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Mapping Land Use

Land Use Change Mapping from 1999 to 2004 for the Burdekin River Catchment

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July 2006

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This project received funding from the Australian Government's $3 Billion Natural Heritage Trust. The views and opinions expressed in this publication are those of the authors and do not necessarily reflect those of the Commonwealth Government or the Minister for the Environment and Heritage.

QNRM06222
July 2006

Land use change mapping was undertaken by the QLUMP team, Natural Resource Sciences, Indooroopilly and Spatial Products and Analysis, Mareeba.

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Front Page Photographs
Cropping and Emu photos supplied by the Burdekin Dry Tropics NRM, 2006
Grazing lands photo supplied by the Statewide Landcover and Trees Study (SLATS), Department of Natural Resources, Mines and Water
Background photo supplied by Robert Hassett, Climate Impacts and Natural Resource Systems, Queensland Department of Natural Resources, Mines and Water.

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Introduction

The Department of Natural Resources, Mines and Water (NRMW) through the Queensland Land Use Mapping Program (QLUMP; www.nrm.qld.gov.au/science/lump) has produced a consistent and seamless statewide land use dataset for the year 1999. This dataset and the mapping methodology are described by Witte *et al.* (2006). The 1999 land use dataset for Queensland provides the basis for monitoring and mapping of land use change.

Information on land use change is important for reporting on trends within catchments or regions. Spatial land use change data is critical for monitoring processes within the landscape and the effectiveness of natural resource management objectives relating to these. This includes salinity and water quality, rates of soil erosion, acidification, nutrient decline and carbon losses. Changing patterns in land use also have strong links to economic and social activities within a catchment or region.

Land use change mapping from 1999 to 2004 has occurred in the Fitzroy, Johnstone and Burdekin River catchments. This report briefly documents the methodology used for mapping land use change in the Burdekin River catchment and the various products:

- the 1999 land use dataset which includes a number of improvements and corrections to the previous 1999 dataset
- the 2004 land use dataset
- the land use change dataset from 1999 to 2004
- summary statistics derived from the above spatial datasets
- the results of the accuracy assessment.

Funding for this project was provided by the Queensland Department of Natural Resources, Mines and Water and the Australian Government's $3 Billion Natural Heritage Trust through the Department of the Environment and Heritage.

QLUMP is part of the Australian Collaborative Land Use Mapping Program (ACLUMP; www.brs.gov.au/landuse) which is coordinated by the Bureau of Rural Sciences (BRS) in Canberra and involves agencies in all states and territories of Australia. ACLUMP promotes the development of nationally consistent land use and land management practices information for Australia. BRS 2006 provides the guidelines for ACLUMP including principles and definitions.

Catchment overview

The Burdekin River catchment is approximately 13.34 million hectares in area and is located in tropical north-east Queensland. It is the second largest river basin on the Queensland east coast and contains the regional centres of Charters Towers, Collinsville and Homehill.

The catchment is dominated by savannah woodlands and grasslands, with livestock grazing the primary land use. national parks and defence areas comprise the next major uses, and extensive wetland systems are also present in the catchment area. Cereals and sugarcane are the major crops grown.

Objectives

The primary objectives of this project were to:

- further develop and improve the methodology to map land use change which is applicable to a broad range of catchments
- apply this methodology to the Burdekin River catchment and produce a detailed land use dataset for 2004
- produce an improved land use dataset for 1999 which includes more detailed attributing of crops and horticulture land uses
- produce a land use change layer between the years of 1999 and 2004
- assess and describe the accuracy of the land use data.

This data can then be utilised for a range of natural resource management applications.

Methodology

An effective method for detecting and mapping land use change has been developed and applied in the Burdekin River catchment. The methodology makes best use of available spatial information, satellite imagery, airphotos, expert knowledge and field survey. It involves successive stages of data collation, interpretation, verification, validation and production of final outputs.

The mapping scale is 1:50,000 with a minimum mapping unit of 1ha and a width of 50m for linear features.

The Burdekin catchment was clipped from the statewide 1999 land use data (for details see Witte *et al.*, 2006) and formed the basis for the 2004 land use dataset. The 1999 and 2004 datasets were then improved and updated, primarily by interpretation of Landsat TM and ETM+ imagery, scanned aerial photography and inclusion of expert local knowledge. This was performed in ERDAS Imagine by overlaying the land use datasets on Landsat imagery (1999, 2000, 2001, 2004) and digitising or modifying areas previously omitted or incorrectly mapped (1999 mapping) as well as areas of actual and potential land use change (2004).

A number of additional datasets were utilised to identify potential land use changes, including:

- woody vegetation change mapping by the Statewide Landcover and Trees Study (SLATS)
- the Queensland Valuations and Sales System (QVAS) data
- the digital cadastral database (DCDB)
- National Park, State Forest and Timber Reserves data.

