Corangamite Soil Health Strategy

Identifying processes threatening assets and setting priorities.

Background report

July 2006

Geology department
School of Science and Engineering

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The authors acknowledge Warren Feltham, Tony Miner, John Turner, and Cam Nicholson for their contributions of data and the members of the Corangamite Soil Health Strategy Steering Committee for their advice.

Published by the Corangamite Catchment Management Authority, 2006
64 Dennis Street
Colac Victoria 3250
Website: http://www.ccma.vic.gov.au

First edition: May 2006

Preferred bibliographic citation:
Dahlhaus P.G. & Clarkson T. 2006. Corangamite Soil Health Strategy: Identifying processes threatening assets and setting priorities. *Background Report, Corangamite Soil Health Strategy,* Corangamite Catchment Management Authority, Colac Victoria.

The National Library of Australia Cataloguing-in-Publication entry:

ISBN

Corangamite Soil Health Strategy 2006

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Cover Photo: Waterways and coastal assets are threatened by gully erosion and the uncontrolled dumping of fill, near Clifton Springs, Bellarine Peninsula (Warren Feltham, April 2005)

Executive Summary

The Corangamite Soil Health Strategy (SHS) aims to improve the health of the soil resources in the Corangamite region and minimise the threat that soil degradation processes pose to the region's assets. This background report aims to identify those processes threatening assets and determine the priorities for investment in soil health actions.

An assets-based approach is used to identify the potential soil-related threats to a variety of assets within each Landscape Zone of the Corangamite region. Where they can be spatially delineated, the potential soil related threats are intersected with particular assets using Geographic Information System (GIS) methods. The methods and results are limited by the available data, as not all soil-related threats are spatially mapped, and not all assets are adequately identified. Even for those where data exists, the quality and spatial resolution of the data sets can still limit their accuracy. Despite these limitations, the method is effective in identifying the specific locations in each Landscape Zone where the assets are potentially threatened by soil degradation processes.

The priorities for investment in soil health management were established using the statistics generated in the GIS analysis to identify the relative risk to the assets potentially threatened by soil processes. The size of the potential threat to the asset was determined using the GIS and quantified in terms of area (hectares) or number of incidences. A relative value was assigned to the assets and combined with a relative severity of the threatening process to provide a relative impact of the threat to the asset. These relative values were assigned with the participation of the Soil Health Strategy Steering Committee. The relative risk to the asset was then calculated by the product of the size of the potential threat and the relative impact on the asset.

For each Landscape Zone the relative risk has been reviewed with consideration of the type of asset at risk and the final priority ranking takes into account the relative risk, the benefit cost values and the significance of the assets at risk. The final evaluation was endorsed by the Soil Health Strategy Steering Committee at a meeting on May 3rd 2006.

The assessment of the relative risk to assets from soil-related threatening processes presented in this report is the limited by the accuracy, resolution and types of available data. However, the asset-based framework is based on that recommended by DSE (2006) and the methods are repeatable when new or improved data is made available. Sensitivity testing demonstrates that the priority setting method is robust, as the identified priorities do not significantly change when the weightings are altered. Within the limits of the data, the process provides an objective assessment of priorities for investment in soil health management in the Corangamite region.

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1 Introduction

The Corangamite Regional Catchment Strategy (RCS) provides the guidelines and framework for investment in catchment health, including soil health. In the RCS, the economic, environmental and social assets have been identified along with broadly stated priorities for action by government, communities and individuals (CCMA, 2003). Soil related issues are recognised as a threat to various assets, especially surface water quality, land use, infrastructure and vegetation.

The Corangamite Soil Health Strategy (SHS) aims to improve the health of the soil resources in the Corangamite region and minimise the threat that soil degradation processes pose to the region's assets. This background report aims to identify those processes threatening assets and determine the priorities for investment in soil health actions.

The threatening processes related to soil health were initially identified in a background paper by MacEwan (2003) and include soil structure decline, soil erosion, waterlogging, nutrient management, soil salinity, soil acidification, acid sulphate soil, soil contamination and management of soil organic matter and biota.

1.1 Soil Health management areas

The SHS has adopted the Corangamite 'Landscape Zones' as the basis for disaggregating the regional landscapes to manage soil health. The Landscape Zones were originally developed for the Corangamite waterways management, and have since become *de facto* the regions for catchment management (Figure 1.1).

