years out of ten
4	Watercourse - non-perennial	A natural channel along which water may flow from time to time; contains water for several months of each year or only contains water intermittently
5	Swamp	Land which is so saturated with water that it is not suitable for agricultural or pastoral use and presents a barrier to free passage
6	Marine swamp	That low lying part of the backshore area of tidal waters, usually immediately behind saline coastal flat, which maintains a high salt water content, and is covered with characteristic thick grasses and reed growths
7	Saline coastal flat	That nearly level tract of land between mean high water and the line of the highest astronomical tide
8	Reservoir	A body of water collected and stored behind a constructed barrier for some specific use (storage for flood irrigation excepted)
10	Built-up area	An area where buildings are close together and have associated road and other infrastructure networks
12	Mine area	An excavation made by the removal of stone, gravel, clay or mineral from the ground for commercial or industrial purposes and tailings dumps from mining operations
13	Pond - aquaculture	Shallow beds, usually segmented by constructed walls, for the use of aquaculture
14	Pond - salt evaporator	A flat area, usually segmented, used for the commercial production of salt by evaporation
15	Pond - effluent	Shallow beds, usually segmented by constructed walls, for the treatment of sewage or other wastes
16	Pond - intensive use/farm dam	A body of water collected and stored behind a constructed barrier for the specific use of flood irrigation farming
17	Wetland - artificial	Artificially constructed wetlands
18	Abandoned aquaculture	Shallow beds, usually segmented by constructed walls, for the use of aquaculture – abandoned

The catchment scale land use layer is defined by the columns *clum_data* and *clum_data_desc*. The values of these attributes are listed in Table 3. The values of the column, *clum_data*, are three digit integers indicating land use according to the ALUMC, Version 6, the three digits indicating, in order from left to right, the primary, secondary and tertiary classification codes respectively. For example, *clum_data* = 540 indicates secondary class 5.4.0, 'Residential', while *clum_data* = 542 indicates tertiary class 5.4.2, 'Rural residential'. The values of the column, *clum_data_desc*, are the land use descriptions for the appropriate level (primary, secondary or tertiary) according to the ALUMC, Version 6. The ALUMC, Version 6, is described in detail at http://www.daff.gov.au (search the site for ALUM).

Table 3. Columns representing the catchment scale land use layer showing values and meanings.

clum_data	***clum_data_desc***
0	Not plantation forestry or intensive uses
310	Plantation forestry
410	Irrigated plantation forestry
500	Intensive uses
510	Intensive horticulture
511	Shadehouses
512	Glasshouses
520	Intensive animal production
521	Dairy
522	Cattle
524	Poultry
525	Pigs
526	Aquaculture
530	Manufacturing and industrial
540	Residential
541	Urban residential
542	Rural residential
543	Rural living
550	Services
551	Commercial services
552	Public services
553	Recreation and culture
554	Defence facilities
555	Research facilities
560	Utilities
561	Electricity generation/transmission
562	Gas treatment, storage and transmission
570	Transport and communication
571	Airports/aerodromes
572	Roads
573	Railways
574	Ports and water transport
575	Navigation and communication
580	Mining
581	Mines
582	Quarries
583	Tailings
590	Waste treatment and disposal
592	Landfill
593	Solid garbage
595	Sewage

The protected areas layer is defined by the columns *prot_areas* and *prot_areas_desc*. The values of these attributes and their meanings are listed in Table 4.

Table 4. Columns representing the protected areas layer showing values and meanings.

prot_ areas	***prot_areas_desc***	**Meaning**
0	Not a protected area	Not a protected area
11	Ia. Strict nature reserve	IUCN category Ia protected area: strict nature reserve; a protected area managed mainly for science
12	Ib. Wilderness area	IUCN category Ib protected area: wilderness area; a protected area managed mainly for wilderness protection
20	II. National park	IUCN category II protected area: national park; a protected area managed mainly for ecosystem conservation and recreation
30	III. Natural monument	IUCN category III protected area: natural monument; a protected area managed for conservation of specific natural features
40	IV. Habitat/species management area	IUCN category IV protected area: habitat/species management area; a protected area managed mainly for conservation through management intervention
50	V. Protected landscape/seascape	IUCN category V protected area: protected landscape/seascape; a protected area managed mainly for landscape/seascape conservation and recreation
60	VI. Managed resource protected areas	IUCN category VI protected area: managed resource protected area; a protected area managed mainly for the sustainable use of natural ecosystems

The world heritage areas layer is defined by the columns *wh_areas* and *wh_areas_desc*. The values of these attributes (which are self explanatory) are listed in Table 5. (Note that 'WHA' is used an abbreviation for 'world heritage area'.)