The SLATS water body dataset and the Environmental Protection Agency (EPA) wetland mapping were used to improve the consistency of mapping *marsh/wetland*, *lakes* and *reservoir/dam* classes.

Digitised areas of uniform land use type were assigned to classes according to Australian Land Use and Management Classification Version 6 (ALUM Version 6; see Appendix 1 in this report and BRS 2006 for more detail). Local authorities, regional QNRMW and other state department officers and landholders supplied information and confirmed land uses not identified from the satellite images and other data. Field checking occurred in areas where the land use was still uncertain.

During the process of mapping land use change, cropping and horticultural areas in both the 1999 and 2004 land use datasets were attributed to the tertiary level of ALUM Version 6 wherever possible. Previously, cropping and horticultural areas were attributed to the secondary level with the exception of *sugar*, *irrigated sugar* and *irrigated cotton*.

Using the completed 2004 and improved 1999 land use datasets as inputs, a differencing algorithm was developed using a python script. This produced a dataset representing the change between the two images (1999-2004) including the land use change classes (eg. from *grazing natural vegetation* to *cropping*) which were included in the attribute table.

An independent validation was undertaken for the 2004 land use map and the land use change layer using a stratified random sample to assess thematic (attribute) accuracy under the ALUM classification. Note that only a subset of classes was sampled for this exercise. Some classes that are defined by tenure and are assumed correct (such as *national parks*) were not assessed. Classes which are small in total area (<10,000ha) and don't occur frequently (<10 polygons) were also not sampled, but the polygons were checked using imagery, photography and in some cases field survey. The number of points assessed for the remaining classes was determined based on the area that each class occupies within the catchment.

Land use was assessed at each point through interpretation of Landsat imagery, aerial photographs and referral to ancillary datasets. Where the land use could not be determined confidently through this process, the point was assessed in the field or the landholder was contacted directly.

Further information on data specifications and land use mapping procedures are provided by BRS (2006).

Products

1999 and 2004 land use data

Figure 1 shows the 2004 land use data for the Burdekin using the secondary level of the ALUM classification (see Appendix 1 for the classification).