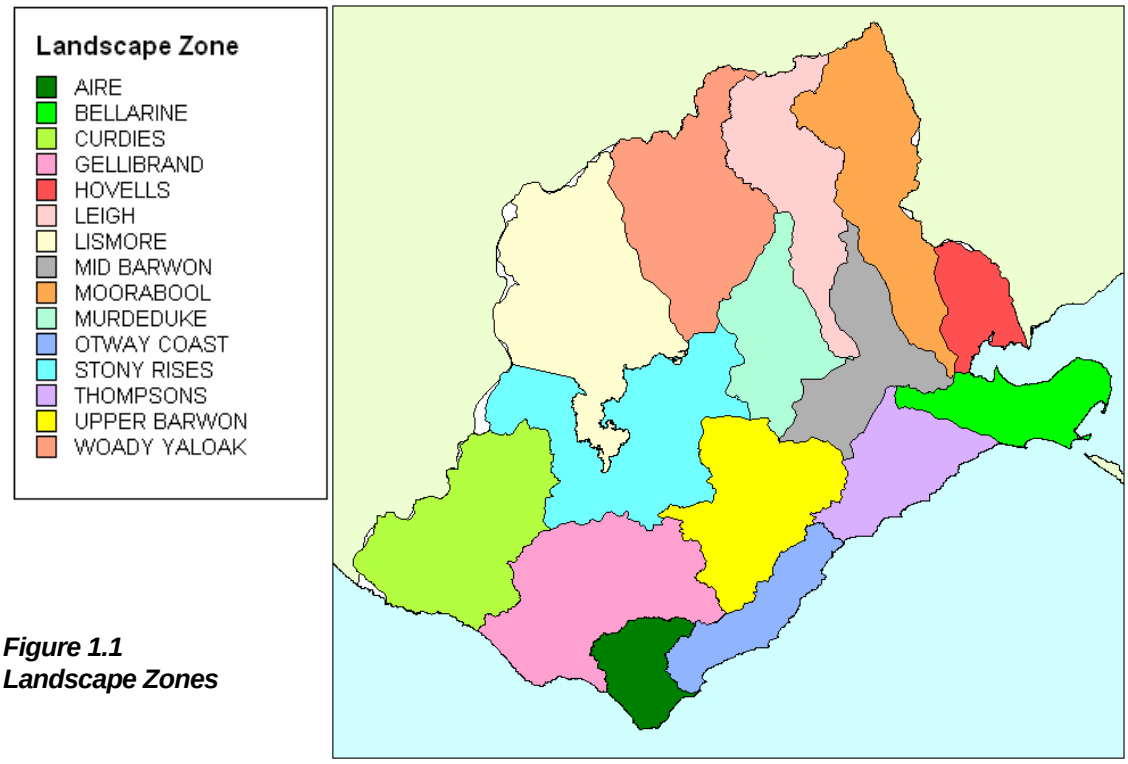


Figure 1.1
Landscape Zones

Although Landscape Zones are not the ideal landscape components to manage soil health, the alternative – soil-landform units – are considered too numerous and fragmented for strategic planning of management actions. The soil-landform units are considered more appropriate for the subsequent development of management action plans to address the identified soil-related threats within each Landscape Zone, and should be considered in the management of soil and land degradation at the local area scale.

1.2 Identifying the potential threat to assets

In October 2003, a workshop of technical experts on regional soil health and managers of regional catchment assets, identified the main soil threats to the economic, environmental and social assets for each Landscape Zone. The threats were rated according to their impact and importance to the asset manager, on both privately owned assets and public assets (Table 1.1). The knowledge gained at the workshop was useful in identifying specific assets and soil issues, the perceived threats to assets, and the relative importance of the issue. However, it was also subject to the interests and knowledge of the selected participants, their perception of threats and assets, and the arguments presented on the day.

This project builds on the asset-threat knowledge by using a more objective method to identify the potential soil-related threats to a variety of assets within each Landscape Zone. Where they can be spatially delineated, the potential soil related threats are intersected with particular assets using Geographic Information System (GIS) methods. The methods and results are limited by the available data, as not all soil-related threats are spatially mapped, and not all assets are adequately identified. Even for those where data exists, the quality and spatial resolution of the data sets can still limit their accuracy. Despite these limitations, the method is effective in identifying the specific locations in each Landscape Zone where the assets are potentially threatened by soil degradation processes.

1.3 Setting priorities

The output from the GIS analysis provides not only the locations of the potential threats to assets, but also quantifies the threat. This project has used these statistics to identify and rank the priority issues within each Landscape Zone, and between the fifteen Landscape Zones, to guide investment in soil health management. Although the analysis subjectively assigns weights to each threatening process, the method is objective in that the weightings are applied uniformly across the region.

The authors recognise that the process is limited by the incomplete data, the subjective weightings and the lack of field verification of the threat to assets. However, the method has provided an objective, repeatable process which can be used to determine the relative ranking of priority issues in each Landscape Zone, and the relative ranking of priorities between Landscape Zones. Improvements can be made to the priority setting framework when more complete data sets become available and more knowledge is gained regarding the value and distribution of assets, the distribution of threatening processes, their trends and impact on assets.

Landscape Zone	Threatening processes																
	1) Soil Structure Decline *1a) Cultivation*	1) Soil Structure Decline *1b) Compaction*	1) Soil Structure Decline *1c) Aggregate stability*	2) Waterlogging	3) Landslides	4) Water Erosion *4a) Sheet & rill erosion*	4) Water Erosion *4b) Gully & tunnel erosion*	5) Wind erosion	6) Nutrient deficiency	7) Excess Nutrients	8) Salinity	9) Acidification	10) Acid Sulfate Soils *10a) Inland*	10) Acid Sulfate Soils *10b) Coastal*	11) Contaminants	12) Organic Carbon Decline	13) Soil Biota Decline
Aire		private		public	private & public	private & public	private & public			public							
Bellarine					public			private	private	public	public	private		public	private		
Curdies		private		private	private & public		public			private & public							
Gellibrand		private		private	private & public	private & public				public							
Hovells						private & public	private & public	private	private	public	public						
Leigh							private & public		private	public							
Lismore	private	private	private	private					private	public	private & public						
Middle Barwon				private		public	public			public							
Moorabool						private & public	private & public			public							
Murdeduke	private	private	private	private					private	public							
Otway Coast					private & public					private & public							
Stony Rises		private							private	public	private & public						
Thompson					public		private & public		private			private					
Upper Barwon				private		private & public	private & public			public		private					
Woady Yaloak	private	private	private	private		public	public		private	public	public	private					

Table 1.1 Priority threats identified by technical experts as affecting both public (orange) and private (blue) assets in each Landscape Zone.

