Australian Government

Bureau of Rural Sciences

Classifying Australian land cover

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December 2006

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Acknowledgments

The authors wish to thank the State and Territory representatives on the National Vegetation Information System Technical Advisory Group and the Executive Steering Committee for Australian Vegetation Information for endorsing the need to take a whole-of-landscape approach to translating and compiling native, non-native and non-vegetated cover types as part of the National Vegetation Information System framework. We also wish to thank Stephen Harris (Tasmanian Department of Primary Industries, Water and Environment) for providing access to the TASVEG 2003 data for testing the approach presented in this report. Lucy Randall and John Davidson edited an earlier version of the report.

Executive summary

Producing a national land cover dataset is problematic because current Australian land cover classifications vary widely between states and territories. Adopting the Food and Agriculture Organization Land Cover Classification (FAOLCC) would overcome this problem.

The Bureau of Rural Sciences (BRS) investigated methods to classify and map land cover in Australia. Integration of existing State and Territory data and the National Vegetation Information System (NVIS) was problematic. These state systems are generally limited in their approach. They use prescriptive classes that reflect the reason the classification was developed.

This report shows that the Food and Agriculture Organization Land Cover Classification (FAOLCC) can be applied to state datasets. That system was used to translate and remap the Tasmanian TASVEG dataset (2003), which is a whole-of-landscape dataset comprising native, non-native and non-vegetated land cover types.

The National Vegetation Information System (NVIS) framework developed by BRS will incorporate the FAOLCC.

The FAOLCC is a comprehensive and flexible system for translating existing State and Territory vegetation and land cover types. An added advantage is that the system can be used to report land cover in national and international applications.

The national coordinating committee for vegetation information supports the need for a nationally consistent whole-of-landscape approach to classifying land cover.

Key findings from this report were presented to the Executive Steering Committee for Australian Vegetation Information (ESCAVI) in May 2005. ESCAVI supports the need for a whole-of-landscape approach classifying all vegetation types within a system, such as the FAOLCC. Discussions at that meeting indicated the need for the BRS, in consultation with representatives from the Environmental Resources Information Network, Department of the Environment and Heritage, to develop and implement a specification for classifying land cover within the NVIS database. Such a classification system would enable high level reporting of the native, non-native and non-vegetated cover types required to describe indicators for the National Monitoring and Evaluation Framework.

The implementation of a national land cover classification system by the states and territories would enable non-native and non-vegetated cover types to be included in NVIS at the same time as the native vegetation types.

Recommendations

1. The developers of the NVIS framework should add an attribute in the NVIS database called 'native vegetation'. That attribute could be used to link/group all definitive native vegetation types in the NVIS database. That change would enable reporting of native vegetation extent and types from the NVIS database under the native vegetation indicators for the National Monitoring and Evaluation Framework.

2. Where State and Territory custodians have supplied non-native and non-vegetated land cover datasets in the national NVIS database, the Australian Government in partnership with the state data custodians should remap these cover types to the FAOLCC system, where possible.

3. Lead agencies for vegetation in each State and Territory should investigate opportunities with relevant stakeholders for using the FAOLCC system to translate and compile existing State and Territory non-native and non-vegetated land cover datasets into their state-wide NVIS databases.

4. The national guidelines for translating and compiling vegetation cover datasets in the NVIS database, that is, the Australian Vegetation Attribute Manual (ESCAVI 2003), should be revised to include the FAOLCC system.

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Introduction

Prior to the development of the National Vegetation Information System (NVIS) framework (ESCAVI 2003), there was no consistent way to translate and compile mapped native vegetation information at the association and sub-association levels across Australia. Vegetation that was predominantly native was included in the first stage of NVIS. That left spaces where there was non-native vegetation and non-vegetated areas. Non-vegetated land includes sand dunes, cities, lakes and mines. Adding non-native and non-vegetated land cover classes to the NVIS framework would enable the development of a comprehensive national land cover classification system for the first time.

At a workshop in May 2004, the Bureau of Rural Sciences (BRS) circulated a draft discussion paper '*Towards a National Framework for Describing and Mapping Non-Native Vegetation and Non-Vegetated Cover Classes in the NVIS Framework*' (Thackway and Atyeo 2003). This discussion paper outlined an approach to develop a national land cover classification system. The BRS undertook to continue developing a national system and to test its application.

In July 2004 the BRS convened a working group of specialists in vegetation and land cover mapping from Geoscience Australia, the Department of the Environment and Heritage and BRS. The working group outlined three major objectives for developing a national land cover classification system:

1. develop an agreed national land cover classification to describe all land cover types for use in mapping at a range of scales
2. use this classification to 'recode and remap' existing land use/cover and vegetation mapping to create integrated land cover datasets at different scales
3. incorporate the final mapping in the NVIS database. This will require an additional module in the Australian Vegetation Attribute Manual (ESCAVI 2003).

Method

Two methods to develop a national land cover classification system were investigated:

1. deriving an Integrated Land Cover Classification system from existing national frameworks to produce a national land cover map, and
2. applying the Food and Agriculture Organization Land Cover Classification System (FAOLCCS) to an Australian state dataset.

1. Deriving an Integrated Land Cover Classification system from existing national frameworks

The working group concentrated on how best to integrate the components of national frameworks to produce a national land cover map that could complement the NVIS dataset with non-native vegetation and/or non-vegetated areas. Four national frameworks that could contribute to a national land cover map are described in Table 1.

Table 1: National frameworks that could contribute components to a national land cover map

National frameworks	Scope of framework	Comments regarding land cover
Australian Land Use and Management (ALUM)	A hierarchy of land use types including those that can have minimal impact on native vegetation and those that remove or significantly change the vegetation.	Land use in Australia is described by the Australian Land Use and Management Classification scheme. Land use is not land cover. Land use describes the arrangements and activities people undertake on the land to change or maintain it. Land cover is the physical state of the earth's surface.
AUSLIG 1:1 000 000 and 1:250 000 topographic map specification	Feature codes to develop topographic maps. The types of features include vegetation cover density, land tenure and many non-vegetated point based features associated with human use and occupation.	Australia's national mapping agency, Geoscience Australia, uses a mixture of land cover and land use as well as other themes such as relief and infrastructure. There is a lot of 'white space' on these maps and generally no indication if a particular land cover, such as a lake, is naturally or artificially made, which helps monitor land cover change.
National Vegetation Information System (NVIS)	A list of native vegetation types described at the association and sub-association levels; non-native vegetation and non-vegetated cover	Although the first stage of NVIS involved native vegetation, most states and territories also provided other data. Those agencies used individual ways to describe land cover. Those ways were

National frameworks	Scope of framework	Comments regarding land cover
	classes to be added.	often incompatible with the NVIS framework.
Vegetation Assets States and Transitions (VAST)	Seven broad cover types that describe states and transitions of native vegetation and non-native vegetation and non-vegetative cover.	VAST was developed within the BRS. Rather than describing land cover, VAST classifies vegetation according to how natural it is. Where native vegetation has been modified, VAST uses the structural and floristic attributes required for natural vegetation regeneration.

The conclusion was that, even if applied collectively, these frameworks could not completely describe land cover in Australia. At best they provide inputs and reliability checks for developing a land cover classification. A well-designed land cover classification system should be able to report at different scales, deal with all vegetated areas — not just natural ones — and be suitable for monitoring land cover change.