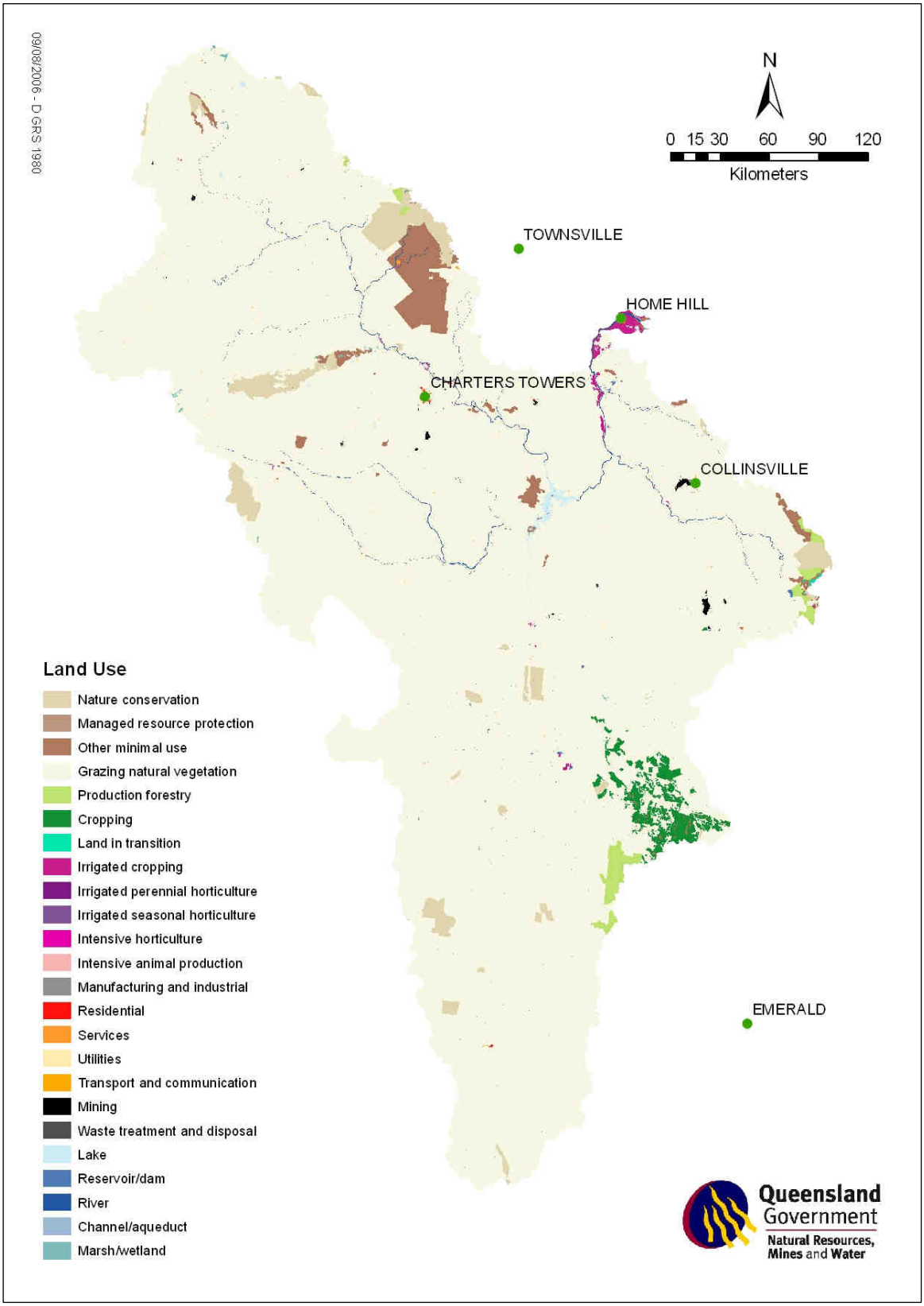

Figure 1: 2004 land use map for the Burdekin River catchment

Some tertiary classes, such as *irrigated sugar* (part of *irrigated cropping*), *dairies* (part of *intensive animal production*), *rural residential* (part of *residential*) and various classes under *nature conservation* have been mapped, but were not shown separately in Figure 1.

A figure showing the 1999 land use data was not included in this report, as the majority of the differences between this and the 2004 map (Figure 1) would be difficult to see at this scale. Table 1 and Table 2 provide the summary statistics for the 1999 and 2004 land use datasets respectively.

Land Use Code	Land Use Classes	Area ha	Area %
1	Conservation and natural environments	467,539	3.59
1.1	Nature conservation	201,517	1.55
1.2	Managed resource protection	38	0.00
1.3	Other minimal use	265,984	2.04
2	Production from relatively natural environments	12,280,259	94.35
2.1	Grazing natural vegetation	12,200,311	93.74
2.2	Production forestry	79,948	0.61
3	Production from dryland agriculture and plantations	129,222	0.99
3.3	Cropping	129,222	0.99
4	Production from irrigated agriculture and plantations	27,945	0.21
4.3	Irrigated cropping	27,580	0.21
4.3.5	Irrigated sugar*	23,975	0.18
4.3.6	Irrigated cotton*	1,169	0.01
4.4	Irrigated perennial horticulture	147	<0.01
4.5	Irrigated seasonal horticulture	217	<0.01
5	Intensive uses	19,676	0.15
5.1	Intensive horticulture	5	<0.01
5.2	Intensive animal production**	2,137	0.02
5.3	Manufacturing and industrial	424	<0.01
5.4	Residential	3,189	0.02
5.5	Services	2,283	0.02
5.6	Utilities	1	<0.01
5.7	Transport and communication	1,435	0.01
5.8	Mining	10,111	0.08
5.9	Waste treatment and disposal	90	<0.01
6	Water	90,547	0.70
6.1	Lake	29,811	0.23
6.2	Reservoir/dam	8,684	0.07
6.3	River	43,964	0.34
6.4	Channel/aqueduct	160	<0.01
6.5	Marsh/wetland	7,927	0.06
	Grand total	13,015,187	100

* The area of *irrigated sugar* and *irrigated cotton* are subsets of the total area of *irrigated cropping*.
***Intensive animal production* in this case refers to *dairies*.

Table 1: Summary statistics of land uses in 1999 in the Burdekin River catchment

Land Use Code	Land Use Classes	Area ha	Area %
1	Conservation and natural environments	569,830	4.38
1.1	Nature conservation	331,962	2.55
1.2	Managed resource protection	38	<0.01
1.3	Other minimal use	237,830	1.83
2	Production from relatively natural environments	12,177,040	93.56
2.1	Grazing natural vegetation	12,097,092	92.95
2.2	Production forestry	79,948	0.61
3	Production from dryland agriculture and plantations	131,487	1.01
3.3	Cropping	129,826	1.00
3.6	Land in transition	1,661	0.01
4	Production from irrigated agriculture and plantations	28,533	0.22
4.3	Irrigated cropping	27,881	0.21
4.3.5	Irrigated sugar*	23,769	0.18
4.3.6	Irrigated cotton*	1,169	0.01
4.4	Irrigated perennial horticulture	169	<0.01
4.5	Irrigated seasonal horticulture	482	<0.01
5	Intensive uses	18,687	0.14
5.1	Intensive horticulture	5	<0.01
5.2	Intensive animal production**	476	<0.01
5.3	Manufacturing and industrial	431	<0.01
5.4	Residential	3,189	0.02
5.5	Services	2,283	0.02
5.6	Utilities	1	<0.01
5.7	Transport and communication	1,435	0.01
5.8	Mining	10,776	0.08
5.9	Waste treatment and disposal	90	<0.01
6	Water	89,612	0.69
6.1	Lake	29,528	0.23
6.2	Reservoir/dam	8,754	0.07
6.3	River	43,936	0.34
6.4	Channel/aqueduct	160	<0.01
6.5	Marsh/wetland	7,234	0.06
	Grand total	13,015,187	100