2 Methods

This project has been completed using two main components: the intersection of potential threatening soil processes with assets; and the analysis of the quantitative data to set priorities.

2.1 Data sources, types and quality.

The data used in the GIS analysis was obtained from a variety of sources, including the Corangamite Catchment Management Authority (CMA), Department of Sustainability and Environment (DSE), Department of Primary Industries (DPI), University of Ballarat and the author (PD). A full list is provided in Appendix A.

The data comprises three distinct types: factual data, derived data and interpretative data.

- **Factual data** includes the located polygons, lines and points representing an asset (lake, road or stream) or threatening process (landslide or gully). This data provides the highest resolution data for targeting the exact intersection of the asset and threat.

- **Derived data** is either interpolated or classified from factual data, such as land-use polygons classified from satellite imagery or aerial photographs. Derived data is useful for determining areas of interest, but cannot generally be used to specify locations.

- **Interpretative data** layers are those where a value is assigned to a particular landscape parameter, usually delineated as a polygon, to represent the data value. As an example, landform units are assigned a number to indicate their susceptibility to soil waterlogging, soil structure decline or soil acidification. Interpretative data provides a much broader intersection of threats and assets, compared to factual or derived data.

2.2 Intersecting assets and potential threats

The intersection of assets with soil related threatening processes was undertaken using MapInfo GIS (version 8), with Vertical Mapper (version 3.1) and Encom Discover (version 7.1) as additional tools. The Spatial Query Language (SQL) tool in MapInfo allows for three main types of queries, known as *contains* (object A *contains* object B if B's centroid is anywhere within A's boundary); *within* (object A is *within* object B if its centroid is within B's boundary); and *intersects* (object A *intersects* object B if they have at least one point in common). An SQL query can be written to instruct the program to count objects, sum the area or perimeter of objects (and other functions), and report the results in a particular order.

Care was required to ensure that the SQL queries did not misrepresent the data by reporting a misleading result. For example, where two polygons - gully erosion polygon and native vegetation with very high conservation significance potential - intersected, the area of native vegetation potentially threatened by the gully was reported as the overlapping area of the polygons. Whereas if the gully intersected the 50 metre buffer zone alongside a waterway, then the area of the entire gully was counted as the threat to the waterway.

The results of the GIS analysis were recorded in spreadsheet using Microsoft Excel (version 2002), which is included in electronic format in Appendix B. The results are also recorded for each Landscape Zone in Section 3 of this report.

In the GIS analysis, it was recognised that each process may not potentially threaten each asset. For example, soil waterlogging may not be a threat to a wetland and it could be argued that a loss of soil waterlogging would be more threatening. As a guide, the relationship of assets to potential threatening processes was determined at a meeting of the Corangamite SHS Steering Committee as tabulated overpage (Table 2.1).

Data type	Data type	Derived					Factual			
	Asset	**Cropping**	**Grazing**	**Horticulture**	**Forestry**	**Native vegetation**	**Public land**	**Wetlands**	**Waterways**	**Roads**
	Threat									
Factual	**Gully erosion**	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Sheet/rill erosion	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Landslides	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Secondary salinity	✓	✓	✓	✓	✓	✓	✓	✓	✓
Interpretative	**Potential acid sulphate soils**					✓	✓	✓	✓	✓
	Wind erosion	✓	✓	✓	✓					
	Soil structure decline	✓	✓	✓	✓					
	Soil waterlogging	✓	✓	✓	✓					
	Soil nutrient decline	✓	✓	✓	✓					
	Soil acidification	✓	✓	✓	✓					

Table 1.2 The asset – threat matrix used to quantify the results.

The ticks in the coloured boxes indicate which potential threatening processes have been intersected with which assets in the GIS analysis.

3 Potential threats to assets in each Landscape Zone

This section describes the land use, assets and potential threatening processes in each Landscape Zone. The full set of statistics is included as an Excel spreadsheet in Appendix B.