2. Applying the FAOLCCS

Most land cover classification systems used throughout Australia and in other countries are single purpose frameworks designed for a specific region or theme.

Corine land cover created by the European Environment Agency is similar to many land cover systems developed around the world. Unlike the FAOLCCS, which is a translator, Corine land cover inventory is based on satellite images that can only map broad features. The Corine nomenclature has therefore been adapted to the sensors capabilities, restricting the systems flexibility. Many land cover classification systems also have subjective classes. For example, Corine records transitional vegetation classes and vegetation degradation and regeneration that are condition types rather than cover (Buttner et al 2002, Di Gregorio and Jansen 2004).

The Food and Agricultural Organization (FAO) developed the FAOLCCS to standardise land cover classification internationally. Using the FAOLCCS will enable national and international monitoring and reporting of land cover and land cover change.

The FAOLCC method predefines the land cover classes. The detail depends on the number of classes; more detailed classification requires a larger number of classifiers. To avoid having an unmanageable number of classes to describe the earth's surface, from forest to glacier, a flexible system was developed with two main phases.

The first, the *dichotomous phase* has three classification levels: presence or absence of vegetation, soil saturation and disturbance of cover. The third level has eight major land cover classes (Table 2).

Table 2: Dichotomous levels of the FAO Land Cover Classification System

First level	Second level	Third level
Primarily vegetated	Terrestrial	Managed terrestrial areas
		Natural and semi-natural terrestrial vegetation
	Aquatic or regularly flooded	Cultivated aquatic areas
		Natural and semi-natural aquatic vegetation
Primarily non-vegetated	Terrestrial	Artificial surfaces
		Bare areas
	Aquatic or regularly flooded	Artificial water bodies, snow and ice
		Natural water bodies, snow and ice

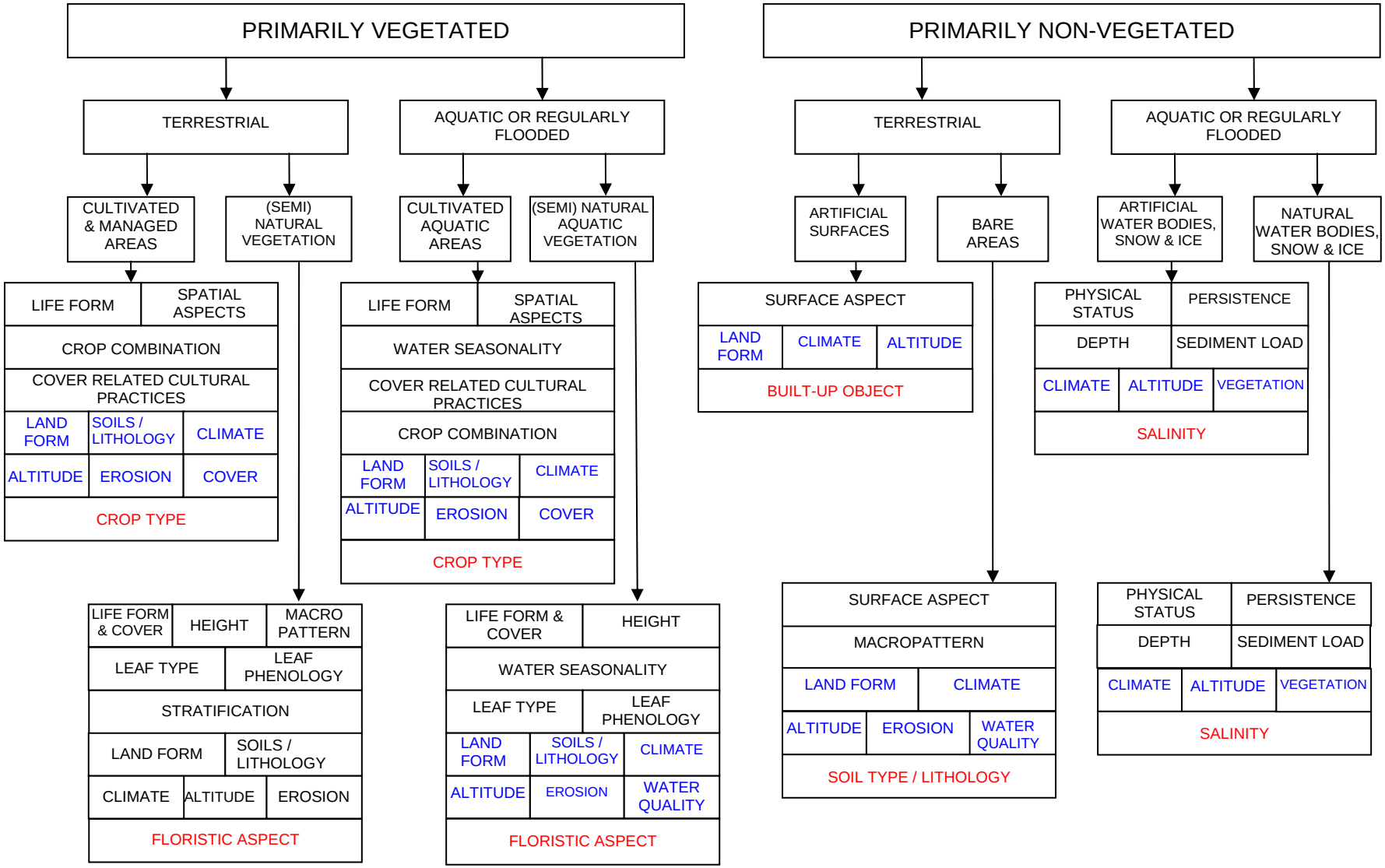
The eight main land cover classes shown in Table 2 can lead to more detailed classes, as shown in Table 3, which represents phase 2. Each of the eight land cover types has predefined land cover classifiers. These classifiers can be combined with environmental attributes, such as climate or soils, as well as specific technical attributes such as floristic aspects or salinity to provide additional land cover information (Appendix A). The FAOLCCS can classify a wide range of agricultural activities, from grazing to orchards and mixed agricultural cover, and has the potential to describe cover-related cultural practices, such as irrigation and cultivation frequency.

To assess the application of the FAOLCCS, the Tasmanian Department of Primary Industries, Water and Environment (DPIWE) provided a copy of TASVEG. While TASVEG maps to the fine scale of 1:25 000, it is primarily concerned with native vegetation, and aggregates many non-native/non-vegetative classes.

Due to operating system difficulties, the FAOLCCS software application could not be used by BRS. Despite that, the FAOLCCS was applied by entering land cover classes into an Excel spreadsheet and assigning identification numbers (Appendix B). The TASVEG codes were assigned a FAOLCCS class using a ‘lookup’ table (Appendix C) which was joined to the TASVEG shapefile.

To aggregate the NVIS classes, all (semi)natural native vegetation was assigned a single map code. The ‘look up’ table was joined to the TASVEG shapefile and the resulting land cover classes were mapped at various scales (Figures 1 and 2). The legend colour on these maps reflects the unique FAOLCCS classes (Appendix B). Where TASVEG has subclasses within a larger grouping, for example, ‘plantations’ and ‘herbaceous’ within ‘cultivated/modified’, these subclasses were assigned unique colours for mapping and within the Appendix.