* The area of *irrigated sugar* and *irrigated cotton* are subsets of the total area of *irrigated cropping*.
** Intensive animal production in this case refers to dairies.

Table 2: Summary statistics of land uses in 2004 in the Burdekin River catchment

The above tables show that grazing is by far the major land use in the Burdekin catchment occurring on over 12 million ha or approximately 93% of the catchment in 2004 and 93.7% in 1999. The estimate for *cropping* (dryland) is 130,000ha for both years and *irrigated sugar* covers approximately 24,000 ha and is the majority of the *irrigated cropping* area.

Data limitations

The ALUM class *grazing modified pasture* has not been included in QLUMP and all grazing in Queensland is classed as *grazing natural vegetation*, due to the difficulty in identifying and separating these classes using imagery, aerial photography and field observation.

Areas mapped as *dairies* include grazing areas and fodder crops. Cadastral parcels are often used to identify the extent of a dairy farm. It's possible that parts of these parcels include other land uses, such as grazing beef cattle. These areas may have been wrongly classified as *dairy*.

Land uses that are linear, such as roads and railways, are generally not mappable at a scale of 1:50,000 with a specified minimum mapping width of 50m and 100m respectively. As a result, the area estimates of these linear features represent only a small proportion of the actual area under this land use in Queensland. This is of relevance to the following land use classes:

- *stock route* (under *other minimal use*)
- *transport and communication*
- *utilities*
- *channel/aqueduct*.

The 1999 and 2004 land use datasets are both a snapshot in time showing what was considered the primary land use for each of those years. However, some effort was given to distinguishing between an actual land use change and a rotation. For example, an area that is usually cropped, but is not used for a particular purpose in the year of interest, was still mapped as cropping in the 2004 dataset even though no crop was present in that year. This was not considered an actual land use change, but rather a rotation, as the primary land use for that paddock would still be cropping.

A number of data sources are used to identify *irrigated cropping* and *irrigated horticulture*. This includes irrigation infrastructure mapping, the location of water entitlements (irrigation licences), local knowledge, field survey and image interpretation. It's possible, that areas mapped as irrigated cropping, for example, are only irrigated on a supplementary basis and were not actually irrigated in either 1999 or 2004.

The ephemeral nature of many water features can lead to confusion as they may be present in imagery of one date and either absent or of differing extent in imagery of subsequent or previous dates. As a result, there are likely to be errors and omissions and some disagreement in the mapping of features such as farm dams, reservoirs, lakes, wetlands and other water features.

The metadata for the datasets should be consulted for details on the mapping of specific classes.

1999 to 2004 land use change data

The total area of mapped land use change from 1999 to 2004 in the Burdekin River catchment is 134,294 hectares. That's 1.03% of the catchment. A breakdown of the change classes by area is shown in Table 3. The major changes were *grazing natural vegetation* to *other conserved area* (81,607 ha), *residual native cover* to *other conserved area* (20,764 ha), *grazing natural vegetation* to *national park* (19,602 ha) and *residual native cover* to *national park* (7,430 ha).