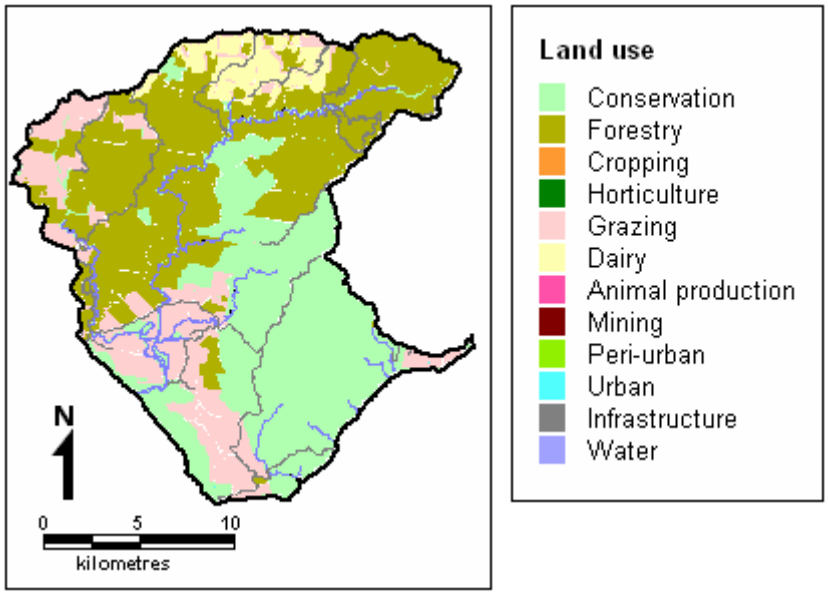
The descriptions are limited by the quality and currency of the available data. Land use is taken from the DPI layer, derived from remote sensing and aerial photography dated from 1999 to 2002, with most data relating to the 2000 – 2001 period. Naturally, the spatial cover of various land-uses, especially grazing and cropping, dramatically changes on an annual basis. The roads and waterways have been taken from the digital VicMap 1:25,000 topographic sheets, which vary in date from the 1970s to the 1990s. Recently constructed roads, especially in urban and peri-urban centres are not included in the statistics. Wetlands are taken from the 1994 statewide coverage, the public land from the 2003 statewide coverage, and the native vegetation from the 2006 DSE layer.

For ease of navigation in the electronic copy of this report, the descriptions for each Landscape Zone are hyperlinked below:

Aire Landscape Zone

35319 hectares or 2.6% of CCMA region

60% public land



Land use (2000 – 2002)

Land use	number of mapped polygons	total area hectares	total area percentage
Conservation	138	13017.9	36.9
Forestry	92	14005.0	39.7
Dairy	37	1773.5	5.0
Grazing	151	5780.0	16.4
Peri-Urban	2	1.1	0.0
Urban	6	11.5	0.0
Total	**426**	**34589**	**97.9**

Assets

- Many of the 989 km of waterways are high value assets because of their pristine condition. In particular, the Aire River estuary is a highly valued environmental asset.
- 4 wetlands (0.2% of area)
- Native vegetation conservation significance potential: 17.8% of total Landscape Zone is rated as Very High, 5.4% of total Landscape Zone is rated as High.
- 152 km roads, including the Great Ocean Road
- Otway Ranges National Park, Cape Otway coastline and associated marine parks
- Cultural and heritage assets including shipwrecks and Cape Otway lighthouse.

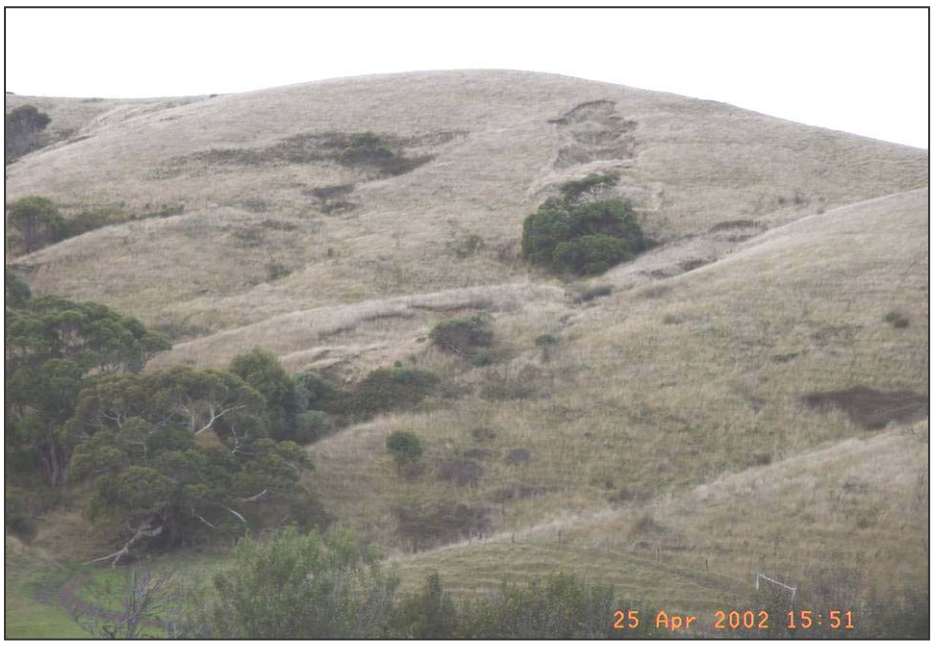
Threats

To public assets

- Landslides. Eighty-three landslides occur within 50 m of a waterway in the upper Aire River valley, the West Branch of the Ford River, and the lower Aire River in the Horden Vale district.
- Soil erosion by water. Five sheet/rill erosion sites are mapped within 50 m of a waterway, and one intersection with native vegetation of high conservation significance potential. The risk of sediment input through erosion of the upper Aire River is considered high. The high turbidity following rainfall events may contribute nutrients and degrade water quality.
- Potential Acid Sulphate Soils. Approximately 465 ha of native vegetation with very high conservation significance value intersects with potential acid sulphate soils in the coastal region, as do 5 wetlands (60 ha). Potential acid sulphate soils have been mapped within a 50 metre buffer of nearly 300 km of waterways and 7 km of roads.

