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Mapping Land Use

Land Use Change Mapping from 1999 to 2004 for the Plane Creek Catchment

Australian Government
Bureau of Rural Sciences

Queensland Government
Natural Resources, Mines and Water

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Authors

Simone Grounds, Christian Witte and Robert Denham

(Queensland Department of Natural Resources and Water)

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Australian Government
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The Director of Product Marketing
Department of Natural Resources, Mines and Water
GPO Box 2454
BRISBANE QLD 4001
Telephone: (07) 3405 5552

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CONTACT

Queensland Department of Natural Resources and Water
Natural Resource Sciences
Block C, 80 Meiers Road
INDOOROOPILLY QLD 4068
Telephone: (07) 3896 9862
Email: NRScDataCoordinator@nrw.qld.gov.au

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Introduction

The Department of Natural Resources and Water (NRW) through the Queensland Land Use Mapping Program (QLUMP; www.nrw.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 been completed for the Fitzroy, Johnstone, Burdekin, Tully, Murray and Pioneer River catchments. This report briefly documents the methodology used for mapping land use change in the Plane Creek catchment and the various products generated:

- 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
- results of the accuracy assessment.

QLUMP is part of the Australian Collaborative Land Use Mapping Programme (ACLUMP) which is coordinated by the Bureau of Rural Sciences in Canberra with partner agencies in all states and territories. For further information on ACLUMP see www.brs.gov.au/landuse.

Catchment overview

The Plane Creek catchment is 260,189 hectares in area and is located in the north of the central Queensland coast. The area extends from southern Mackay in the north to south of Carmila where it adjoins the Fitzroy catchment. Annual rainfall in the Mackay-Whitsunday region ranges from 1000mm in inland areas to 3000mm in elevated sections of the coastal ranges (MWNRM, 2007), with Mackay's average annual rainfall being 1585mm (BOM, 2007). The catchment is managed for many land use types, with grazing and sugar cane being dominant.

Sugarcane production was the most important regional industry driving much of the growth within the catchment (EPA_1, 2007) and has resulted in much of the development of infrastructure, including ports, roads and sugar mills. In recent years, the mining sector has become a major contributor with the Department of Tourism, Regional Development and Industry (TRDI, 2007) citing the Mackay-Whitsunday region as the black coal mining capital of Queensland. Over half of Queensland's open cut mines and two of Queensland's eleven underground mines operate in the area. The port of Hay Point services the coal mines of Central Queensland and was the largest coal port, by tonnage, in the world in 2004/2005 (EPA_2, 2007).

The population in the Mackay region also continues to grow steadily with an annual average growth rate of 3.1%, which is the fastest average annual growth rate among the Queensland statistical districts outside South-east Queensland (ABS, 2007).

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
- produce an improved land use dataset for 1999 which includes more detailed attribution 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

A method for detecting and mapping land use change has been developed and applied in the Plane Creek catchment. The method follows Witte et al, 2006 and makes use of best available spatial information, satellite imagery, aerial photography, 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 minimum mapping width of 50m for linear features.

The Plane 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 - 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, Nature Refuge and State Forest data.

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 Bureau of Rural Sciences (BRS) 2006 for more detail). Regional NRW 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 in the 1999 data, cropping and horticultural areas were attributed to the secondary level with the exception of *sugar*, *irrigated sugar* and *irrigated cotton*.

A differencing algorithm was developed in the python scripting language to produce a dataset representing the land use change (eg. from *grazing natural vegetation* to *cropping*) between 1999 and 2004.

An independent validation was undertaken for the improved 1999 and 2004 land use map and the land use change layer using a stratified random sample to assess thematic (attribute) accuracy based on 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 (e.g. *national parks*) were generally not assessed. Classes which are small in total area (<10,000ha) and do not occur frequently (<10 polygons) were also not sampled, but the polygons were checked using imagery, aerial 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. Any points which could not be confidently classified were not used in the accuracy assessment.

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 1999 and Figure 2 the 2004 land use data for the Plane catchment using the secondary level of the ALUM classification (see Appendix 1 for the classification).