Table 3: FAO Land Cover Classification System, (phase 2 environmental attributes, specific technical attributes)



Results

How well the FAOLCCS performed using the TASVEG dataset as a pilot dataset is described in the remaining sections of this paper.

Of the 185 TASVEG classes, 171 were grouped into the NVIS equivalent of a single (semi)natural class of native vegetation. The 14 remaining classes of non-vegetative or disturbed/cultivated non-native land cover classes are presented in Table 4.

Table 4: TASVEG classes reclassified using the FAOLCCS codes

	TASVEG	FAO-LCC	FAOLCCS codes*
1	agricultural land	cultivated/modified	30
2	alkaline pans	hard pans	59
3	extra-urban miscellaneous	built up	65
4	lowland and coastal disturbance sedgeland	cultivated/modified herbaceous	34
5	permanent easements	no reclassification possible	66
6	plantations for silviculture	plantations	31
7	regenerating cleared land	cultivated/modified	30
8	sand, mud	loose sands	61
9	seabird rookery complex	no reclassification possible	777
10	*Spartina anglica* grassland	cultivated/modified herbaceous	34
11	talus, boulder-fields, rock-plates	bare rock	58
12	urban areas	urban	69
13	water, sea	non-vegetated	37
14	weed infestation	cultivated/modified	30

* FAOLCC codes are listed in Appendix B

Discussion

Aggregation of the detailed native vegetation classes clearly show the extent of modified vegetation in two areas of Tasmania. Figure 1 shows an area dominated by the class 'cultivated/disturbed vegetation'; this was TASVEG 'agricultural land'.

The existence of the class 'cultivated/disturbed herbaceous' along the Tamar River (Figure 1) illustrates that non-native/non-vegetative classes can include exotic species, in this case *Spartina anglica* (rice grass).

Given that the TASVEG 'agricultural land' is a broad category, it was not possible to infer land cover life form, distribution or density. It was assumed that non-vegetation cover classes such as 'alkaline pans' or 'sand' are naturally bare. The class 'seabird rookery complex' is hard to categorise. While many seabirds have bare or rocky rookeries, others use vegetated land. In this case a unique class was made for this cover. A unique class was also created for the TASVEG cover 'permanent easements'. It is possible for easement land cover to be composed of native vegetation, as well as modified land and inundated land. 'Urban areas' were classified to level V (non-vegetated, terrestrial, built up, non-linear, urban). 'Extra-urban miscellaneous' was not described and was left at a coarser level III (non-vegetated, terrestrial, built up).

While Table 3 and Appendix A illustrate the detail possible using the FAOLCCS, the TASVEG dataset did not comprise the equivalent level of detail to reflect this.

The 70 possible FAO land cover classes are listed in Appendix B. TASVEG has been grouped into 14 of them (Table 4). This system is flexible, enabling greater descriptions of environmental and cultural aspects of the land cover (Table 3).

This report was presented by BRS to the 9th meeting of the Executive Steering Committee for Australian Vegetation Information (ESCAVI) in May 2005. ESCAVI supported the need for a whole-of-landscape approach to coding all vegetation cover types within a national land cover classification system, such as the FAOLCC system. Discussions at that meeting indicated the need for the bureau, in consultation with representatives from the Environmental Resources Information Network, Department of the Environment and Heritage to develop and implement a specification for classifying Australia's vegetation using a national land cover classification system within the NVIS database. Such a system would enable high level reporting of native, non-native and non-vegetated cover types required as indicators under the National Monitoring and Evaluation Framework. The future implementation of a national land cover classification system by the states and territories would enable non-native and non-vegetated cover types to be compiled at the same time as the native vegetation types.

Conclusions and recommendations

The BRS compiled and assessed the State and Territory vegetation, land cover and land use classification and mapping systems used by the State and Territory agencies for describing and mapping non-native and non-vegetated cover types in the NVIS database. BRS also assessed the merits of developing an Australian land cover classification system by combining the existing State and Territory vegetation and land cover types. Collectively there are major inconsistencies and gaps among these systems.

These state systems do not include all the land cover types known to occur across Australia, that is, they are limited to the cover types described and mapped by an agency. Those cover types are grouped as one class reflecting the purpose for which the classification system was developed. Examples are that softwood and hardwood plantations are grouped together, agriculture and urban areas are grouped together and naturally bare areas are not distinguished from cropping areas.

Despite these shortcomings, this report shows the FAOLCCS can be used to translate and remap the Tasmanian TASVEG 2003 dataset, which is a whole-of-landscape dataset comprising native, non-native and non-vegetated land cover types. The FAOLCCS is a comprehensive and flexible system for remapping existing State and Territory vegetation and land cover types. An added advantage of the FAOLCCS is that, provided it is used by the data custodians, it allows for reporting of land cover in national and international applications. The system can describe land cover comprehensively if data are collected and described to a sufficient level of detail. Implementing a national land cover classification system, based on the FAOLCCS, would also enable the national monitoring and reporting of land cover change.

Recommendations:

1. The developers of the NVIS framework should add an attribute in the NVIS database called 'native vegetation'. That attribute could be used to link/group all definitive native vegetation types in the NVIS database. That change would enable reporting of native vegetation extent and types from the NVIS database under the native vegetation indicators for the National Monitoring and Evaluation Framework.

2. Where State and Territory custodians have supplied non-native and non-vegetated land cover datasets in the national NVIS database, the Australian Government in partnership with the state data custodians should remap these cover types to the FAOLCCS, where possible.

3. Lead agencies for vegetation in each State and Territory should discuss opportunities for using the FAOLCCS to translate and compile existing State and Territory non-native and non-vegetated land cover datasets into their state-wide NVIS databases.

4. The national guidelines for translating and compiling vegetation cover datasets in the NVIS database, that is, the Australian Vegetation Attribute Manual (ESCAVI 2003), should be revised to include the FAOLCCS.

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Figure 1: Map of the Launceston region with TASVEG reclassified according to the FAOLCCS