To private assets

- Susceptibility to soil structure decline. Ninety-eight hectares of dairy land is highly susceptible to soil structure decline in the Little Aire Creek valley, 3,016 ha of grazing land highly susceptibly to structural decline in the Horden Vale, Glenaire and Johanna Heights area.
- Susceptibility to soil waterlogging. About 1187 ha of grazing land is highly susceptible to soil waterlogging in the Cape Otway, Horden Vale, and Glen Aire areas.
- Landslides. Seventeen landslides are mapped in dairy land mostly in the Weeaproinah – Wyelangta area, 43 landslides are mapped on grazing land mostly in the Horden Vale - Glenaire district and the Johanna Heights – Lavers Hill district.
- Soil erosion by water. The occurrences are relatively minor when compared to other Landscape Zones. Six sheet/rill erosion sites are mapped on dairy land and 14 sheet/rill erosion sites are mapped on grazing land.

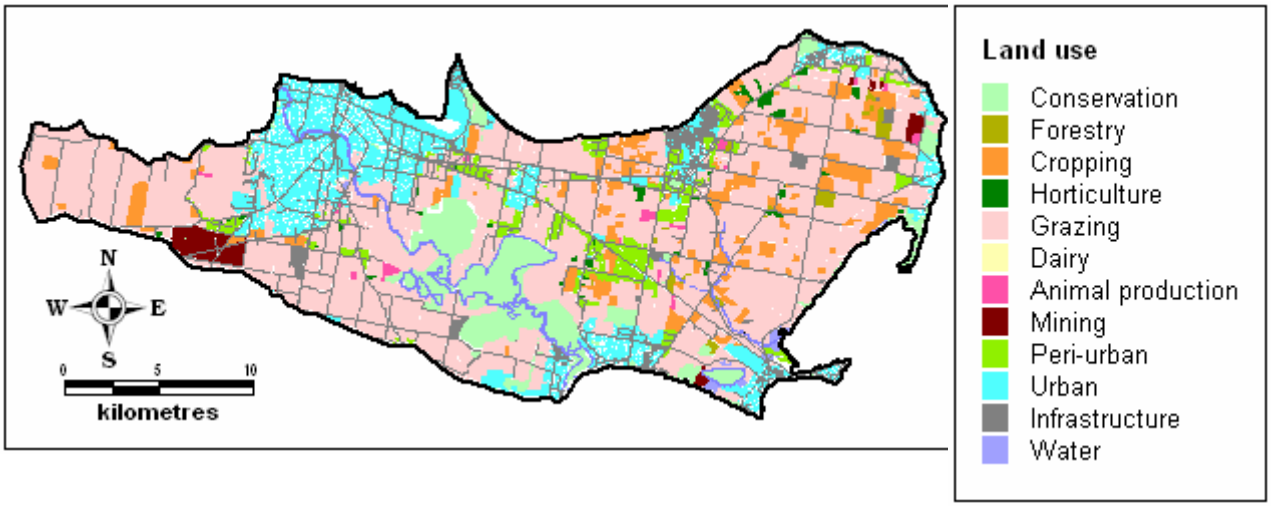


Landslides in the Horden Vale district

Bellarine Landscape Zone

53625 hectares or 4.0% of CCMA region

11% public land



Land use (2000 – 2002)

Land use	number of mapped polygons	total area hectares	total area percentage
Animal production	20	290.8	0.5
Conservation	429	5378.3	10.0
Cropping	128	3856.2	7.2
Forestry	18	357.8	0.7
Grazing	339	28004.7	52.2
Horticulture	42	449.7	0.8
Infrastructure	147	663.6	1.2
Mining	12	741.8	1.4
Peri-urban	180	2462.4	4.6
Urban	2412	7754.2	14.5
Water	11	196.8	0.4
Total	3738	50156.17	93.5

Assets

- 425 km of waterways, including the lower Barwon River in Geelong.
- 139 wetlands (9.6% of area), including wetlands of international, national, state and local significance. The Lake Connewarre game reserve is highly ranked.
- Native vegetation conservation significance potential: 9% of total Landscape Zone is rated as Very High, 14% of total Landscape Zone is rated as High.
- At least 1243 km roads, not including many of the urban roads in more recent subdivisions.
- Major provincial City of Greater Geelong, including industrial and port facilities.
- Coastline and marine parks.
- Cultural and heritage assets include many aboriginal archaeological sites and Victoria's early pastoral settlement history.

Threats

To public assets

- Landslides. Nine landslide intersections with waterways and five landslides occur on public land. Infrastructure and coastal assets are threatened along the northern coast of the Bellarine Peninsula east of Point Henry (i.e. the Curlewis Monocline), especially at Clifton Springs. Landslides also threaten infrastructure and waterways at Waurn Ponds, rockfalls are prevalent along the coast at Point Lonsdale and Barwon Heads.
- Soil erosion by water. Sediments and nutrients are contributed to Lake Connewarre and lower Barwon River wetlands by stormwater runoff and erosion in the higher catchment areas. Twenty-seven gullies (76.4 ha) and seven sheet erosion sites (26 ha) occur within a 50 m buffer of waterways.
- Secondary salinity. Approximately 300 ha of secondary salinity have been mapped. Secondary salinity threatens 42 ha of native vegetation with very high conservation significance potential and 119 ha of native vegetation with high conservation significance potential, as well as 3 km of waterways and 2.5 km of roads. The majority of the secondary salinity fringes the primary salinity sites, especially the wetlands.
- Potential acid sulphate soils. Sixty-eight polygons of potential acid sulphate soils have been mapped, totalling 4,112 ha (7.7% of area), mostly in coastal and estuarine wetlands of the lower Barwon River and estuary. Potential for disturbance is highest in the Point Henry environs. Over 2,000 ha of native vegetation with high or very high conservation significance potential are intersected, along with 2,170 ha of wetlands, 46.5 km of waterways (465 ha within a 50 m buffer) and 57 km of roads (571 ha within a 50 m buffer).