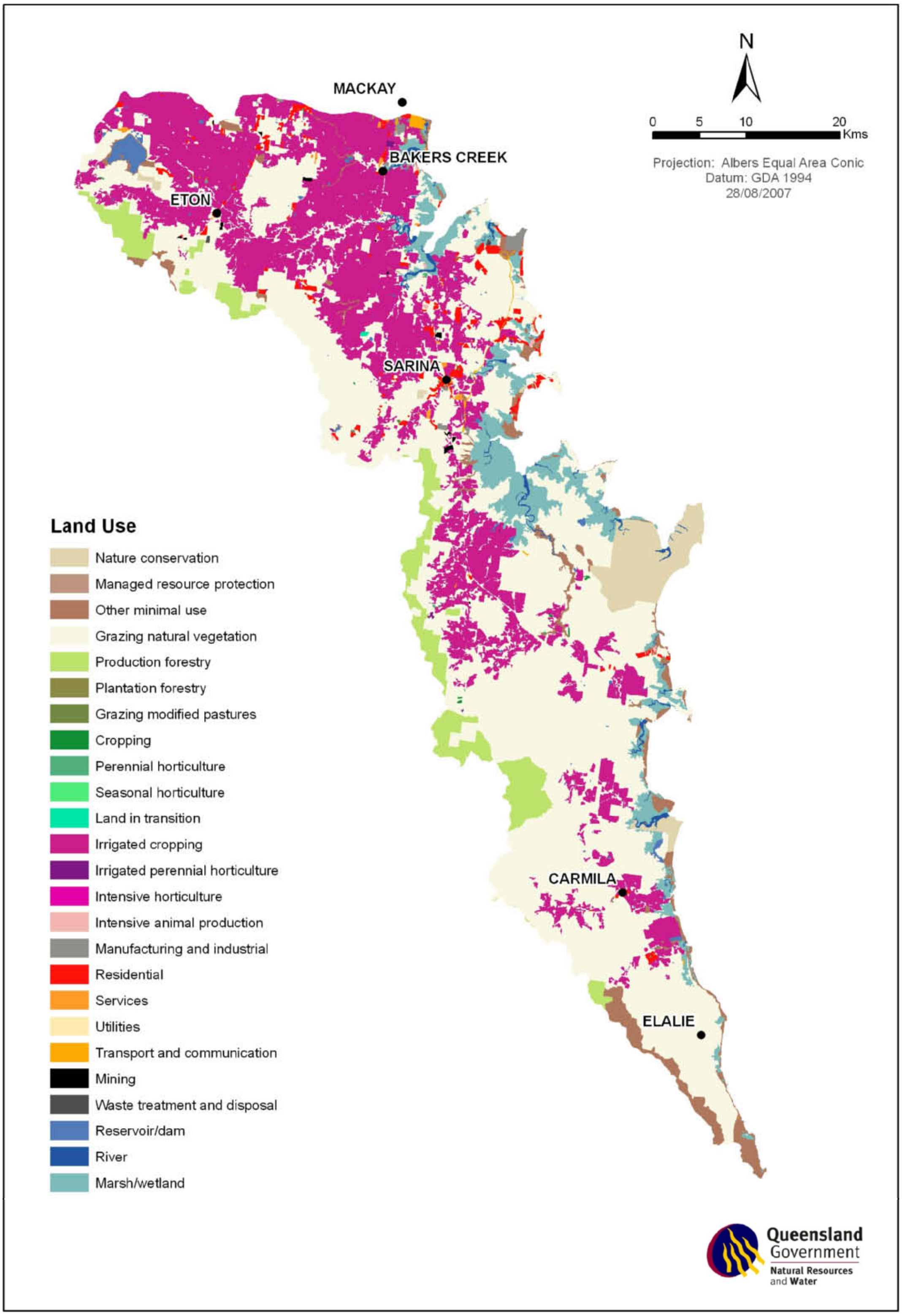

Figure 1: 1999 land use map for the Plane Creek catchment

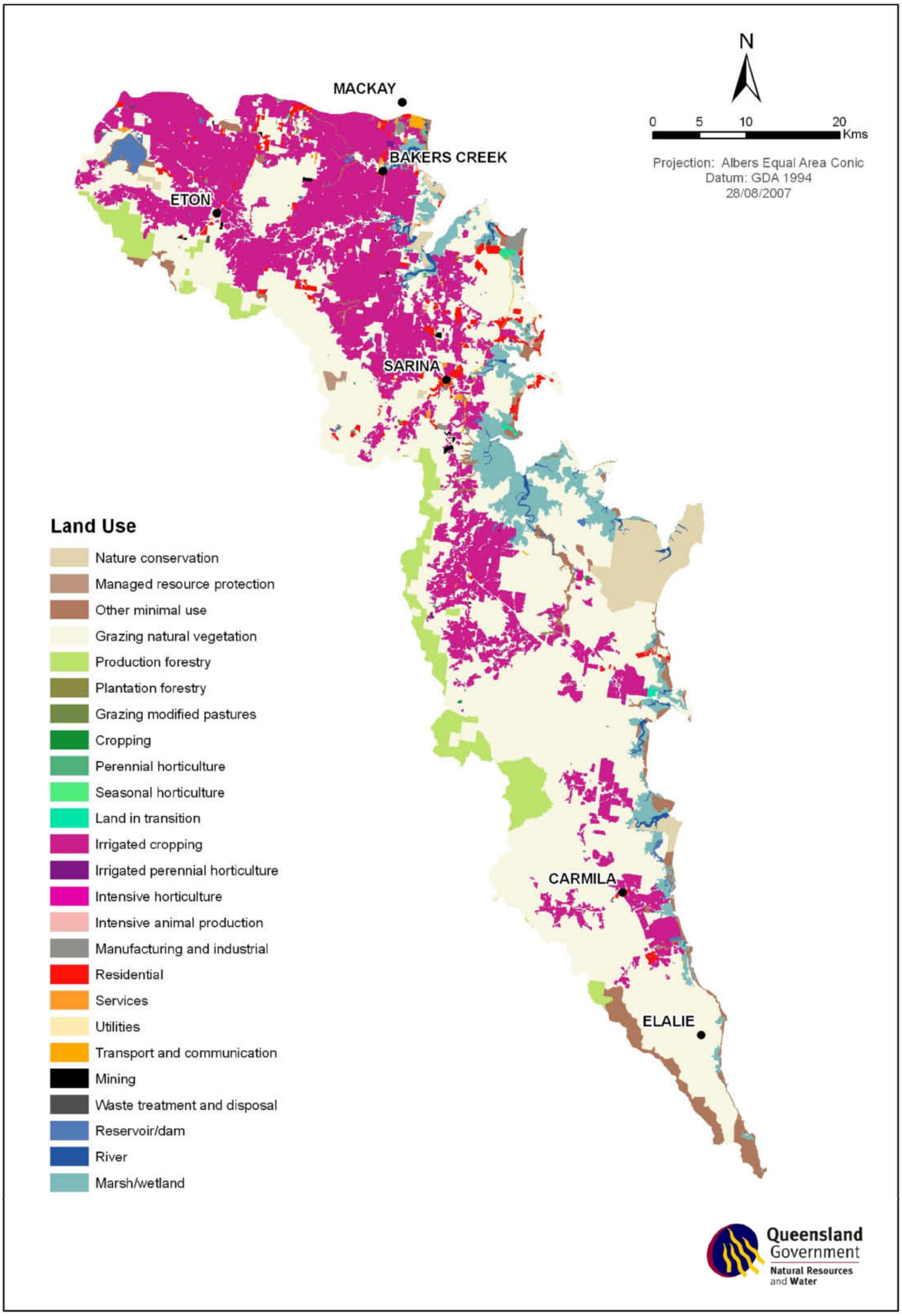

Figure 2: 2004 land use map for the Plane Creek catchment

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 Figures 1 and 2.