Land Use Code 1999	Land Use Class 1999	Land Use Code 2004	Land Use Class 2004	Area of change ha	Area of Catchment %
2.1.0	Grazing natural vegetation	1.1.7	Other conserved area	81,607	0.63
1.3.3	Residual native cover	1.1.7	Other conserved area	20,764	0.16
2.1.0	Grazing natural vegetation	1.1.3	National park	19,602	0.15
1.3.3	Residual native cover	1.1.3	National park	7,430	0.06
5.2.1	Dairy	3.6.0	Land in transition	1,659	0.01
6.5.1	Marsh / wetland - conservation	1.1.7	Other conserved area	695	0.01
2.1.0	Grazing natural vegetation	5.8.0	Mining	668	<0.01
2.1.0	Grazing natural vegetation	3.3.1	Cereals	606	<0.01
6.1.0	Lake	1.1.7	Other conserved area	269	<0.01
2.1.0	Grazing natural vegetation	4.3.0	Irrigated cropping	242	<0.01
4.3.5	Irrigated sugar	4.5.4	Irrigated vegetables & herbs	207	<0.01
2.1.0	Grazing natural vegetation	4.3.3	Irrigated hay & silage	159	<0.01
2.1.0	Grazing natural vegetation	4.3.1	Irrigated cereals	108	<0.01
2.1.0	Grazing natural vegetation	6.2.0	Reservoir/dam	87	<0.01
2.1.0	Grazing natural vegetation	4.5.4	Irrigated vegetables & herbs	60	<0.01
2.1.0	Grazing natural vegetation	1.3.0	Other minimal uses	32	<0.01
6.3.0	River	1.1.7	Other conserved area	29	<0.01
2.1.0	Grazing natural vegetation	4.4.4	Irrigated vine fruits	24	<0.01
6.2.0	Reservoir/dam	1.1.3	National park	17	<0.01
6.1.0	Lake	1.1.3	National park	16	<0.01
2.1.0	Grazing natural vegetation	5.3.0	Manufacturing & industrial	7	<0.01
1.3.3	Residual native cover	1.3.0	Other minimal uses	3	<0.01
5.8.0	Mining	6.2.0	Reservoir/dam	3	<0.01
6.2.0	Reservoir/dam	1.1.7	Other conserved area	2	<0.01
			Total	134,294	1.03

Table 3: Summary statistics for land use changes between the years of 1999 and 2004 in the Burdekin River catchment

Accuracy assessment

1999 land use data

The original version of the 1999 dataset demonstrated an overall accuracy of 91%. Accuracy assessment was not undertaken for the improved 1999 land use data, however it is expected that the total accuracy would be in line with the 2004 map (96.4%; see below). This suggests that the revised version of the 1999 datasets represents an improvement on the original version.

2004 land use data

The 2004 land use dataset was accuracy assessed using 271 points. The total accuracy is 96.4% (0.90, 0.99) and the Kappa is 0.721 (0.468, 0.908). Values in parentheses after the estimate represent 95% posterior intervals, reflecting the uncertainty of the estimate. The estimates of total accuracy and Kappa are estimates of the overall accuracy of the map. The total accuracy is an estimate of the total area that is mapped correctly. Total accuracy can be misleading, particularly when one class dominates the others. The Kappa statistic attempts to overcome this problem by adjusting for chance agreement. A common rule of thumb suggests a value of Kappa between 0.6 and 0.8 represents moderate agreement between the map and the ground truth, a value greater than 0.8 suggests strong agreement. Values less than 0.2 suggest the map is little better than a map produced by random allocation.

Table 4 provides the error matrix for the accuracy assessment of the 2004 land use data. For each of the sample points, the true land class was determined (reference data) based on field work, aerial photograph interpretation, landholder contact or expert knowledge. These points were then compared to the mapped class (map data) and the information summarised in the error matrix. For the majority of classes, the reference data agreed with the map data. For example, 59 reference

points were identified to be *grazing natural vegetation*. For 51 of those points, the map data was also *grazing* and therefore correct. For eight of the points the map data was incorrect with three points falling onto the mapped class *services*, one point on *reservoir/dam*, one point on *river* and three points on *marsh/wetland*.

The column propn in Table 4 is the relative proportion in area of the classes that were assessed, not of the catchment as a whole. For example, *national parks* aren't assessed, so the area occupied by *national parks* is first removed from the total area before the proportions are calculated. This column will thus sum to 100%.

Sometimes points that differ between the map and the reference data are due to positional or spatial errors. Inaccurate registration of datasets is an example of spatial error. Thematic errors are the incorrect labelling of an area due to difficulties in determining the true land use in that area, or by oversight or other operational errors. Spatial errors influence thematic accuracy. The purpose here is to assess the thematic accuracy of land use data. However, the separation of spatial and thematic errors can be difficult and was not undertaken. As a result, the accuracy assessment reflects properties of the land use data as a whole.