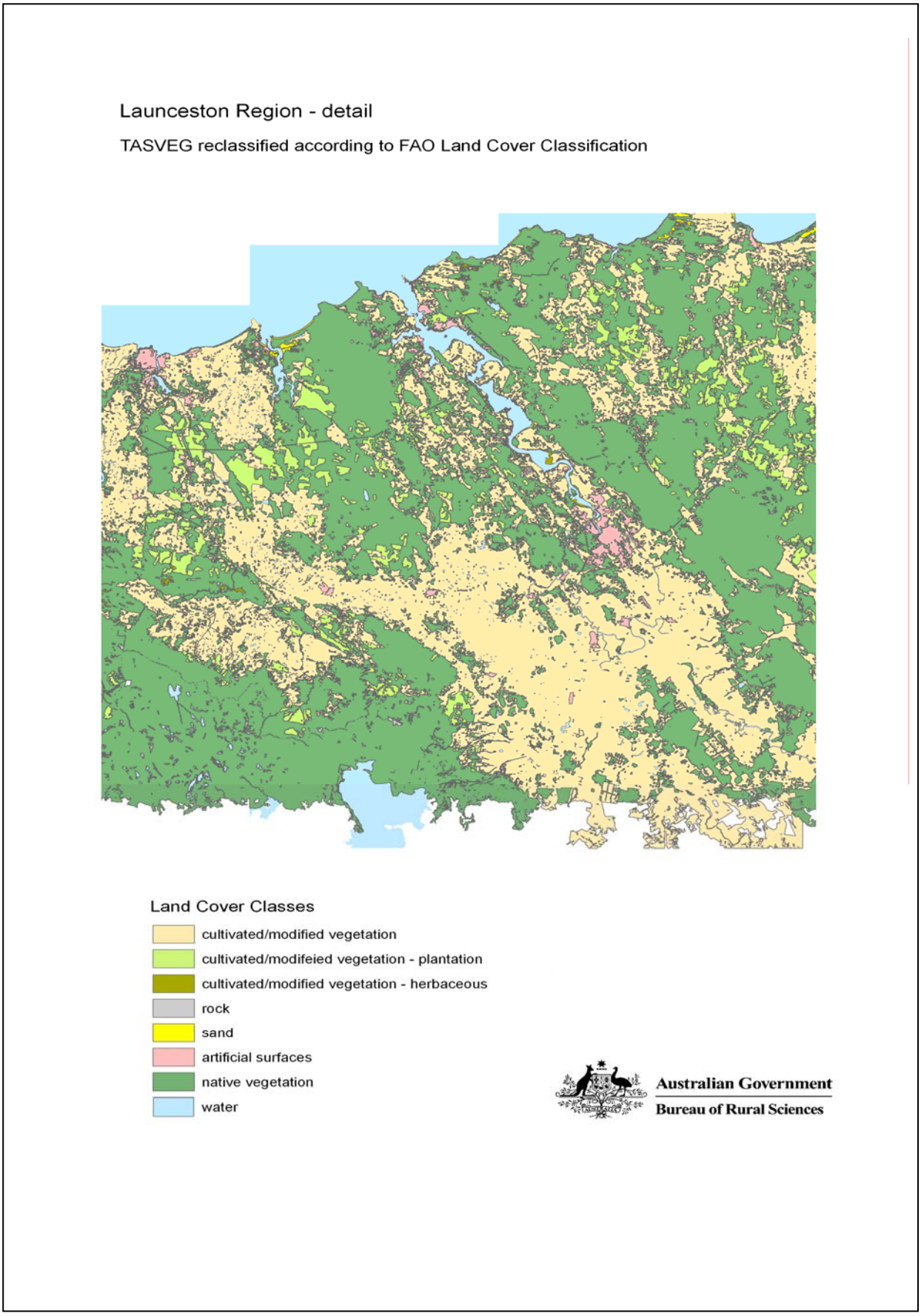
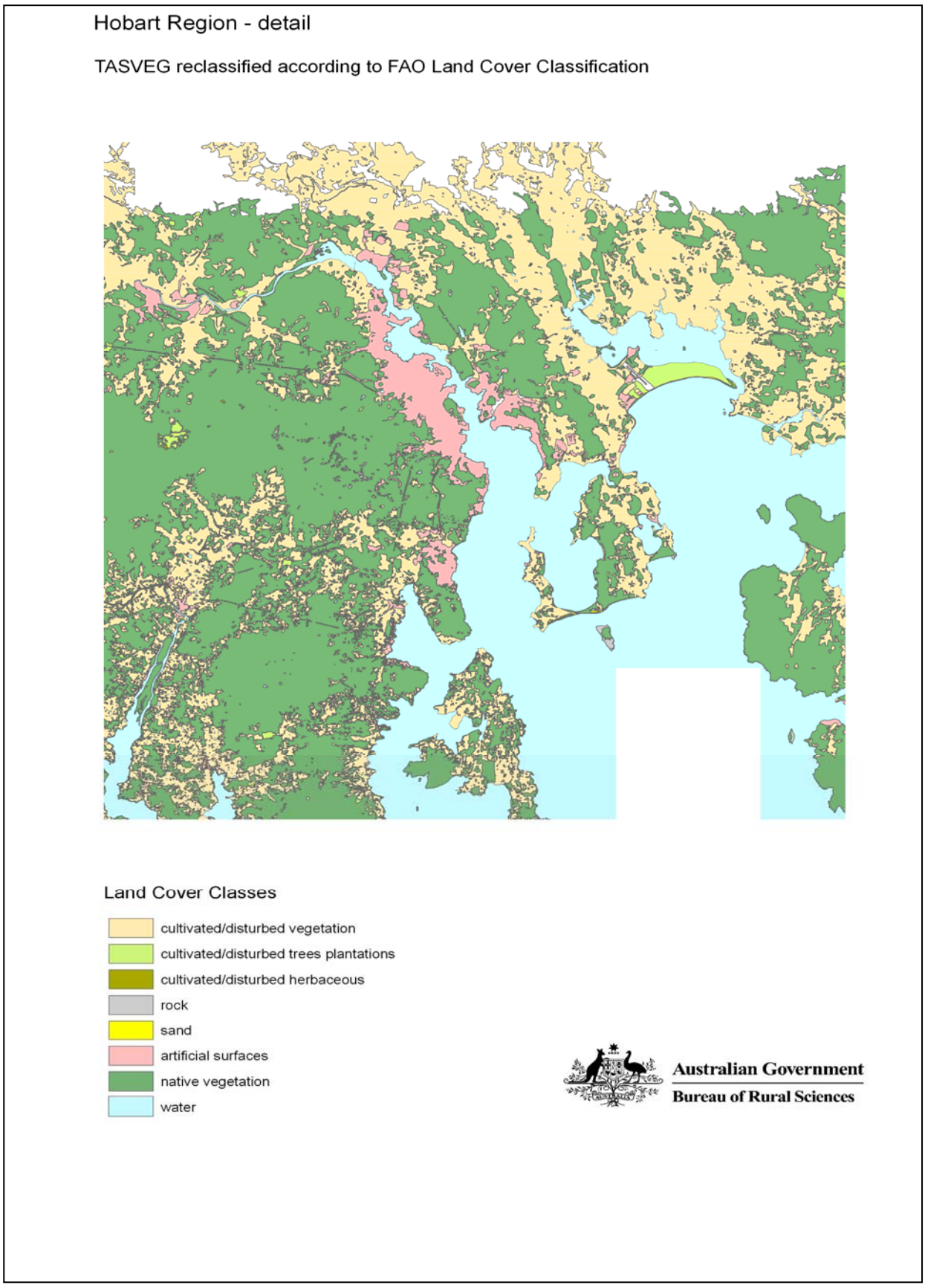


Figure 2: Map of the Hobart region with TASVEG reclassified according to the FAOLCCS