Table 5. Columns representing the world heritage areas layer showing values and meanings.

wh_areas	***wh_areas_desc***
0	IUCN management category unassigned or not a WHA
1	WHA managed as one or more of IUCN categories Ia to V

The tenure layer is defined by the columns *tenure* and *tenure_desc*. The values of these attributes and their meanings are listed in Table 6.

Table 6. Columns representing the tenure layer showing values and meanings.

tenure	***tenure_desc***	**Meaning**
0	Ocean, estuary with no tenure; no data	Ocean or estuary; also areas where the tenure is not known
1	Multiple use forests	Forestry areas on public land managed and controlled by state and territory forestry services in accordance with forestry acts and regulations; includes state forests and timber reserves
4	Nature conservation areas	National parks, nature reserves, state and territory recreation areas, conservation parks, environmental parks etc; crown land reserved for environmental conservation and recreational purposes; includes aboriginal freehold land leased back to conservation authorities as national park and jointly controlled. The term 'crown land' means land not subject to freehold or leasehold title of any individual or incorporated group.
6	Private freehold	Land held under freehold title: mainly privately owned land. Freehold title held, with special conditions attached, by designated Aboriginal communities, in all states except the Northern Territory, is classified separately as 'Private freehold – Aboriginal' (*tenure* = 8). For the Northern Territory, 'Private freehold' (*tenure* = 6) includes 'Private freehold – Aboriginal' (*tenure* = 8).
7	Private leasehold	Land held under leasehold title: leased from the crown, regarded as 'privately owned' land. Leasehold title held, with special conditions attached, by designated Aboriginal communities, in all states except the Northern Territory, is classified separately as 'Private leasehold – Aboriginal' (*tenure* = 18). For the Northern Territory, 'Private leasehold' (*tenure* = 7) includes 'Private leasehold – Aboriginal' (*tenure* = 18).
8	Private freehold - Aboriginal	Land held under freehold title, with special conditions attached, by designated Aboriginal communities
9	Reserved crown land - Aboriginal reserve	Crown land reserved for Aborigines; under the control of state and territory government Aboriginal affairs authorities
10	Reserved crown land - not elsewh. class.	Reserved crown land not elsewhere classified; includes stock routes
11	Water production	Crown land reserved to protect a water supply catchment or accommodate works associated with water supplies; includes privately or publicly owned land used for other purposes but subject to land use or access restrictions
12	Defence reserve or facility	Crown land reserved for use by the armed forces
13	Reserved crown land - mine reserve	Crown land held in reserve for mining
14	Other crown land - vacant	Crown land not reserved for any purpose
15	Other crown land - institutional	Institutional crown land – utilities, scientific, research, educational, other
18	Private leasehold - Aboriginal	Land held under leasehold title, with special conditions attached, by designated Aboriginal communities
20	Private freehold - Aboriginal, non-ag.	Aboriginal freehold land with negligible agriculture
21	Private leasehold - Aboriginal, non-ag.	Aboriginal leasehold land with negligible agriculture
22	Private freehold or private leasehold	Land that falls into either the 'Private freehold' or the 'Private leasehold' categories (*tenure* = 6 or 7). This category only applies to the Ord River irrigation area of Western Australia.

The forest type layer is defined by the columns *forest_type* and *forest_type_desc*. The values of these attributes and their meanings are listed in Table 7.

Table 7. Columns representing the forest type layer showing values and meanings.

forest_type	***forest_type_desc***	**Meaning**
0	Non-forest or no data	Non-forest (crown cover between 0% and 20%) or no data
2	Native woodland	Native forest with crown cover between 20% and 50%
3	Native open forest	Native forest with crown cover between 50% and 80%
4	Native closed forest	Native forest with crown cover between 80% and 100%
5	Plantation forestry - unknown or mixed	Plantation forest of unknown or mixed type
6	Plantation forestry - hardwood	Hardwood plantation forest
7	Plantation forestry - softwood	Softwood plantation forest

The agricultural commodities layer is defined by the columns *commodities* and *commodities_desc*. The values of these attributes and their meanings are listed in Table 8.