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	17,335	6.84
1.1	Nature conservation	8,254	3.25
1.3	Other minimal use	9,081	3.58
2	Production from relatively natural environments	140,625	55.44
2.1	Grazing natural vegetation	128,175	50.54
2.2	Production forestry	12,450	4.91
3	Production from dryland agriculture and plantations	200	0.08
3.3	Cropping	71	0.03
3.4	Perennial horticulture	80	0.03
3.5	Seasonal horticulture	5	0.00
3.6	Land in transition	44	0.02
4	Production from irrigated agriculture and plantations	71,033	28.01
4.3	Irrigated cropping	70,875	27.94
4.3.5	Irrigated sugar*	70,780	27.91
4.4	Irrigated perennial horticulture	133	0.05
4.6	Irrigated land in transition	25	0.01
5	Intensive uses	5,871	2.32
5.1	Intensive horticulture	1	0.00
5.2	Intensive animal production	142	0.06
5.3	Manufacturing and industrial	742	0.29
5.4	Residential	3,761	1.48
5.5	Services	474	0.19
5.6	Utilities	10	0.00
5.7	Transport and communication	418	0.17
5.8	Mining	246	0.10
5.9	Waste treatment and disposal	77	0.03
6	Water	18,568	7.32
6.2	Reservoir/dam	1,824	0.72
6.3	River	1,725	0.68
6.5	Marsh/wetland	15,019	5.92
	Grand total	253,631	100.00

* The area of *irrigated sugar* is a subset of the total area of *irrigated cropping*.

Table 1: Summary statistics of land uses in 1999 in the Plane Creek catchment

Land Use Code	Land Use Classes	Area ha	Area %
1	Conservation and natural environments	18,254	7.20
1.1	Nature conservation	9,059	3.57
1.2	Managed Resource Protection	419	0.17
1.3	Other minimal use	8,776	3.46
2	Production from relatively natural environments	139,892	55.16
2.1	Grazing natural vegetation	127,443	50.25
2.2	Production forestry	12,450	4.91
3	Production from dryland agriculture and plantations	437	0.17
3.1	Plantation forestry	6	0.00
3.3	Cropping	42	0.02
3.4	Perennial horticulture	75	0.03
3.5	Seasonal horticulture	19	0.01
3.6	Land in transition	295	0.12
4	Production from irrigated agriculture and plantations	71,222	28.08
4.3	Irrigated cropping	71,083	28.03
4.3.5	Irrigated sugar	71,071	28.02
4.4	Irrigated perennial horticulture	139	0.06
5	Intensive uses	5,960	2.35
5.1	Intensive horticulture	1	0.00
5.2	Intensive animal production	142	0.06
5.3	Manufacturing and industrial	748	0.30
5.4	Residential	3,805	1.50
5.5	Services	497	0.20
5.6	Utilities	10	0.00
5.7	Transport and communication	420	0.17
5.8	Mining	247	0.10
5.9	Waste treatment and disposal	89	0.04
6	Water	17,865	7.04
6.2	Reservoir/dam	1,831	0.72
6.3	River	1,725	0.68
6.5	Marsh/wetland	14,309	5.64
	Grand total	253,631	100.00

* The area of *irrigated sugar* is a subset of the total area of *irrigated cropping*.

Table 2: Summary statistics of land uses in 2004 in the Plane Creek catchment

Data limitations

The ALUM class *grazing modified pasture* has not specifically been mapped separately from *grazing natural vegetation* due to the difficulty in identifying and separating these classes using imagery, aerial photography and field observation.

Land uses that include linear features (e.g. roads and railways) are generally not mappable at the minimum mapping scale of 1:50,000 and minimum mapping width of 50m. Area estimates of these linear features therefore represent only a small proportion of the actual area of these land use classes. This is of relevance to the following land use classes:

- *transport* and *communication*
- *utilities*

The 1999 and 2004 land use datasets are both a snapshot in time showing what was considered the main land use, or primary management objective of the land manager, for each of those years. However, some effort was given to distinguish between an actual land use change and a rotation. For example, an area of cropping that did not appear to be under crop in the year of interest was often still mapped as cropping, as this was not considered an actual land use change, but rather a rotation, with the primary management objective likely to 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 on one date and either absent or of differing extent in imagery on 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-related features.

Please refer to the metadata for details on the mapping of specific classes.