Appendix A: FAO classification tables

PRIMARILY VEGETATED			PRIMARILY NON-VEGETATED
Cultivated & Managed Lands	Nat.& Semi-Nat. Terrestrial Veg.	Nat. & Semi-Nat. Aquatic Veg.	Artificial Surfaces and Ass. Areas
I. A. Life form of the Main Crop	**I. A. Life form of the Main Strata**	**I. A. Life Form of the Main Strata**	**I. A. Surface Aspect**
Trees	**Woody**	**Woody**	**Built Up**
Broadleaved	Trees	Trees	Linear
Needleleaved	Shrubs	Shrubs	Roads
Evergreen	**Herbaceous**	**Herbaceous**	Paved
Deciduous	Forbs	Forbs	Unpaved
Shrubs	Graminoids	Rooted	Railways
Broadleaved	**Lichens / Mosses**	Free Floating	Comm. Lines/Pipelines
Needleleaved	Lichens	Graminoids	Non-Linear
Evergreen	Mosses	**Lichens / Mosses**	Industrial a/o Other
Deciduous	**A. Cover**	Lichens	High Density
Herbaceous	**Closed** (>70-60%)	Mosses	Medium Density
Graminoids	**Open** (70-60 - 20-10%)	**A. Cover**	Low Density
Non-Graminoids	(70-60 - 40%)	**Closed** (>70-60%)	Scattered Density
Urban Vegetated Area(s)	(40-20 – 10%)	**Open** (70-60 – 20-10%)	Urban Areas
Parks	**Closed to Open** (100-15%)	**Closed to Open** (100-15%)	High Density
Parkland	(100-40%)	(100-40%)	Medium Density
Lawns	**Sparse** (20-10% - 1%)	(70-60 – 40%)	Low Density
B. Spatial Aspect - Size	(<20-10 – 4%)	(40-20 – 10%)	**Non Built Up**
Large to Medium Sized Field(s)	Scattered (4-1%)	**Sparse** (20-10% - 1%)	Waste Dump Deposit
Large Sized Field(s)	**B. Height**	(<20-10 – 4%)	Extraction Sites
Medium Sized Fields(s)	**7-2m** (Woody)	Scattered (4-1%)	**A. Built-Up Object**
Small Sized Field(s)	**>30-3m** (Trees)	**B. Height**	(scroll list with pre-defined objects)
B. Spatial Aspect - Distribution	>14m	**7-2m** (Woody)	
Continuous	14-7m	**>30-3m** (Trees)	**BARE AREAS**
Scattered Clustered	7-3m	>14m	**I. A. Surface Aspects**
Scattered Isolated	**5-0.3m**	14-7m	**Consolidated**
II. C. Crop Combination	5-0.5m	7-3m	Bare Rock a/o Coarse Frgm.
Single Crop	5-2m	**5-0.3m**	Bare rock
Multiple Crop	2-0.5m	5-0.5m	Gravel/Stones/Boulders
One Additional Crop	<0.5m	5-2m	Gravel
Trees	**3-0.3m**	2-0.5m	Stones
Shrubs	3-0.3m	<0.5m	Boulders
Herbaceous Terrestrial	3-0.8m	**3-0.3m**	**Hardpans**
Herbaceous Aquatic	0.8-0.3m	3-0.3m	Ironpan/Laterite
Simultaneous	0.3-0.03m	3-0.8m	Petrocalcic
Overlapping	**C. Spatial Distribution / Macropattern**	0.8-0.3m	Petrogypsic
Sequential	**Continuous**	0.3-0.03m	**Unconsolidated**
Trees	**Fragmented**	**II. C. Water Seasonality**	Bare Soil a/o Other Uncon. Mat.
Shrubs	Striped	**More Than 3 Months a Year**	Stony (5-40%)
Graminoids	Cellular	Persistent for Whole Day	Very Stony (40-80%)
Non-graminoids	**Parklike Patches**	With Daily Variations	**Loose and Shifting Sands**
Simultaneous	**II. D. Leaf Type**	**Less Than 3 Months a Year**	Stony (5-40%)

Overlapping	**Broadleaved**	**Waterlogged**	Very Stony (40-80%)
Sequential	**Needleleaved**	**III. D. Leaf Type**	**II. B. Macropattern - Sands**
III. D. Cultural Practices – Water Supply	**Aphyllous**	**Broadleaved**	**Dunes**
Rainfed	**E. Leaf Phenology**	**Needleleaved**	Barchans
Post-flooding	**Evergreen**	**Aphyllous**	Saturated
Irrigated	Semi-Evergreen	**E. Leaf Phenology**	Unsaturated
Surface Irrigation	**Deciduous**	**Evergreen**	Parabolic Dunes
Sprinkler Irrigation	Semi-Deciduous	Semi-Evergreen	Saturated
Drip Irrigation	Mixed	**Deciduous**	Unsaturated
D. Cult. Practices – Cult. Time	**Mixed** (Forbs/Graminoids)	Semi-Deciduous	Longitudinal Dunes
Shifting Cultivation	Annual	Mixed	Saturated
Fallow System	Perennial	**Mixed** (Forbs/Graminoids)	Unsaturated
Permanent Cultivation	**III. F. Stratification – 2nd Layer**	Annual	**Salt Flat**
	Second Layer Absent	Perennial	**B. Macropattern - Soils**
S. Crop Type	**Second Layer Present**	**III. F. Stratification – 2nd Layer**	**Gilgai**
Food Crops	**Woody**	**Second Layer Absent**	**Termite Mounds**
Cereals	Trees	**Second Layer Present**	
Roots & Tubers	Shrubs	**Woody**	**ARTIFICIAL WATERBODIES**
Pulses & Vegetables	**Herbaceous**	Trees	**I. A. Physical Status**
Fruit & Nuts	**G. Cover – 2nd Layer**	Shrubs	**Water**
Fodder Crops	**Closed to Open**	**Herbaceous**	Flowing
Beverages & Stimulants	Closed (>70-60%)	**G. Cover – 2nd Layer**	Standing
Other	Open (70-60 – 20-10%)	**Closed to Open**	**Snow**
Non-Food Crops	**Sparse** (20-10 – 1%)	Closed (>70-60%)	**Ice**
Industrial Crops	**H. Height – 2nd Layer**	Open (70-60 – 20-10%)	Moving
Wood/Timber	**7-2 m** (Woody)	**Sparse** (20-10 – 1%)	Stationary
Other	**>30-3 m**	**H. Height – 2nd Layer**	**B. Persistence**
	>14m	**7-2 m** (Woody)	**Perennial** (>9 months)
CULTIVATED AQUATIC AREAS	14-7m	**>30-3 m**	9-7 months
I. A. Life Form of the Main Crop	7-3m	>14m	6-4 months
Graminoids	**5-0.3m**	14-7m	3-1 months
Non-Graminoids	5-2m	7-3m	**Non-Perennial** (<9 months)
Woody	2-0.5m	**5-0.3m**	Surface Aspect: Bare Rock
B. Spatial Aspect - Size	<0.5m	5-2m	Surface Aspect: Bare Soil
Large to Medium Sized Field(s)	**3-0.03m**	2-0.5m	Surface Aspect: Sand
Large Sized Field(s)	3-0.3m	<0.5m	**Tidal Area**
Medium Sized Field(s)	0.3–0.03	**3-0.03m**	Surface Aspect: Bare Rock
Small Sized Field(s)	**F. Stratification – 3rd Layer**	3-0.3m	Surface Aspect: Bare Soil
B. Spatial Distribution	**Third Layer Absent**	0.3–0.03	Surface Aspect: Sand
Continuous	**Third Layer Present**	**T. Floristic Aspect**	**II. C. Depth**
Scattered Clustered	**Woody**	**Single Plant Species**	**Deep to Medium**
Scattered Isolated	Trees	Dominant Species	**Shallow**
II. C. Water Seasonality	Shrubs	Most Frequent Species	**D. Sediment Load**
Persistent for Whole Day	**Herbaceous**	**Groups of Plant Species**	**Almost No Sediment**
With Daily Variations	**G. Cover – 3rd Layer**	Statistically Derived Groups	**With Sediment**
Waterlogged	**Closed to Open**	Non-Statistically Derived	**V. SALINITY**
	Closed (>70-60%)		**Fresh** (<1 000 ppm of TDS)