		Reference Data																					
		Other minimal uses	Residual native cover	Grazing natural vegetation	Woody fodder plants	Cropping	Land in transition	Irrigated cropping	Irrigated sugar	Irrigated perennial horticulture	Irrigated seasonal horticulture	Intensive animal production	Residential	Services	Transport & communication	Mining	Lake	Reservoir/dam	River	Channel/aqueduct	Marsh/wetland	total	propn (%)
Map Data	Other minimal uses	**9**	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0.08
	Residual native cover	0	**16**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16	0.59
	Grazing natural vegetation	1	0	**51**	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	53	97.18
	Woody fodder plants	0	0	0	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
	Cropping	0	0	0	1	**34**	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	36	1.04
	Land in transition	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01
	Irrigated cropping	0	0	0	0	0	0	**5**	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0.02
	Irrigated sugar	0	1	0	0	0	0	0	**15**	0	0	0	0	0	0	0	0	0	0	0	0	16	0.20
	Irrigated perennial horticulture	0	0	0	0	0	0	0	0	**5**	0	0	0	0	0	0	0	0	0	0	0	5	0.00
	Irrigated seasonal horticulture	0	0	0	0	0	0	0	0	0	**7**	0	0	0	0	0	0	0	0	0	0	7	0.00
	Intensive animal production	0	0	0	0	0	0	0	0	0	0	**5**	0	0	0	0	0	0	0	0	0	5	0.00
	Residential	0	0	0	0	0	0	0	0	0	0	0	**10**	0	0	0	0	0	0	0	0	10	0.03
	Services	2	0	3	0	0	0	0	0	0	0	0	0	**5**	0	0	0	0	0	0	0	10	0.02
	Transport & communication	0	0	0	0	0	0	0	0	0	0	0	0	0	**10**	0	0	0	0	0	0	10	0.01
	Mining	0	0	0	0	0	1	0	0	0	0	0	0	0	0	**14**	0	0	0	0	0	15	0.09
	Lake	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**12**	1	2	0	0	15	0.24
	Reservoir/dam	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	**14**	0	0	0	16	0.07
	River	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**17**	0	0	18	0.35
	Channel/aqueduct	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**1**	0	1	0.00
	Marsh/wetland	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**5**	8	0.06
	Totals	12	18	59	1	34	1	6	15	5	7	5	10	6	10	15	12	15	19	1	5	256	100

Table 4: Error matrix for the Burdekin River catchment land use dataset

User's and producer's accuracies of 2004 data

User's and producer's accuracies are per-class measures of accuracy. User's accuracy for class *i* is the conditional probability that a site is correct according to the reference data collected, given it was mapped as class *i*. Producer's accuracy for class *j* is the conditional probability that the map will show a site as class *j* given its true state is class *j*. For example, the user's accuracy for class *irrigated cropping* is 0.867. If a random sample of 100 points chosen from areas on the map in this class were checked in the field, we would expect around 87 of them to be correct. This suggests that the mapped class *irrigated cropping* is approximately 87% correct. The producer's accuracy for this class is 0.502. If we randomly selected 100 sites from the field which we know to be in this class, we would expect around 50 of them to be mapped correctly. The uncertainty of the estimates is summarised by using 95% posterior intervals. For *irrigated cropping*, we can say that there is a 95% probability that the user's accuracy lies between 0.474 and 0.995. Relatively few points (5) were available to assess the accuracy of class *irrigated cropping*, and so the uncertainty is large and the intervals wide. More points (15) were available for the assessment of *nature conservation*, and so the precision is greater and the 95% interval smaller.

Class	User's			Producer's		
	50.00%	95% interval		50.00%	95% interval	
Other minimal use	0.842	0.556	0.978	0.049	0.010	0.545
Residual native cover	0.958	0.799	0.998	0.970	0.890	0.995
Grazing natural vegetation	0.967	0.896	0.995	0.998	0.997	0.999
Woody fodder plants	n/a	n/a	n/a	0.000	0.000	0.000
Cropping	0.926	0.815	0.982	1.000	0.941	1.000
Land in transition	0.000	0.000	0.000	0.000	0.000	0.000
Irrigated cropping	0.872	0.478	0.995	0.498	0.148	0.951
Irrigated sugar	0.898	0.702	0.984	1.000	0.978	1.000
Irrigated perennial horticulture	0.875	0.478	0.996	1.000	1.000	1.000
Irrigated seasonal horticultue	0.907	0.591	0.997	1.000	1.000	1.000
Intensive animal production	0.872	0.491	0.995	1.000	1.000	1.000
Residential	0.931	0.680	0.998	1.000	1.000	1.000
Services	0.453	0.188	0.730	0.733	0.312	0.987
Transport & communication	0.934	0.692	0.998	1.000	1.000	1.000
Mining	0.893	0.680	0.985	0.054	0.011	0.570
Lake	0.760	0.516	0.920	1.000	0.978	1.000
Reservoir/dam	0.834	0.619	0.958	0.838	0.504	0.993
River	0.910	0.727	0.987	0.923	0.785	0.986
Channel/aqueduct	0.513	0.026	0.976	1.000	1.000	1.000
Marsh/wetland	0.558	0.246	0.842	1.000	0.999	1.000

Table 5: User's and producer's accuracy for the Burdekin River catchment in 2004

The majority of land use classes in this catchment have been mapped accurately. The largest land use class in this catchment, *grazing natural vegetation* has been mapped with a producer's accuracy of 0.997 and user's accuracy 0f 0.967. All land use classes occupying greater than 1% of the assessed area reported both user's and producer's accuracies greater than 0.9.