1999 to 2004 land use change data

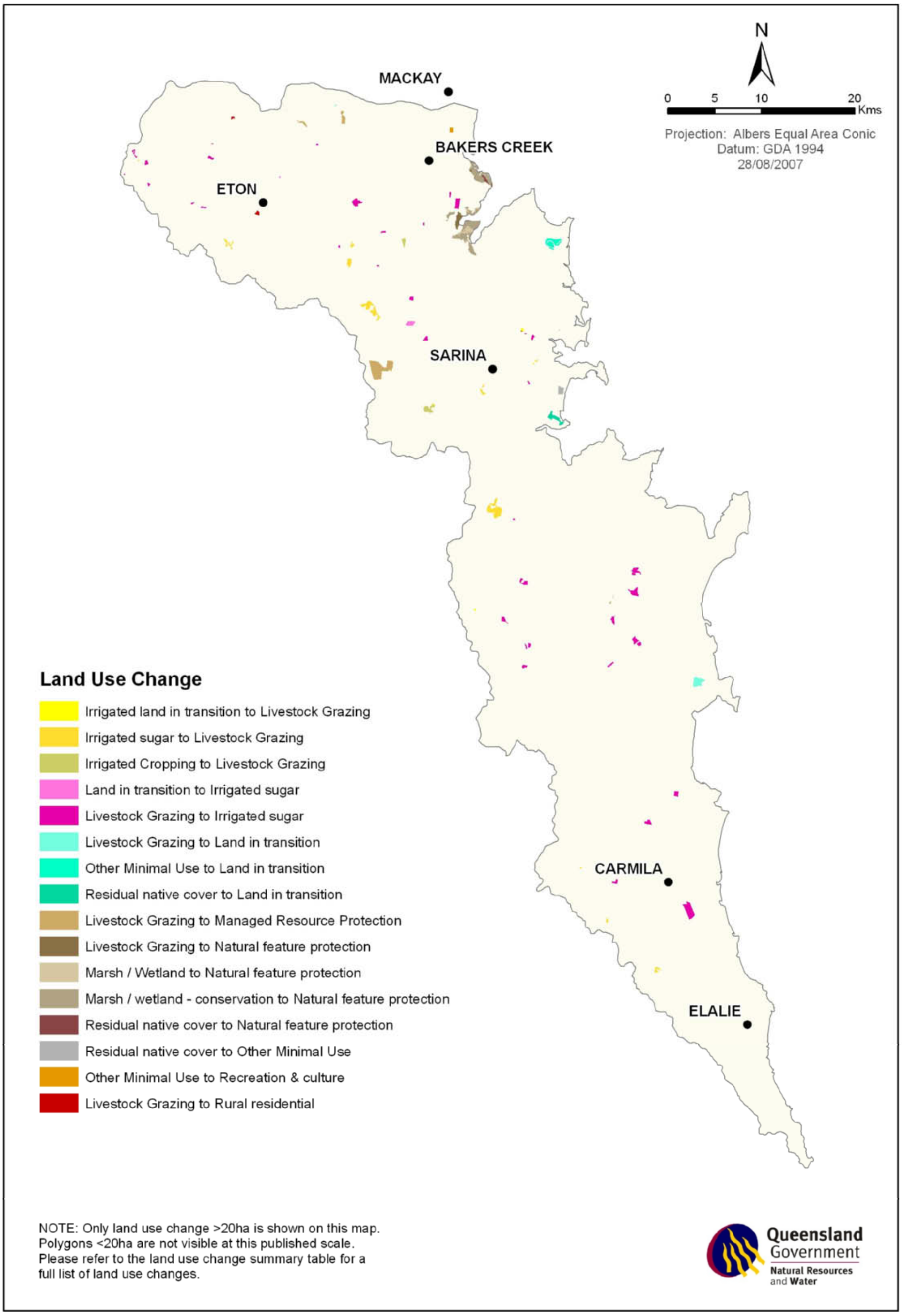

Figure 3: 1999 - 2004 land use change map for the Plane Creek catchment

The total area of land use change from 1999 to 2004 in the Plane Creek catchment is 3,049 ha or 1.20% of the catchment. A breakdown of the change classes by area is shown in Table 3. The major changes are from the classes *grazing natural vegetation* to *irrigated sugar* (708 ha), *marsh/wetland conservation* to *natural feature protection* (547 ha), *irrigated sugar* to *grazing natural vegetation* (424 ha), *grazing natural vegetation* to *managed resource protection* (376 ha) and *marsh/wetland* to *natural feature protection* (135 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	4.3.5	Irrigated sugar	708	0.28
6.5.1	Marsh/wetland - conservation	1.1.4	Natural feature protection	547	0.22
4.3.5	Irrigated sugar	2.1.0	Grazing Natural Vegetation	424	0.17
2.1.0	Grazing Natural Vegetation	1.2.0	Managed Resource Protection	376	0.15
6.5.0	Marsh/wetland	1.1.4	Natural feature protection	136	0.05
1.3.0	Other Minimal Use	3.6.0	Land in transition	114	0.04
2.1.0	Grazing Natural Vegetation	3.6.0	Land in transition	91	0.04
2.1.0	Grazing Natural Vegetation	1.1.4	Natural feature protection	88	0.03
4.3.0	Irrigated Cropping	2.1.0	Grazing Natural Vegetation	83	0.03
1.3.3	Residual native cover	3.6.0	Land in transition	76	0.03
1.3.3	Residual native cover	1.3.0	Other Minimal Use	44	0.02
3.6.0	Land in transition	4.3.5	Irrigated sugar	40	0.02
1.3.3	Residual native cover	1.1.4	Natural feature protection	27	0.01
2.1.0	Grazing Natural Vegetation	5.4.2	Rural residential	26	0.01
1.3.0	Other Minimal Use	5.5.3	Recreation & culture	23	0.01
1.3.0	Other Minimal Use	2.1.0	Grazing Natural Vegetation	17	0.01
3.3.0	Cropping	2.1.0	Grazing Natural Vegetation	15	0.01
1.3.3	Residual native cover	2.1.0	Grazing Natural Vegetation	15	0.01
2.1.0	Grazing Natural Vegetation	3.5.2	Nuts	15	0.01
3.3.0	Cropping	4.3.5	Irrigated sugar	14	0.01
6.5.1	Marsh/wetland - conservation	1.2.0	Managed Resource Protection	13	0.01
4.6.0	Irrigated land in transition	2.1.0	Grazing Natural Vegetation	12	<0.01
1.3.0	Other Minimal Use	1.2.0	Managed Resource Protection	12	<0.01
4.3.5	Irrigated sugar	5.9.0	Waste Treatment and Disposal	12	<0.01
6.5.0	Marsh/wetland	1.2.0	Managed Resource Protection	10	<0.01
4.3.5	Irrigated sugar	3.6.0	Land in transition	9	<0.01
1.3.3	Residual native cover	1.2.0	Managed Resource Protection	9	<0.01
4.3.5	Irrigated sugar	5.4.1	Urban residential	9	<0.01
4.6.0	Irrigated land in transition	4.3.5	Irrigated sugar	8	<0.01
4.4.1	Irrigated tree fruits	2.1.0	Grazing Natural Vegetation	8	<0.01
4.3.5	Irrigated sugar	6.2.0	Reservoir/dam	8	<0.01
4.3.5	Irrigated sugar	4.4.5	Irrigated shrub nuts fruits & berries	7	<0.01
4.3.5	Irrigated sugar	5.3.0	Manufacturing & Industrial	6	<0.01
1.3.3	Residual native cover	5.4.0	Residential	6	<0.01
4.3.5	Irrigated sugar	3.1.0	Plantation Forestry	5	<0.01
4.3.5	Irrigated sugar	5.4.0	Residential	5	<0.01
3.4.0	Perennial Horticulture	5.7.0	Transport & Communication	5	<0.01
4.6.0	Irrigated land in transition	4.4.5	Irrigated shrub nuts fruits & berries	4	<0.01
4.4.1	Irrigated tree fruits	4.3.5	Irrigated sugar	4	<0.01
1.3.0	Other Minimal Use	1.1.4	Natural feature protection	4	<0.01
2.1.0	Grazing Natural Vegetation	4.4.1	Irrigated tree fruits	3	<0.01
5.4.2	Rural residential	4.4.1	Irrigated tree fruits	3	<0.01
5.7.0	Transport & Communication	2.1.0	Grazing Natural Vegetation	2	<0.01
2.1.0	Grazing Natural Vegetation	1.3.0	Other Minimal Use	2	<0.01
4.3.5	Irrigated sugar	4.4.1	Irrigated tree fruits	1	<0.01
6.2.0	Reservoir/dam	2.1.0	Grazing Natural Vegetation	1	<0.01
2.1.0	Grazing Natural Vegetation	5.8.2	Quarries	1	<0.01
2.1.0	Grazing Natural Vegetation	5.4.0	Residential	1	<0.01
Total				3049	1.20