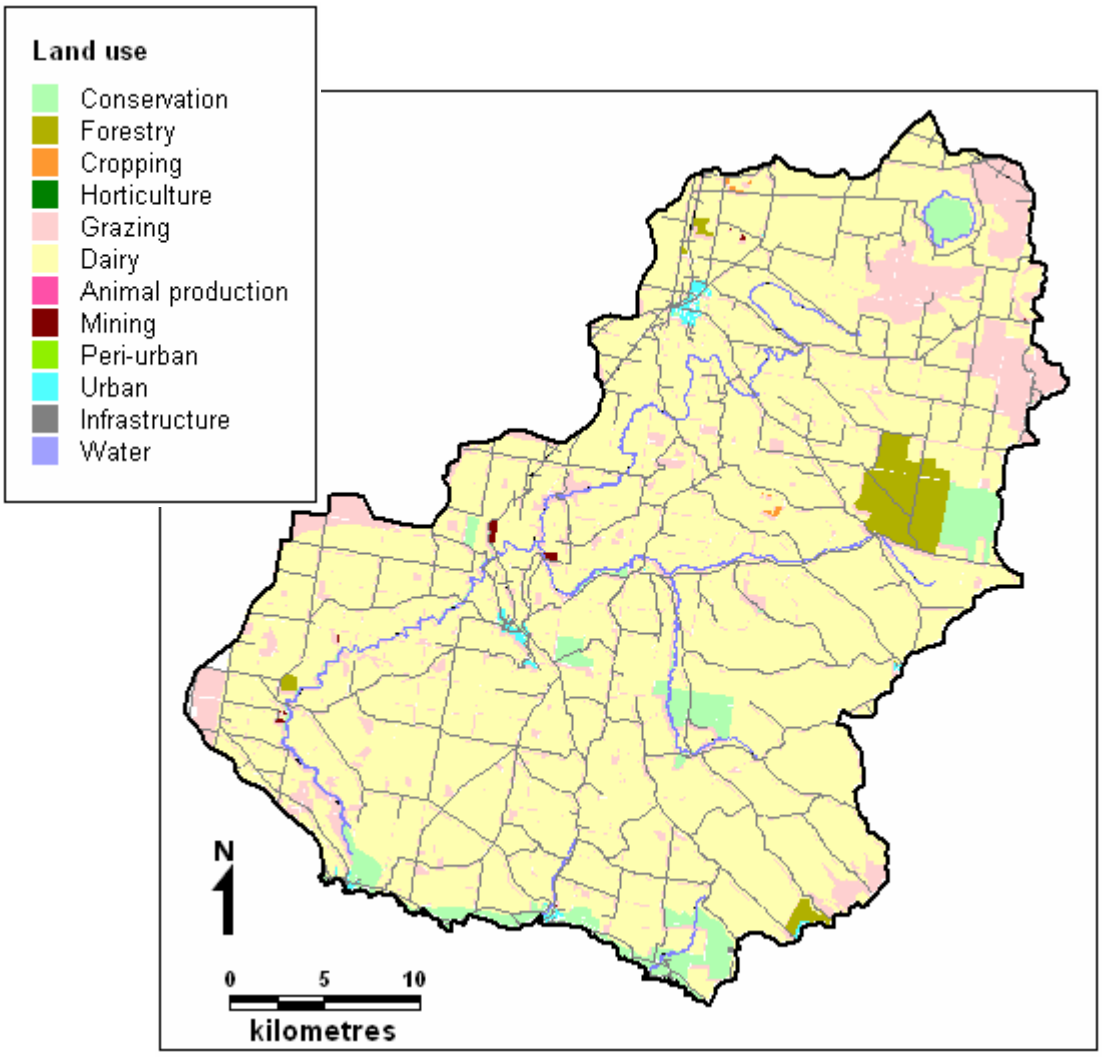
To private assets

- Susceptibility to soil erosion by wind. Over 10,000 ha of the Landscape Zone are highly susceptible to wind erosion, mostly in the Wallington, Drysdale, Bellarine, Indented Head and St Leonards areas. Coastal dune movement is prevalent in the Queenscliff, Point Lonsdale, Ocean Grove and Barwon Heads areas.
- Susceptibility to soil nutrient decline. Over 8,000 ha of grazing land and 1,400 ha of cropping land with sandy soils (developed on the marine sands of Pliocene age) on the Bellarine Peninsula (Bellarine Horst) are highly susceptible to nutrient decline under agricultural production.
- Susceptibility to soil acidification. The same sandy soils that are susceptible to soil nutrient decline are also susceptible to soil acidification.
- Contaminants. At least 41 known sites scattered across the Bellarine Peninsula, east of an arc through Point Henry – Moolap – Barwon Heads.
- Susceptibility to soil structure decline. Nearly all of the land used for agriculture is highly susceptible to soil structure decline (23,000 ha), with the exception of the soils developed on the elevated volcanic landscapes around Mount Drysdale.
- Susceptibility to soil waterlogging. Approximately 1,435 ha of agricultural land are very highly susceptible and 18,875 ha are highly susceptible to soil waterlogging. The vast majority are the grazing lands in the low elevation landscapes of the Moolap Sunkland, along the lower Barwon River estuary.
- Soil erosion by water. Twenty-seven gullies (76 ha) and seven sheet erosion sites (24 ha) occur on agricultural land, almost all of which are on the grazing land on the edges of the elevated part of the Bellarine Peninsula (i.e. the Bellarine Horst).