Table 8. Columns representing the agricultural commodities layer showing values and meanings.

com-modities	***commodities_desc***	**Meaning – all allocated by SPREAD II in the zone of non-timbered agricultural land unless stated otherwise**
-1	Non-agricultural land or no data	Non-agricultural land or no data
0	Unallocated agricultural land	Unallocated agricultural land – occurs in SLAs in which the area of agricultural commodities to be allocated was less than the area of agricultural land available
1	Grazing - native or naturalised pasture or native-exotic pasture mosaic	Grazing of native or naturalised pasture or native-exotic pasture mosaic
2	Grazing sown pastures	Grazing of sown pastures
3	Agroforestry - newly planted	Agroforestry, newly planted (seed sown and seedlings planted)
5	Winter cereals	Winter cereals
6	Summer cereals excluding rice	Summer cereals excluding rice
7	Rice	Rice
8	Winter legumes	Winter legumes
9	Summer legumes	Summer legumes
10	Winter oilseeds	Winter oilseeds
11	Summer oilseeds	Summer oilseeds
12	Sugar cane	Sugar cane
13	Pastures and crops for hay	Pastures and crops for hay
14	Cotton	Cotton
15	Other non-cereal crops	Other non-cereal crops
16	Vegetables	Vegetables
17	Citrus	Citrus
18	Apples	Apples
19	Pears and other pome fruit	Pears and other pome fruit
20	Stone fruit excluding tropical	Stone fruit excluding tropical stone fruit
21	Tropical stone fruit	Tropical stone fruit
22	Nuts	Nuts
24	Plantation fruit	Plantation fruit
25	Grapes	Grapevines
26	Grazing - largely of woodland and open forest	Grazing land mapped outside SPREAD II largely in agricultural land covered by woodland or open forest

The irrigation layer is defined by the columns, *irrigation* and *irrigation_desc*. The values of these attributes and their meanings are listed in Table 9.

Table 9. Columns representing the irrigation layer showing values and meanings.

irrigation	***irrigation_desc***	**Meaning**
0	Dryland agriculture, not ag. or no data	Dryland agriculture or not an agricultural commodity or no data
1	Irrigated agriculture	Irrigated agriculture

The grazing split layer is defined by the columns, *graz_split* and *graz_split_desc*. The values of these attributes and their meanings are listed in Table 10.

Table 10. Columns representing the grazing split layer showing values and meanings.

graz_ split	***graz_split_desc***	**Meaning**
0	Offshore	Offshore
1	Minimal modification of natural vegn	More likely to be grazing of natural vegetation, if grazed at all
2	Significant modification of natural vegn	More likely to be grazing of modified pasture, if grazed at all

The land use layer is defined by the columns, *lu_code*, *lu_desc*, *lu_desc2*, *lu_desc3* and *t-code*. The values of the first two of these attributes and their meanings are listed in Table 11. The values of the column, *lu_code*, are three digit integers indicating land use according to the ALUMC, Version 6, the three digits indicating, in order from left to right, the primary, secondary and tertiary classification codes respectively, in the manner described above for the column, *clum_data*. The values of the columns, *lu_desc*, *lu_desc2* and *lu_desc3* are the land use descriptions at the primary, secondary and tertiary level, respectively, of the ALUMC, Version 6. The values of the column, *t-code*, are the land use codes, according to the ALUMC, Version 6, in the published format; i.e. they are strings comprising the three digits making up the corresponding *lu_code* value, in the same order, but separated by periods. As mentioned previously, the ALUMC, Version 6, is described in detail at http://www.daff.gov.au (search the site for ALUM).

Table 11. Values and meanings for the columns, *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.

Probability grids

The meaning of the cell values in a probability grid is as follows: for a pixel that, in the categorical summary land use map, has a value in the *commodities* column of the VAT, which is in the range 1 to 25 (noting that values 4 and 23 will not occur), each probability grid has a cell value between 0 and 1, which gives the probability that the land use for the pixel concerned was the land use to which the probability surface relates. The sum of the probabilities from all of the probability grids for that pixel is 1.

Rationale for classification of land uses according to the ALUMC, Version 6

In a number of circumstances, the rationale for the classification of land uses in the categorical summary grid according to the ALUMC, Version 6, was not obvious. The following explanations are therefore provided.