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

Accuracy assessment

The accuracy assessment provided reference data suitable for assessing the 1999 and 2004 land use maps and the map describing the change in land use between these two dates. For each of the sample points, the true land class was determined (reference data) based on landholder survey, 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. The accuracy is summarised in terms of total accuracy, the Kappa statistic and user's and producer's accuracies. Each accuracy parameter is reported using a point estimate and a 95% posterior interval. Accuracy figures are provided as probabilities between 0 and 1. A value of 1 suggests that the map or specific land use class is 100% accurate based on the reference data.

Total accuracy provides an estimate of the overall accuracy of the map and can be expressed as the probability that a point is mapped correctly. However, it 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.

User's and producer's accuracies are *per-class* measures of accuracy. User's accuracy for class *A* is the probability that a point mapped as *A* is truly in class *A*. If we estimated the user's accuracy of class *A* to be 0.91, then from a random sample of 100 points chosen from areas on the map in this class, around 91 would be found to be correct when checked in the field. Producer's accuracy for class *B* is the conditional probability that the map will show a site as class *B* given its true state is class *B*. If the producer's accuracy for class *B* were 0.85, then from a random sample of 100 points known to be in class *B* around 85 would also be in class *B* according to the map. An accurate map should have high user's and producer's accuracies.

Within the user and producer accuracy assessment, the per-class estimates of accuracy are often not very precise, since only part of the total sample points are used to estimate them. As a guide, 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.

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 can 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 has not been undertaken. As a result, the accuracy assessment reflects properties of the land use data as a whole.

1999 improved land use data

The original version of the 1999 dataset for the Plane Creek catchment demonstrated an overall accuracy of 0.80. Accuracy assessment was undertaken for the improved 1999 land use data using 270 points. The estimated overall accuracy for the improved 1999 data is 0.93 using an informative prior with a 95% posterior interval of (0.88, 0.96). The Kappa statistic is 0.90 (0.83, 0.94).

The analysis used an informative prior for the classes *national park* and *natural feature protection*. These features are not targeted for sampling (although occasionally points do fall into these mapped classes). When low sampling intensities are used within a class, the precision of the estimate is also low. In the case of *national park* and *natural feature protection* we have high confidence that these are rarely incorrectly mapped, and a prior which reflects this confidence is used. The strength of the prior is equivalent to placing 10 additional points within these two classes, and increases the precision of the estimates of these classes. When these classes make up a large proportion of the total map there will be a corresponding increase in precision for the overall summaries. A non-informative prior is used for all other classes.

Table 4 shows the error matrix for the accuracy assessment of the 1999 land use data. For the majority of classes, the reference data agreed with the map data. For example, 111 reference points were identified to be *grazing natural vegetation*. For 99 of those points, the map data was also *grazing* and therefore correct. For 12 *grazing* points, the map data was incorrect with the following misclassification: *perennial horticulture* (2 points), *residential* (2), *mining* (3), *reservoir/dam* (1) and *marsh/wetland* (4).

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. The areas of other classes that are not amenable to assessment, for example, nature conservation classes, are removed from the total area before the proportions are calculated. This column will thus sum to 100%.

Table 5 shows the user's and producer's accuracy. The majority of land use classes in this catchment have been mapped accurately. The largest assessable land use class in this catchment is *grazing natural vegetation* which has been mapped with a high user's and producer's accuracy. The user's accuracy is 0.92 and there is a 95% probability that the user's accuracy lies between 0.86 and 0.96. Likewise the producer's accuracy is 0.98 with a 95% confidence interval of 0.95 and 0.99. The next largest class by area is *irrigated sugar* with user's and producer's accuracies of 1.00 and 0.98 respectively, indicating that the map represents these classes very well.

Some classes with low accuracies have insufficient sample points to provide precise estimates. The user's accuracy for *irrigated perennial horticulture* is 0.85, however, from the 95% interval (0.49, 0.99) we see that more sample points would be required to confidently determine how accurate this class is.