S. Crop Type	Open (70-60 – 20-10%)
Food Crops	**Sparse** (20-10 – 1%)
Cereals	**H. Height 3rd Layer**
Food Crops	**7-2 m** (Woody)
Other	**>30-3 m**
Non-Food Crops	>14m
Crops for Biological Filtration	14-7m
Fibre Crops & Struct. Material	7-3m
Other	**5-0.3m**
	5-2m
	2-0.5m
	<0.5m
	3-0.03m
	3-0.3m
	0.3–0.03
	T. FLORISTIC ASPECT
	Single Plant Species
	Dominant Species
	Most Frequent Species
	Groups of Plant Species
	Statistically Derived Groups
	Non-Statistically Derived

Slightly Saline
Moderately Saline
Very Brine
Brine
INLAND WATERBODIES, SNOW & ICE
I. Physical Status
Water
Flowing
Standing
Snow
Ice
Moving
Stationary
B. Persistence
Perennial (>9 months)
9-7 months
6-4 months
3-1 months
Non-Perennial (<9 months)
Surface Aspect: Bare Rock
Surface Aspect: Bare Soil
Surface Aspect: Sand
Tidal Area
Surface Aspect: Bare Rock
Surface Aspect: Bare Soil
Surface Aspect: Sand
II. C. Depth
Deep to Medium
Shallow
D. Sediment Load
Almost No Sediment
With Sediment
V. SALINITY
Fresh (<1 000 ppm of TDS)
Slightly Saline
Moderately Saline
Very Brine
Brine

Appendix B: FAO land cover classification codes

Land cover classification codes (I-V)					
Code	**I**	**II**	**III**	**IV**	**V**
1	vegetated	semi-aquatic	largely uncult (semi) natural		
2	vegetated	semi-aquatic	largely uncult (semi) natural	trees	
3	vegetated	semi-aquatic	largely uncult (semi) natural	trees	closed
4	vegetated	semi-aquatic	largely uncult (semi) natural	trees	open
5	vegetated	semi-aquatic	largely uncult (semi) natural	trees	sparse
6	vegetated	semi-aquatic	largely uncult (semi) natural	shrubs	
7	vegetated	semi-aquatic	largely uncult (semi) natural	shrubs	closed
8	vegetated	semi-aquatic	largely uncult (semi) natural	shrubs	open
9	vegetated	semi-aquatic	largely uncult (semi) natural	shrubs	sparse
10	vegetated	semi-aquatic	largely uncult (semi) natural	grass/forbs	
11	vegetated	semi-aquatic	largely uncult (semi) natural	grass/forbs	closed
12	vegetated	semi-aquatic	largely uncult (semi) natural	grass/forbs	open
13	vegetated	semi-aquatic	largely uncult (semi) natural	grass/forbs	sparse
14	vegetated	semi-aquatic	cultivated/modified		
15	vegetated	semi-aquatic	cultivated/modified	graminoids	
16	vegetated	semi-aquatic	cultivated/modified	non-graminoids	
17	vegetated	terrestrial	largely uncult (semi) natural		
18	vegetated	terrestrial	largely uncult (semi) natural	trees	
19	vegetated	terrestrial	largely uncult (semi) natural	trees	closed
20	vegetated	terrestrial	largely uncult (semi) natural	trees	open
21	vegetated	terrestrial	largely uncult (semi) natural	trees	sparse
22	vegetated	terrestrial	largely uncult (semi) natural	shrubs	
23	vegetated	terrestrial	largely uncult (semi) natural	shrubs	closed
24	vegetated	terrestrial	largely uncult (semi) natural	shrubs	open
25	vegetated	terrestrial	largely uncult (semi) natural	shrubs	sparse
26	vegetated	terrestrial	largely uncult (semi) natural	grass/forbs	
27	vegetated	terrestrial	largely uncult (semi) natural	grass/forbs	closed

Land cover classification codes (I-V)					
Code	**I**	**II**	**III**	**IV**	**V**
28	vegetated	terrestrial	largely uncult (semi) natural	grass/forbs	open
29	vegetated	terrestrial	largely uncult (semi) natural	grass/forbs	sparse
30	vegetated	terrestrial	cultivated/modified		
31	vegetated	terrestrial	cultivated/modified	plantation	
32	vegetated	terrestrial	cultivated/modified	trees	
33	vegetated	terrestrial	cultivated/modified	shrubs	
34	vegetated	terrestrial	cultivated/modified	herbaceous	
35	vegetated	terrestrial	cultivated/modified	urban vegetated areas	
36	non-vegetated	terrestrial			
37	non-vegetated	aquatic			
38	non-vegetated	aquatic or flooded	natural water features		
39	non-vegetated	aquatic or flooded	natural water features	perennial	
40	non-vegetated	aquatic or flooded	natural water features	perennial	
41	non-vegetated	aquatic or flooded	natural water features	perennial	fresh
42	non-vegetated	aquatic or flooded	natural water features	perennial	moderately saline
43	non-vegetated	aquatic or flooded	natural water features	non-perennial	very saline
44	non-vegetated	aquatic or flooded	natural water features	non-perennial	
45	non-vegetated	aquatic or flooded	natural water features	non-perennial	fresh
46	non-vegetated	aquatic or flooded	natural water features	non-perennial	moderately saline
					very saline
47	non-vegetated	aquatic or flooded	artificial water features		
48	non-vegetated	aquatic or flooded	artificial water features	perennial	
49	non-vegetated	aquatic or flooded	artificial water features	perennial	
50	non-vegetated	aquatic or flooded	artificial water features	perennial	fresh
51	non-vegetated	aquatic or flooded	artificial water features	perennial	moderately saline
52	non-vegetated	aquatic or flooded	artificial water features	non-perennial	very saline
53	non-vegetated	aquatic or flooded	artificial water features	non-perennial	
54	non-vegetated	aquatic or flooded	artificial water features	non-perennial	fresh
55	non-vegetated	aquatic or flooded	artificial water features	non-perennial	moderately saline

Land cover classification codes (I-V)					
Code	**I**	**II**	**III**	**IV**	**V**
					very saline
56	non-vegetated	terrestrial			
57	non-vegetated	terrestrial	(semi) natural bare areas		
58	non-vegetated	terrestrial	(semi) natural bare areas	consolidated	
59	non-vegetated	terrestrial	(semi) natural bare areas	consolidated	bare rock
60	non-vegetated	terrestrial	(semi) natural bare areas	unconsolidated	hard pans
61	non-vegetated	terrestrial	(semi) natural bare areas	unconsolidated	bare soil
					loose sands
62	non-vegetated	terrestrial	non-built up		
63	non-vegetated	terrestrial	non-built up	waste dumps	
64	non-vegetated	terrestrial	non-built up	extraction sites	
65	non-vegetated	terrestrial	built up		
66	non-vegetated	terrestrial	built up	easements	
67	non-vegetated	terrestrial	built up	linear	
68	non-vegetated	terrestrial	built up	linear	transport
69	non-vegetated	terrestrial	built up	non-linear	communication
70	non-vegetated	terrestrial	built up	non-linear	urban
71	non-vegetated	terrestrial	Built-up	non-linear	industrial