Some classes with low accuracies have insufficient sample points to provide precise estimates. Producer's accuracy for *irrigated cropping* is 0.5, however from the 95% interval (0.153-0.964) we see that more sample points would be required to determine how accurate this class is. If the upper bound of the interval for either user's or producer's accuracy is less than 0.5, this can indicate a true misclassification problem, rather than one due to inadequacies in sample size.

The upper bound of the 95% interval for producer's accuracy is close to 0.5 for the two classes *other minimal use* and *mining*. The error matrix shows that *other minimal use* is occasionally incorrectly mapped as *grazing natural vegetation* or *services*. *Mining* is occasionally incorrectly mapped as *grazing natural vegetation.*

The upper bound of the 95% interval for user's accuracy is less than 50% for the class *services*. The error matrix shows that areas mapped as *services* may mistakenly include areas of *other minimal use* and *grazing natural vegetation*.

1999 to 2004 land use change data

A random sample of 35 sites were also generated from areas identified as change between the 1999 and 2004 datasets, to assess the accuracy of the change layer. The accuracy of the areas mapped as change was estimated to be 100%. There is no information available on the probability of missed change.

Metadata

Metadata documents have been produced for the improved 1999 and the 2004 land use datasets, as well as 1999 to 2004 land use change data.

Data format and availability

The land use datasets are stored in raster format (.img files) with a pixel size of 25m.

Digital copies of the 1999 land use data, the 2004 land use data and the 1999 to 2004 land use change data and the metadata documents can be obtained from the NRSc data coordinator (NRScDataCoordinator@nrm.qld.gov.au).

References

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Acknowledgements

The authors would like to acknowledge the Australian Government Department of the Environment and Heritage for facilitating the NHT funding for this project and the Queensland Department of Natural Resources, Mines and Water for providing the additional funding.

We would like to thank Bob Shepherd from the Department of Primary Industries and Fisheries, Charters Towers, for sharing his detailed local knowledge about land use in this area. We would also like to thank the local experts from the Dalrymple Landcare Committee, Kate Masters from the Burdekin Dry Tropics NRM and Nev Christianos from the Department of Natural Resources, Mines and Water, Ayr.

The authors would like to acknowledge the valuable input by the project reference group members, in particular Paul Doyle from the Department of Environment and Heritage, Rob Lesslie from the Bureau of Rural Sciences, Guy Byrne, Tim McVicar and Bradford Sherman from CSIRO, Jon Brodie from James Cook University and Anthony Morrison from the Queensland Environmental Protection Agency.