		Reference Data																	
		National Park	Other conserved area	Other minimal use	Grazing natural vegetation	Production forestry	Perennial Horticulture	Irrigated sugar	Irrigated Perennial Horticulture	Manufacturing \& Industrial	Residential	Services	Transport & Communication	Mining	Reservoir/dam	River	Marsh/wetland	**total**	prop (%)
Map Data	National Park	**1**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3.05
	Other conserved area	0	**3**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0.04
	Other minimal use	0	0	**9**	0	0	0	0	0	0	0	0	0	0	0	0	1	10	3.99
	Grazing natural vegetation	0	0	5	**99**	0	0	1	0	0	1	0	0	0	0	0	1	107	50.4
	Production forestry	0	0	0	0	**10**	0	0	0	0	0	0	0	0	0	0	0	10	5.22
	Perennial Horticulture	0	0	0	2	0	**0**	0	2	0	3	0	0	0	0	0	0	7	0.03
	Irrigated sugar	0	0	0	0	0	0	**23**	0	0	0	0	0	0	0	0	0	23	27.7
	Irrigated Perennial Horticulture	0	0	0	0	0	0	1	**6**	0	0	0	0	0	0	0	0	7	0.05
	Manufacturing & Industrial	0	0	1	0	0	0	0	0	**4**	0	0	3	0	0	0	0	8	0.31
	Residential	0	0	0	2	0	0	0	0	0	**8**	0	0	0	0	0	0	10	1.49
	Services	0	1	0	0	0	0	0	0	0	1	**8**	0	0	0	0	0	10	0.2
	Transport & Communication	0	0	0	0	0	0	0	0	0	0	0	**10**	0	0	0	0	10	0.17
	Mining	0	3	1	3	0	0	0	0	0	0	0	0	**4**	0	0	0	11	0.1
	Reservoir/dam	0	0	0	1	0	0	1	0	0	0	0	0	0	**7**	0	1	10	0.71
	River	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**9**	2	11	0.71
	Marsh/wetland	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	**28**	32	5.89
	total	1	7	16	111	10	0	26	8	4	13	8	13	4	7	9	33	270	100

Table 4: Error matrix for the Plane Creek catchment 1999 land use dataset

Class	User's				Producer's		
	50%	95% interval			50%	95% interval	
National Park	1.00	0.78	1.00		1.00	0.80	1.00
Other conserved area	0.85	0.56	1.00		0.35	0.03	0.67
Other minimal use	0.89	0.61	1.00		0.60	0.39	0.80
Grazing natural vegetation	0.92	0.86	0.96		0.98	0.95	0.99
Production forestry	1.00	0.78	1.00		1.00	0.88	1.00
Perennial Horticulture	0.00	0.00	0.04		0.00	0.00	0.09
Irrigated sugar	1.00	0.90	1.00		0.98	0.94	1.00
Irrigated Perennial Horticulture	0.85	0.49	0.99		0.78	0.05	0.96
Manufacturing & Industrial	0.48	0.17	0.80		1.00	0.14	1.00
Residential	0.79	0.48	0.96		0.73	0.34	0.96
Services	0.79	0.49	0.96		1.00	0.17	1.00
Transport & Communication	1.00	0.77	1.00		0.55	0.17	0.83
Mining	0.34	0.11	0.64		1.00	0.04	1.00
Reservoir/dam	0.69	0.38	0.92		1.00	0.39	1.00
River	0.81	0.52	0.97		1.00	0.44	1.00
Marsh/wetland	0.87	0.73	0.96		0.84	0.65	0.95

Table 5: Users and producer's accuracy for the Plane Creek catchment 1999 land use dataset

2004 land use data

The accuracy of the 2004 land use dataset was assessed using 272 points. The informative prior total accuracy is 0.93 (0.87, 0.96) and the Kappa is 0.90 (0.82, 0.94). An explanation for the informative prior is provided in the description of the '1999 Land Use Data' accuracy assessment. Table 6 provides the error matrix for the accuracy assessment of the 2004 land use data. For the majority of classes, the reference data agreed with the map data. For example, 108 reference points were identified to be *grazing natural vegetation*. For 96 of those points, the map data was also *grazing* and therefore correct. For 14 *grazing* points, the map data was incorrect with the following misclassification: *perennial horticulture* (4 points), *residential* (2), *mining* (3), *reservoir/dam* (1) and *marsh/wetland* (4).

Table 7 display's the user's and producer's accuracy. The majority of land use classes in the Plane catchment have been mapped accurately for 2004. The two largest assessable land use classes in this catchment have been mapped with a high user's and producer's accuracy: *grazing natural vegetation* 0.92 and 0.98; and *irrigated sugar,* 1.00 and 0.98, respectively. The next major class by area is *marsh/wetland* with user's and producer's accuracies of 0.87 and 0.82 respectively. The accuracy values for *mining*, 0.34 and 1.00, suggest that some areas of *mining* have been mapped incorrectly. Table 6 shows that some *mining* areas have been misclassified and should have been classified as *other conserved area* (specifically mining, quarry or gravel reserves; three points misclassified) or *grazing natural vegetation* (three points misclassified).

As was the case for the 1999 dataset, some classes in the 2004 dataset with low accuracies have insufficient sample points to provide precise estimates. User's accuracy for *manufacturing and industrial* is low at 0.47, however from the 95% interval (0.18, 0.79) we see that more sample points would be required to confidently determine how accurate this class is. Similarly, *reservoir/dam* has a moderate user's accuracy of 0.68 and a wide confidence intervals (0.37, 0.91).

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. This is demonstrated by the *perennial horticulture* class which has a very poor accuracy of 0.00. *Perennial horticulture* had seven accuracy assessment points assigned, two of these were actually *grazing natural vegetation,* two were *irrigated perennial horticulture* and three were *residential* (rural residential at the tertiary level). In this instance, this result may be partially explained by rural residential blocks often having a tree crop planted (e.g. lychees) – which can raise uncertainty about the primary land use. Similarly, differentiating between perennial horticulture and irrigated perennial horticulture can be subjective.