Curdies Landscape Zone

119393 hectares or 9.0% of the CCMA region

6.6% public land



Land use (2000 – 2002)

Land use	number of polygons mapped	total area hectares	total area percentage
Conservation	144	4969.2	4.2
Cropping	7	47.0	0.0
Dairy	449	97040.0	81.3
Forestry	13	2379.0	2.0
Grazing	586	13263.1	11.1
Infrastructure	4	20.7	0.0
Mining	12	118.0	0.1
Urban	150	437.8	0.4
Water	1	2.0	0.0
Total	1366	118276.7	99.1

Assets

- 1891 km of waterways including the Curdies River and estuary.
- 93 wetlands (1.3% of area) including Lake Purrumbete.
- Native vegetation conservation significance potential: 6.6% of total Landscape Zone is rated as Very High, 10.2% of total Landscape Zone is rated as High.
- 876 km roads including a section of the Great Ocean Road
- Coastline including beaches, coastal cliffs and sea stacks (eg. Bay of Islands), marine sanctuary and marine parks which include significant cultural and heritage assets (eg. shipwrecks).

Threats

To public assets

- Landslides. At least 287 landslides occur within a 50 m buffer of waterways, especially along Scotts Creek, Curdies River, Cowley Creek and Port Campbell Creek (at least 4895 ha). Roads are known to be at risk (e.g. Port Campbell – Cobden Road, Williams Rd) and 46 landslides are mapped on public land. Rockfalls and landslides threaten coastal assets including the sea cliffs and areas of high scenic and recreational value.
- Soil erosion by water. There are 13 intersections of mapped gullies within 50 m of a waterway, especially in tributaries of the upper catchment of the Curdies River and Scotts Creek. Sediment and nutrient export to the Curdies Inlet is of concern, with dairy effluent and runoff from fertilised pastures and farm tracks being targeted as the most likely sources. Stream erosion forms deeply incised gullies along the coastal cliffs near Port Campbell.
- Potential acid sulphate soils. Potential acid sulphate soils intersect with 68 ha of native vegetation with very high and high conservation significance potential, 32 ha of wetlands, 22 km of waterways (219 ha within a 50 m buffer) and 1.6 km of roads. Most intersections are along the lower Curdies River and estuary.
- Secondary salinity. Secondary salinity affects 4.7 ha of public land (near Scotts Creek), 31 ha of native vegetation with very high and high conservation significance potential, 119 ha within 50 m of a waterway and 24 ha within 50 m of a road.