1. The procedure for assignment of land uses to agricultural land pixels that received no SPREAD II allocation, such pixels occurring in SLAs for which the total area of agricultural commodities to be allocated was less than the area of agricultural land (value 0 in the *commodities* column of the VAT), was as follows:

    1.1. If the pixel fell in aboriginal land, 'Traditional indigenous uses' (ALUMC, Version 6, code 1.2.5) was assigned.

    1.2. If the pixel did not fall in aboriginal land, the following steps were taken:

        1.2.1. If the pixel had crown cover of 20% or more, 'Residual native cover' (ALUMC, Version 6, code 1.3.3) was assigned

        1.2.2. If the pixel had crown cover less than 20%, 'Other minimal use' (ALUMC, Version 6, code 1.3.0) was assigned.

2. The procedure for assignment of land uses to agricultural land pixels that received SPREAD II allocation, 'Grazing - native or naturalised pasture or native-exotic pasture mosaic' (value 1 in the *commodities* column of the VAT), was as follows:

    2.1. If the pixel was irrigated, 'Irrigated modified pastures' (ALUMC, Version 6, code 4.2.0) was assigned.

    2.2. If the pixel was not irrigated, the following steps were taken:

        2.2.1. If the grazing split value was 'offshore', indicating a coastal pixel, 'Grazing natural vegetation' (ALUMC, Version 6, code 2.1.0) was assigned.

        2.2.2. If the grazing split value was 'native', 'Grazing natural vegetation' (ALUMC, Version 6, code 2.1.0) was assigned.

        2.2.3. If the grazing split value was 'modified', 'Grazing modified pastures' (ALUMC, Version 6, code 3.2.0) was assigned.

3. The procedure for assignment of land uses to agricultural land pixels that received SPREAD II allocation, ‘Grazing sown pastures’ (value 2 in the *commodities* column of the VAT), was as follows:

    3.1. If the pixel was irrigated, ‘Irrigated modified pastures’ (ALUMC, Version 6, code 4.2.0) was assigned.

    3.2. If the pixel was not irrigated then, regardless of the grazing split value, ‘Grazing modified pastures’ (ALUMC, Version 6, code 3.2.0) was assigned.

4. Agricultural land pixels that received SPREAD II allocation, ‘Agroforestry - newly planted’, this commodity being assumed to be all dryland (value 3 in the *commodities* column of the VAT), were, in all cases, assigned to ‘Plantation forestry’ (ALUMC, Version 6, code 3.1.0).

5. Grazing of cereals is included in the SPREAD II allocation, ‘Grazing sown pastures’ (value 2 in the *commodities* column of the VAT).

6. The areas of crops for silage or green feed cannot be determined, explicitly, from the agricultural census data. This commodity has been assumed to occupy a negligible area and has not been mapped.

7. Agricultural land pixels that received SPREAD II allocation, ‘Other non-cereal crops’ (value 15 in the *commodities* column of the VAT), were, in all cases, assigned to ‘Production from Dryland Agriculture and Plantations’ or ‘Production from Irrigated Agriculture and Plantations’ (ALUMC, Version 6, codes 3.0.0 or 4.0.0), since ‘Other non-cereal crops’ includes representatives of categories 3.3.0, 3.4.0, 3.5.0, 4.3.0, 4.4.0 and 4.5.0.

8. Agricultural land pixels that received SPREAD II allocation, ‘Plantation fruit’ (value 24 in the *commodities* column of the VAT), were, in all cases, assigned to ‘Perennial horticulture’ or ‘Irrigated perennial horticulture’ (ALUMC, Version 6, codes 3.4.0 or 4.4.0), since ‘Plantation fruit’ includes representatives of ALUMC, Version 6, categories 3.4.1, 3.4.4, 3.4.5, 4.4.1, 4.4.4 and 4.4.5.

9. The procedure for assignment of land uses to agricultural land pixels that received the allocation made outside SPREAD II, ‘Grazing - largely of woodland and open forest’, this commodity being all dryland and only being allocated to pixels with crown cover less than 80% (value 26 in the *commodities* column of the VAT), was as follows:

    9.1. If the pixel had woodland or open forest cover (crown cover between 20% and 80%), ‘Grazing natural vegetation’ (ALUMC, Version 6, code 2.1.0) was assigned.

    9.2. If the pixel was non-timbered (crown cover less than 20%), the following steps were taken:

        9.2.1. If the grazing split value was ‘offshore’, indicating a coastal pixel, ‘Grazing natural vegetation’ (ALUMC, Version 6, code 2.1.0) was assigned.

9.2.2. If the grazing split value was ‘native’, ‘Grazing natural vegetation’ (ALUMC, Version 6, code 2.1.0) was assigned.

9.2.3. If the grazing split value was ‘modified’, ‘Grazing modified pastures’ (ALUMC, Version 6, code 3.2.0) was assigned.

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