	(semi)natural vegetation classified by NVIS		bare areas
	cultivated aquatic areas		artificial surfaces
	cultivated/modified terrestrial areas		cultivated/modified - plantations
	non-vegetated		cultivated/modified - herbaceous
	non-vegetated aquatic		cultivated/modified - trees
	natural water bodies, snow and ice		bare areas (sand)
	artificial water bodies, snow and ice		seabird rookery
	non-vegetated terrestrial		

Appendix C: TASVEG codes reclassified using the FAO Land Cover Classification System

Vegetation type		LCC III	LCC IV	LCC V	map code
1.	*Acacia dealbata* forest	17	18	19	888
2.	*Acacia longifolia* coastal scrub	17	22	0	888
3.	*Acacia melanoxylon* forest on flats	17	18	19	888
4.	*Acacia melanoxylon* on rises	17	18	0	888
5.	*Acacia* spp. (not *A. melanoxylon* or *A. dealbata*)	17	22	0	888
6.	Agricultural land	30	0	0	30
7.	Alkaline pans	57	0	59	59
8.	*Allocasuarina littoralis* closed forest	17	18	19	888
9.	*Allocasuarina verticillata* forest	17	18	19	888
10.	Alpine coniferous heathland	17	26	0	888
11.	Alpine sedgeland/herbland	17	26	0	888
12.	*Athrotaxis cupressoides* open woodland	17	18	20	888
13.	*Athrotaxis cupressoides* rainforest	17	18	19	888
14.	*Athrotaxis cupressoides*/*Nothofagus gunnii* rainforest	17	18	19	888
15.	*Athrotaxis selaginoides* rainforest	17	18	19	888
16.	*Athrotaxis selaginoides/Nothofagus gunnii* short rainforest	17	18	19	888
17.	*Banksia marginata* wet scrub	17	22	0	888
18.	*Banksia serrata* woodland	17	18	20	888
19.	Broadleaf scrub	17	22	0	888
20.	*Bursaria spinosa/Acacia* spp. woodland and dry scrub	17	22	0	888
21.	Buttongrass moorland (undifferentiated)	17	26	0	888
22.	Buttongrass moorland with emergent *Melaleuca squamea/Leptospermum nitidum*	17	26	0	888
23.	*Callitris rhomboidea* forest	17	18	19	888
24.	Coastal *Eucalyptus amygdalina* forest	17	18	19	888
25.	Coastal *Eucalyptus amygdalina* woodland	17	18	20	888
26.	Coastal grass and herbfield	17	26	0	888
27.	Coastal rainforest	17	18	19	888
28.	Coastal scrub on alkaline sands	17	22	0	888
29.	Cushion heathland	17	26	0	888
30.	*Danthonia*/*Austrostipa*/sparse *Themeda* grassland	17	26	0	888
31.	Eastern alpine heathland	17	26	0	888
32.	Eastern alpine sedgeland	17	26	0	888
33.	Eastern alpine vegetation (undifferentiated)	17	0	0	888
34.	Eastern buttongrass moorland	17	26	0	888
35.	*Eucalyptus amygdalina* forest on dolerite	17	18	19	888
36.	*Eucalyptus amygdalina* forest on sandstone	17	18	19	888
37.	*Eucalyptus amygdalina* woodland on dolerite	17	18	20	888
38.	*Eucalyptus amygdalina* woodland on sandstone	17	18	20	888
39.	*Eucalyptus barberi* low forest	17	18	20	888
40.	*Eucalyptus brookeriana* wet forest	17	18	19	888
41.	*Eucalyptus brookeriana* woodland	17	18	20	888
42.	*Eucalyptus coccifera* forest and woodland	17	18	19	888
43.	*Eucalyptus cordata* forest	17	18	19	888
44.	*Eucalyptus dalrympleana/Eucalyptus pauciflora* woodland	17	18	20	888

Vegetation type		LCC III	LCC IV	LCC V	map code
45.	*Eucalyptus dalrympleana* forest	17	18	19	888
46.	*Eucalyptus dalrympleana* woodland	17	18	20	888
47.	*Eucalyptus dalrympleana/Eucalyptus pauciflora* forest	17	18	20	888
48.	*Eucalyptus delegatensis* dry forest	17	18	19	888
49.	*Eucalyptus delegatensis* dry woodland	17	18	20	888
50.	*Eucalyptus delegatensis* forest	17	18	20	888
51.	*Eucalyptus delegatensis* forest over broadleaf or sclerophyll	17	18	20	888
52.	*Eucalyptus delegatensis* over rainforest	17	18	20	888
53.	*Eucalyptus delegatensis* wet forest	17	18	19	888
54.	*Eucalyptus delegatensis* woodland	17	18	20	888
55.	*Eucalyptus gunnii* woodland	17	18	20	888
56.	*Eucalyptus morrisbyi* forest	17	18	19	888
57.	*Eucalyptus nitida* dry forest	17	18	19	888
58.	*Eucalyptus nitida* forest over tall *Leptospermum*	17	18	19	888
59.	*Eucalyptus nitida* over rainforest	17	18	19	888
60.	*Eucalyptus nitida* wet forest	17	18	19	888
61.	*Eucalyptus obliqua* broadleaf wet forest	17	18	19	888
62.	*Eucalyptus obliqua* dry forest	17	18	19	888
63.	*Eucalyptus obliqua* dry woodland	17	18	20	888
64.	*Eucalyptus obliqua* mixed forest	17	18	19	888
65.	*Eucalyptus obliqua* tea tree wet forest	17	18	19	888
66.	Eucalyptus obliqua wet forest	17	18	19	888
67.	*Eucalyptus ovata* heathy woodland	17	18	20	888
68.	*Eucalyptus pauciflora* forest non-Jurassic dolerite	17	18	19	888
69.	*Eucalyptus pauciflora* forest on Jurassic dolerite	17	18	19	888
70.	*Eucalyptus pauciflora* woodland	17	18	20	888
71.	*Eucalyptus pauciflora* woodland on Jurassic dolerite	17	18	20	888
72.	*Eucalyptus pauciflora* woodland on sediments	17	18	20	888
73.	*Eucalyptus pauciflora*, *Eucalyptus viminalis* woodland	17	18	20	888
74.	*Eucalyptus perriniana* low forest	17	18	19	888
75.	*Eucalyptus pulchella/Eucalyptus globulus/Eucalyptus viminalis* woodland	17	18	20	888
76.	*E. pulchella*/*E. globulus*/*E. viminalis* grassy/shrubby woodland	17	18	0	888
77.	*Eucalyptus regnans* forest	17	18	19	888
78.	*Eucalyptus regnans* woodland	17	18	20	888
79.	*Eucalyptus risdonii* low forest	17	18	19	888
80.	*Eucalyptus rodwayi* forest	17	18	19	888
81.	*Eucalyptus rodwayi* woodland	17	18	20	888
82.	*Eucalyptus sieberi* forest on granite	17	18	19	888
83.	*Eucalyptus sieberi* forest on non-granite substrates	17	18	19	888
84.	*Eucalyptus sieberi* woodland on granite	17	18	20	888
85.	*Eucalyptus sieberi* woodland on other substrates	17	18	20	888
86.	*Eucalyptus subcrenulata*	17	18	0	888
87.	*Eucalyptus tenuiramis* forest on dolerite	17	18	19	888
88.	*Eucalyptus tenuiramis* forest on granite	17	18	19	888
89.	*Eucalyptus tenuiramis* woodland on dolerite	17	18	19	888
90.	*Eucalyptus viminalis* and/or *Eucalyptus globulus* heathy shrubby woodland	17	18	20	888
91.	*Eucalyptus viminalis* grassy forest	17	18	19	888
92.	*Eucalyptus viminalis* grassy woodland	17	18	20	888
93.	*Eucalyptus viminalis* heathy woodland	17	18	20	888
94.	*Eucalyptus viminalis* wet forest	17	18	19	888
95.	*Eucalyptus* viminalis/*Eucalyptus globulus* coastal shrubby forest	17	18	19	888