Appendix 1: ALUM classification version 6

1 Conservation and Natural Environments	2 Production from Relatively Natural Environments	3 Production from Dryland Agriculture and Plantations	4 Production from Irrigated Agriculture and Plantations	5 Intensive Uses	6 Water
1.1.0 Nature conservation	**2.1.0 Grazing natural vegetation**	**3.1.0 Plantation forestry**	**4.1.0 Irrigated plantation forestry**	**5.1.0 Intensive horticulture**	**6.1.0 Lake**
1.1.1 Strict nature reserves		3.1.1 Hardwood production	4.1.1 Irrigated hardwood production	5.1.1 Shadehouses	6.1.1 Lake - conservation
1.1.2 Wilderness area	**2.2.0 Production forestry**	3.1.2 Softwood production	4.1.2 Irrigated softwood production	5.1.2 Glasshouses	6.1.2 Lake - production
1.1.3 National park	2.2.1 Wood production	3.1.3 Other forest production	4.1.3 Irrigated other forest production	5.1.3 Glasshouses (hydroponic)	6.1.3 Lake - intensive use
1.1.4 Natural feature protection	2.2.2 Other forest production	3.1.4 Environmental	4.1.4 Irrigated environmental	**5.2.0 Intensive animal production**	**6.2.0 Reservoir/dam**
1.1.5 Habitat/species management area		**3.2.0 Grazing modified pastures**	**4.2.0 Irrigated modified pastures**	5.2.1 Dairy	6.2.1 Reservoir
1.1.6 Protected landscape		3.2.1 Native/exotic pasture mosaic	4.2.1 Irrigated woody fodder plants	5.2.2 Cattle	6.2.2 Water storage - intensive use/farm dams
1.1.7 Other conserved area		3.2.2 Woody fodder plants	4.2.2 Irrigated pasture legumes	5.2.3 Sheep	6.2.3 Evaporation basin
1.2.0 Managed resource protection		3.2.3 Pasture legumes	4.2.3 Irrigated legume/grass mixtures	5.2.4 Poultry	6.2.4 Effluent pond
1.2.1 Biodiversity		3.2.4 Pasture legume/grass mixtures	4.2.4 Irrigated sown grasses	5.2.5 Pigs	**6.3.0 River**
1.2.2 Surface water supply		3.2.5 Sown grasses	**4.3.0 Irrigated cropping**	5.2.6 Aquaculture	6.3.1 River - conservation
1.2.3 Groundwater		**3.3.0 Cropping**	4.3.1 Irrigated cereals	**5.3.0 Manufacturing and industrial**	6.3.2 River - production
1.2.4 Landscape		3.3.1 Cereals	4.3.2 Irrigated beverage & spice crops	**5.4.0 Residential**	6.3.3 River - intensive use
1.2.5 Traditional indigenous uses		3.3.2 Beverage & spice crops	4.3.3 Irrigated hay & silage	5.4.1 Urban residential	**6.4.0 Channel/aqueduct**
1.3.0 Other minimal use		3.3.3 Hay & silage	4.3.4 Irrigated oil seeds	5.4.2 Rural residential	6.4.1 Supply channel/aqueduct
1.3.1 Defence		3.3.4 Oil seeds	4.3.5 Irrigated sugar	5.4.3 Rural living	6.4.2 Drainage channel/aqueduct
1.3.2 Stock route		3.3.5 Sugar	4.3.6 Irrigated cotton	**5.5.0 Services**	**6.5.0 Marsh/wetland**
1.3.3 Residual native cover		3.3.6 Cotton	4.3.7 Irrigated tobacco	5.5.1 Commercial services	6.5.1 Marsh/wetland - conservation
1.3.4 Rehabilitation		3.3.7 Tobacco	4.3.8 Irrigated legumes	5.5.2 Public services	6.5.2 Marsh/wetland - production
		3.3.8 Legumes	**4.4.0 Irrigated perennial horticulture**	5.5.3 Recreation and culture	6.5.3 Marsh/wetland - intensive use
		3.4.0 Perennial horticulture	4.4.1 Irrigated tree fruits	5.5.4 Defence facilities	**6.6.0 Estuary/coastal waters**
		3.4.1 Tree fruits	4.4.2 Irrigated oleaginous fruits	5.5.5 Research facilities	6.6.1 Estuary/coastal waters - conservation
		3.4.2 Oleaginous fruits	4.4.3 Irrigated tree nuts	**5.6.0 Utilities**	6.6.2 Estuary/coastal waters - production
		3.4.3 Tree nuts	4.4.4 Irrigated vine fruits	5.6.1 Electricity generation/transmission	6.6.3 Estuary/coastal waters - intensive use
		3.4.4 Vine fruits	4.4.5 Irrigated shrub nuts fruits & berries	5.6.2 Gas treatment, storage and transmission	
		3.4.5 Shrub nuts fruits & berries	4.4.6 Irrigated flowers & bulbs	**5.7.0 Transport and communication**	
		3.4.6 Flowers & bulbs	4.4.7 Irrigated vegetables & herbs	5.7.1 Airports/aerodromes	
		3.4.7 Vegetables & herbs	**4.5.0 Irrigated seasonal horticulture**	5.7.2 Roads	
		3.5.0 Seasonal horticulture	4.5.1 Irrigated fruits	5.7.3 Railways	
		3.5.1 Fruits	4.5.2 Irrigated nuts	5.7.4 Ports and water transport	
		3.5.2 Nuts	4.5.3 Irrigated flowers & bulbs	5.7.5 Navigation and communication	
		3.5.3 Flowers & bulbs	4.5.4 Irrigated vegetables & herbs	**5.8.0 Mining**	
		3.5.4 Vegetables & herbs	**4.6.0 Irrigated land in transition**	5.8.1 Mines	
		3.6.0 Land in transition	4.6.1 Degraded irrigated land	5.8.2 Quarries	
		3.6.1 Degraded land	4.6.2 Abandoned irrigated land	5.8.3 Tailings	
		3.6.2 Abandoned land	4.6.3 Irrigated land under rehabilitation	**5.9.0 Waste treatment and disposal**	
		3.6.3 Land under rehabilitation	4.6.4 No defined use (irrigation)	5.9.1 Stormwater	
		3.6.4 No defined use		5.9.2 Landfill	
				5.9.3 Solid garbage	
				5.9.4 Incinerators	
				5.9.5 Sewage	

minimum level of attribution

Note that tertiary level cropping and horticulture classes (e.g. cereals and irrigated tree fruits) are attributed during the change mapping from 1999 to 2004 whenever possible. Dairies and rural residential areas are also attributed at the tertiary level.