		Reference Data																			
		National Park	Natural feature protection	Other conserved area	Managed resource protection	Other minimal use	Grazing natural vegetation	Production forestry	Perennial Horticulture	Irrigated sugar	Irrigated Perennial Horticulture	Manufacturing \& Industrial	Residential	Services	Transport & Communication	Mining	Reservoir/dam	River	Marsh/wetland	**total**	proprotion (%)
Map Data	National Park	**1**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3.03
	Natural feature protection	0	**1**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.47
	Other conserved area	0	0	**3**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0.18
	Managed resource protection	0	0	0	**5**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0.00
	Other minimal use	0	0	0	0	**8**	0	0	0	0	0	0	0	0	0	0	0	0	1	9	3.85
	Grazing natural vegetation	0	0	0	0	5	**96**	0	0	1	0	0	1	0	0	0	0	0	1	104	50.30
	Production forestry	0	0	0	0	0	0	**11**	0	0	0	0	0	0	0	0	0	0	0	11	5.20
	Perennial Horticulture	0	0	0	0	0	2	0	**0**	0	2	0	3	0	0	0	0	0	0	7	0.03
	Irrigated sugar	0	0	0	0	0	0	0	0	**21**	0	0	0	0	0	0	0	0	0	21	27.62
	Irrigated Perennial Horticulture	0	0	0	0	0	0	0	0	1	**8**	0	0	0	0	0	0	0	0	9	0.06
	Manufacturing & Industrial	0	0	0	0	1	0	0	0	0	0	**4**	0	0	3	0	0	0	0	8	0.31
	Residential	0	0	0	0	0	2	0	0	0	0	0	**8**	0	0	0	0	0	0	10	1.50
	Services	0	0	1	0	0	0	0	0	0	0	0	1	**8**	0	0	0	0	0	10	0.21
	Transport & Communication	0	0	0	0	0	0	0	0	0	0	0	0	0	**10**	0	0	0	0	10	0.17
	Mining	0	0	3	0	1	3	0	0	0	0	0	0	0	0	**4**	0	0	0	11	0.10
	Reservoir/dam	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	**7**	0	1	10	0.71
	River	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**9**	2	11	0.71
	Marsh/wetland	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	**27**	31	5.57
	total	1	1	7	5	15	108	11	0	24	10	4	13	8	13	4	7	9	32	272	100

Table 6: Error matrix for the Plane Creek catchment 2004 land use dataset

Class	User's				Producer's		
	50%	2.50%	97.50%		50%	2.50%	97.50%
National Park	1.00	0.77	1.00		1.00	0.81	1.00
Natural feature protection	0.96	0.71	1.00		1.00	0.37	1.00
Other conserved area	1.00	0.40	1.00		0.37	0.03	0.69
Managed resource protection	1.00	0.57	1.00		1.00	0.16	1.00
Other minimal use	0.88	0.58	0.99		0.58	0.38	0.79
Grazing natural vegetation	0.92	0.86	0.96		0.98	0.95	0.99
Production forestry	1.00	0.78	1.00		1.00	0.88	1.00
Perennial Horticulture	0.00	0.00	0.03		0.00	0.00	0.05
Irrigated sugar	1.00	0.88	1.00		0.98	0.93	1.00
Irrigated Perennial Horticulture	0.88	0.57	0.99		0.80	0.06	0.97
Manufacturing & Industrial	0.48	0.17	0.79		1.00	0.16	1.00
Residential	0.79	0.48	0.96		0.72	0.35	0.96
Services	0.79	0.48	0.96		1.00	0.17	1.00
Transport & Communication	1.00	0.77	1.00		0.55	0.16	0.82
Mining	0.34	0.12	0.63		1.00	0.04	1.00
Reservoir/dam	0.69	0.37	0.91		1.00	0.39	1.00
River	0.81	0.51	0.97		1.00	0.43	1.00
Marsh/wetland	0.87	0.71	0.96		0.82	0.63	0.94

Table 7: User's and producer's accuracy for the Plane Creek catchment 2004 land use dataset

1999 to 2004 land use change data

The accuracy of the change layer was assessed using the 270 points. Approximately 1.20% of the catchment was mapped as having had a change in land use between 1999 and 2004.

The accuracy of the areas mapped as change was estimated to be 0.998 with a 95% confidence interval of (0.99, 1.00).

Table 8 displays the user's and producer's accuracy for the change mapping. The accuracy of the areas mapped as change was estimated to be 0.95 with a 95% confidence interval of (0.71, 1.00). It's likely that 5% of the area mapped as change did not actually change.

There is a high probability that areas mapped as non-change actually did not change (1.00) with a 95% posterior interval of (1.00, 1.00). Further, areas that did not change based on the reference data have a high probability of being mapped correctly (1.00) with a 95% posterior interval of (0.99, 1.00).

Data	User's			Producer's		
	50.00%	2.50%	97.50%	50.00%	2.50%	97.50%
Change	0.95	0.72	1.00	1.00	0.96	1.00
No Change	1.00	1.00	1.00	1.00	1.00	1.00

Table 8: User's and producer's accuracy for the Plane Creek catchment 1999 to 2004 land use change dataset

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@nrw.qld.gov.au).

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Appendix 1: ALUM classification version 6

1 Conservation and Natural Environments

- **1.1.0 Nature conservation**
  - 1.1.1 Strict nature reserves
  - 1.1.2 Wilderness area
  - 1.1.3 National park
  - 1.1.4 Natural feature protection
  - 1.1.5 Habitat/species management area
  - 1.1.6 Protected landscape
  - 1.1.7 Other conserved area
- **1.2.0 Managed resource protection**
  - 1.2.1 Biodiversity
  - 1.2.2 Surface water supply
  - 1.2.3 Groundwater
  - 1.2.4 Landscape
  - 1.2.5 Traditional indigenous uses
- **1.3.0 Other minimal use**
  - 1.3.1 Defence
  - 1.3.2 Stock route
  - 1.3.3 Residual native cover
  - 1.3.4 Rehabilitation

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.