Vegetation type		LCC III	LCC IV	LCC V	map code
96.	*Eucalyptus viminalis/Eucalyptus ovata/Eucalyptus amygdalina/E. obliqua*	17	18	0	888
97.	Extra-urban miscellaneous	65	0	0	65
98.	Flinders Island heath-scrub-shrub mosaic	17	22	0	888
99.	Flinders Island scrub	17	22	0	888
100.	Fresh water aquatic plants	1	0	0	888
101.	Furneaux *Eucalyptus nitida* forest	17	18	19	888
102.	Furneaux *Eucalyptus viminalis* woodland-forest	17	18	20	888
103.	Generic *Eucalyptus amygdalina* woodland	17	18	20	888
104.	Generic *Eucalyptus tenuiramis* woodland	17	18	20	888
105.	Grassland and herbfield marginal to wetland	17	26	0	888
106.	Grassy *Eucalyptus globulus* woodland	17	18	20	888
107.	Grassy/shrubby *Eucalyptus globulus* forest	17	18	19	888
108.	Heath on granite	17	22	0	888
109.	Highland grassy sedgeland	17	26	0	888
110.	Highland *Poa* grassland	17	26	0	888
111.	Highland rainforest scrub with dead *Athrotaxis selaginoides*	17	22	0	888
112.	Inland *Eucalyptus amygdalina* forest	17	18	19	888
113.	Inland *Eucalyptus amygdalina* woodland	17	18	20	888
114.	Inland *Eucalyptus tenuiramis* forest	17	18	20	888
115.	Inland *Eucalyptus tenuiramis* woodland	17	18	19	888
116.	King Island coastal heathland complex	17	22	0	888
117.	King Island *Eucalyptus globulus* forest	17	18	19	888
118.	King Island *Eucalyptus globulus* woodland	17	18	20	888
119.	King Island heathland complex	17	22	0	888
120.	*Lagarostrobos franklinii* rainforest	17	22	19	888
121.	*Leptospermum lanigerum/Melaleuca squarrosa* swamp forest	17	22	19	888
122.	*Leptospermum scoparium/Acacia mucronata* short forest	17	22	19	888
123.	*Leptospermum* spp. scrub	17	22	0	888
124.	Lowland and coastal disturbance sedgeland	30	34	0	34
125.	Lowland grassy sedgeland	17	26	0	888
126.	Lowland heathland	17	22	0	888
127.	Lowland heathland on calcarenite	17	22	0	888
128.	Lowland *Melaleuca squarrosa* scrub	17	22	0	888
129.	Lowland *Poa labillardierei* grassland	17	26	0	888
130.	Lowland *Themeda triandra* grassland	17	26	0	888
131.	Lowland sedgeland	17	26	0	888
132.	*Melaleuca ericifolia* forest	17	18	19	888
133.	*Melaleuca pustulata* scrub	17	18	0	888
134.	*Melaleuca squamea* scrub	17	22	0	888
135.	Midlands woodland complex	17	18	20	888
136.	Montane low rainforest and scrub	17	18	20	888
137.	*Notelaea/Pomaderris* forest	17	18	19	888
138.	*Nothofagus cunninghamii* tall rainforest	17	18	19	888
139.	*Nothofagus gunnii* open shrubland	17	22	24	888
140.	*Nothofagus/Leptospermum* short rainforest	17	22	23	888
141.	*Nothofagus/Phyllocladus* short rainforest	17	18	19	888
142.	Permanent easements	66	0	0	66
143.	Plantations for silviculture	30	31	0	31
144.	*Pteridium esculentum* fernland	17	26	0	888
145.	Pure buttongrass moorland	17	0	0	888
146.	Queenstown regrowth mosaic	17	26	0	888

Vegetation type	LCC III	LCC IV	LCC V	map code
147. Rainforest fernland	17	22	0	888
148. Rainforest scrub	17	22	0	888
149. Regenerating cleared land	30	0	0	30
150. Restionaceae rushland	17	26	0	888
151. Riparian scrub	17	22	0	888
152. Saline grassland	17	26	0	888
153. Saline herbfield (undifferentiated)	17	26	0	888
154. Saline herbland	17	26	0	888
155. Sand, mud	61	0	0	61
156. Seabird rookery complex	777	0	777	777
157. Sedge rush wetland	10	0	0	888
158. Shrubby coastal heathland	17	22	0	888
159. Shrubby *Eucalyptus ovata* woodland	17	22	24	888
160. Shrubby *Eucalyptus ovata/Eucalyptus viminalis* forest	17	22	24	888
161. Southwest buttongrass moorland	17	26	0	888
162. Sparse buttongrass moorland on slopes	17	26	29	888
163. *Spartina anglica* grassland	30	34	0	34
164. Sphagnum peatland	17	26	0	888
165. Sphagnum peatland with emergent trees	17	26	0	888
166. Subalpine *Leptospermum nitidum* dwarf forest	17	18	19	888
167. Subalpine *Athrotaxis selaginoides* scrub	17	18	0	888
168. Subalpine *Diplarrena latifolia* rushland	17	26	0	888
169. Subalpine *Leptospermum nitidum* shrubland	17	22	0	888
170. Subalpine heath scree flora	17	22	0	888
171. Tall or wind-pruned coastal scrub or shrubby coastal heath	17	22	0	888
172. Tall or wind-pruned scrub	17	22	0	888
173. Tall wet scrub	17	22	0	888
174. Talus, boulder-fields, rock-plates	57	0	58	58
175. Tea tree forest	17	18	19	888
176. Undifferentiated dry scrub	17	0	0	888
177. Urban areas	65	66	69	69
178. Water, sea	37	0	0	37
179. Weed infestation	30	0	0	30
180. Western alpine heathland	17	26	0	888
181. Western subalpine scrub	17	0	0	888
182. Western wet scrub	17	22	0	888
183. Wet heath	17	22	0	888
184. Wetland	1	0	0	888
185. Wingaroo scrub complex	17	22	0	888