2 Production from Relatively Natural Environments

- **2.1.0 Grazing natural vegetation**
- **2.2.0 Production forestry**
  - 2.2.1 Wood production
  - 2.2.2 Other forest production

3 Production from Dryland Agriculture and Plantations

- **3.1.0 Plantation forestry**
  - 3.1.1 Hardwood production
  - 3.1.2 Softwood production
  - 3.1.3 Other forest production
  - 3.1.4 Environmental
- **3.2.0 Grazing modified pastures**
  - 3.2.1 Native/exotic pasture mosaic
  - 3.2.2 Woody fodder plants
  - 3.2.3 Pasture legumes
  - 3.2.4 Pasture legume/grass mixtures
  - 3.2.5 Sown grasses
- **3.3.0 Cropping**
  - 3.3.1 Cereals
  - 3.3.2 Beverage & spice crops
  - 3.3.3 Hay & silage
  - 3.3.4 Oil seeds
  - 3.3.5 Sugar
  - 3.3.6 Cotton
  - 3.3.7 Tobacco
  - 3.3.8 Legumes
- **3.4.0 Perennial horticulture**
  - 3.4.1 Tree fruits
  - 3.4.2 Oleaginous fruits
  - 3.4.3 Tree nuts
  - 3.4.4 Vine fruits
  - 3.4.5 Shrub nuts fruits & berries
  - 3.4.6 Flowers & bulbs
  - 3.4.7 Vegetables & herbs
- **3.5.0 Seasonal horticulture**
  - 3.5.1 Fruits
  - 3.5.2 Nuts
  - 3.5.3 Flowers & bulbs
  - 3.5.4 Vegetables & herbs
- **3.6.0 Land in transition**
  - 3.6.1 Degraded land
  - 3.6.2 Abandoned land
  - 3.6.3 Land under rehabilitation
  - 3.6.4 No defined use

4 Production from Irrigated Agriculture and Plantations

- **4.1.0 Irrigated plantation forestry**
  - 4.1.1 Irrigated hardwood production
  - 4.1.2 Irrigated softwood production
  - 4.1.3 Irrigated other forest production
  - 4.1.4 Irrigated environmental
- **4.2.0 Irrigated modified pastures**
  - 4.2.1 Irrigated woody fodder plants
  - 4.2.2 Irrigated pasture legumes
  - 4.2.3 Irrigated legume/grass mixtures
  - 4.2.4 Irrigated sown grasses
- **4.3.0 Irrigated cropping**
  - 4.3.1 Irrigated cereals
  - 4.3.2 Irrigated beverage & spice crops
  - 4.3.3 Irrigated hay & silage
  - 4.3.4 Irrigated oil seeds
  - 4.3.5 Irrigated sugar
  - 4.3.6 Irrigated cotton
  - 4.3.7 Irrigated tobacco
  - 4.3.8 Irrigated legumes
- **4.4.0 Irrigated perennial horticulture**
  - 4.4.1 Irrigated tree fruits
  - 4.4.2 Irrigated oleaginous fruits
  - 4.4.3 Irrigated tree nuts
  - 4.4.4 Irrigated vine fruits
  - 4.4.5 Irrigated shrub nuts fruits & berries
  - 4.4.6 Irrigated flowers & bulbs
  - 4.4.7 Irrigated vegetables & herbs
- **4.5.0 Irrigated seasonal horticulture**
  - 4.5.1 Irrigated fruits
  - 4.5.2 Irrigated nuts
  - 4.5.3 Irrigated flowers & bulbs
  - 4.5.4 Irrigated vegetables & herbs
- **4.6.0 Irrigated land in transition**
  - 4.6.1 Degraded irrigated land
  - 4.6.2 Abandoned irrigated land
  - 4.6.3 Irrigated land under rehabilitation
  - 4.6.4 No defined use (irrigation)

5 Intensive Uses

- **5.1.0 Intensive horticulture**
  - 5.1.1 Shadehouses
  - 5.1.2 Glasshouses
  - 5.1.3 Glasshouses (hydroponic)
- **5.2.0 Intensive animal production**
  - 5.2.1 Dairy
  - 5.2.2 Cattle
  - 5.2.3 Sheep
  - 5.2.4 Poultry
  - 5.2.5 Pigs
  - 5.2.6 Aquaculture
- **5.3.0 Manufacturing and industrial**
- **5.4.0 Residential**
  - 5.4.1 Urban residential
  - 5.4.2 Rural residential
  - 5.4.3 Rural living
- **5.5.0 Services**
  - 5.5.1 Commercial services
  - 5.5.2 Public services
  - 5.5.3 Recreation and culture
  - 5.5.4 Defence facilities
  - 5.5.5 Research facilities
- **5.6.0 Utilities**
  - 5.6.1 Electricity generation/transmission
  - 5.6.2 Gas treatment, storage and transmission
- **5.7.0 Transport and communication**
  - 5.7.1 Airports/aerodromes
  - 5.7.2 Roads
  - 5.7.3 Railways
  - 5.7.4 Ports and water transport
  - 5.7.5 Navigation and communication
- **5.8.0 Mining**
  - 5.8.1 Mines
  - 5.8.2 Quarries
  - 5.8.3 Tailings
- **5.9.0 Waste treatment and disposal**
  - 5.9.1 Stormwater
  - 5.9.2 Landfill
  - 5.9.3 Solid garbage
  - 5.9.4 Incinerators
  - 5.9.5 Sewage

6 Water

- **6.1.0 Lake**
  - 6.1.1 Lake - conservation
  - 6.1.2 Lake - production
  - 6.1.3 Lake - intensive use
- **6.2.0 Reservoir/dam**
  - 6.2.1 Reservoir
  - 6.2.2 Water storage - intensive use/farm dams
  - 6.2.3 Evaporation basin
  - 6.2.4 Effluent pond
- **6.3.0 River**
  - 6.3.1 River - conservation
  - 6.3.2 River - production
  - 6.3.3 River - intensive use
- **6.4.0 Channel/aqueduct**
  - 6.4.1 Supply channel/aqueduct
  - 6.4.2 Drainage channel/aqueduct
- **6.5.0 Marsh/wetland**
  - 6.5.1 Marsh/wetland - conservation
  - 6.5.2 Marsh/wetland - production
  - 6.5.3 Marsh/wetland - intensive use
- **6.6.0 Estuary/coastal waters**
  - 6.6.1 Estuary/coastal waters - conservation
  - 6.6.2 Estuary/coastal waters - production
  - 6.6.3 Estuary/coastal waters - intensive use

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