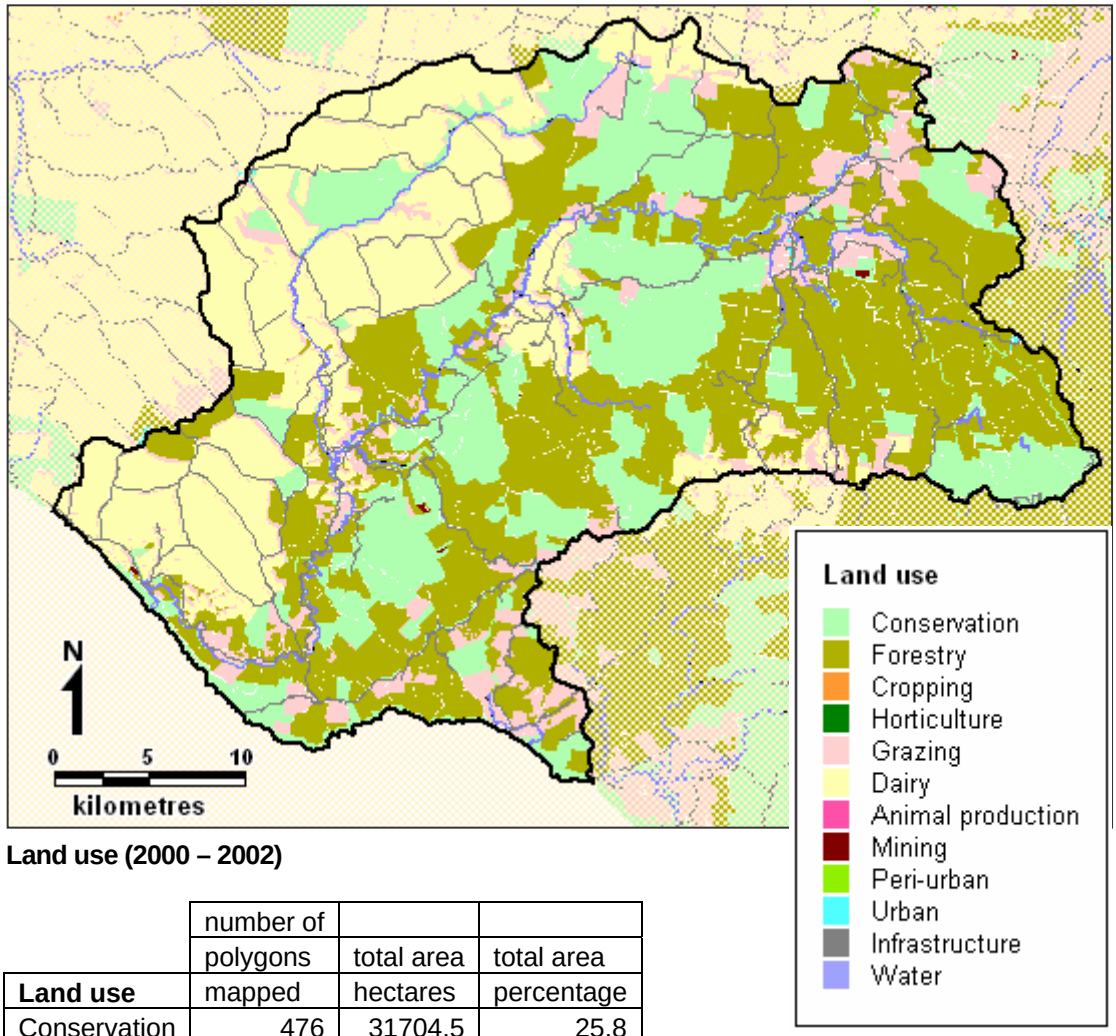
To private assets

- Susceptibility to soil structure decline. Nearly 80% (77,087 ha) of dairy land and 49% (6,500 ha) of grazing land is highly susceptible to soil structure decline. Soil pugging (or poaching) by animals is the primary cause of soil structure decline, with the clay soils (Gellibrand Marl) of the Heytesbury Settlement worst affected.
- Susceptibility to soil waterlogging. About 12% (11,520 ha) of dairy land is very highly susceptible to waterlogging and 75% (73,049 ha) is highly susceptible to waterlogging. The most severe threat is in the area around Waarre, Cooriemungle and Simpson. Of the grazing lands, 5% (642 ha) are very highly susceptible to waterlogging and 52% (6,861 ha) are highly susceptible to waterlogging.
- Landslides. At least 429 landslides have been mapped on dairy land (4665 ha), ranging up to 150 ha in size. Most occur west of Simpson around Scotts Creek and Cowleys Creek, also Cooriemungle, Newfield and Port Campbell. Eighteen are mapped on grazing land.
- Susceptibility to soil nutrient decline. Of the land used for dairy farming, around 300 ha are very highly susceptible and over 30,000 ha are highly susceptible to nutrient decline under agricultural production. These are mostly the sandy loams and coffee-rock soils around Simpson, Jancourt, Timboon, Nirranda, Peterborough and Curdie Vale.
- Secondary salinity. Secondary salinity affects around 330 ha of dairy lands and 30 ha of grazing land, mostly as small outbreaks in the lower slopes of the Heytesbury Settlement.

Gellibrand Landscape Zone

122,943 hectares or 9.2% of CCMA area

50.2% public land



Land use (2000 – 2002)

Land use	number of polygons mapped	total area hectares	total area percentage
Conservation	476	31704.5	25.8
Dairy	181	29229.3	23.8
Forestry	585	47038.1	38.3
Grazing	460	11750.1	9.6
Infrastructure	6	2.0	0.0
Mining	10	64.6	0.1
Urban	38	86.9	0.1
Water	1	0.7	0.0
Total	1757	119876.2	97.5

Assets

- 3107 km of waterways including the Gellibrand River and coastal wetlands.
- 47 wetlands (0.3% of area) with the coastal wetlands of the lower Gellibrand River as significant assets.

- Native vegetation conservation significance potential: 11.0% of total Landscape Zone is Very High, 17.1% of total Landscape Zone is High. Many of these are included in National Parks and State Parks.
- 548 km roads including part of the Great Ocean Road.
- Coastal assets include beaches, coastal cliffs, sea stacks (i.e. the Twelve Apostles), marine parks and sanctuary, cultural and heritage assets (including aboriginal archaeological sites, shipwrecks and buildings).

Threats

To public assets

- Landslides. There are 392 intersections (at least 3308 ha) of mapped landslides within 50 m of waterways, especially the Lower Gellibrand River tributaries (LaTrobe Creek, Boggy Creek), Johanna River and Stafford Creek, and the headwaters of the Kennedy Creek system. Roads are known to be at risk (e.g. Princeton – Simpson Rd) and considerable efforts have been made at stabilisation. There are 242 landslides mapped on public land.
- Soil erosion by water. Three gullies and 26 sheet/rill erosion sites are mapped within 50 m of a waterway, as relatively small sized incidences in the tributaries to Kennedys Creek and the Gellibrand River. Sediment and nutrient export to the Kennedys Creek system and the Lower Gellibrand River tributaries (LaTrobe Creek, Boggy Creek) is of some concern, with the likely sources being runoff from fertilised pastures and farm tracks, and dairy effluent.
- Potential acid sulphate soils. Potential acid sulphate soils (both coastal and inland) are mapped on 172 ha of public land, and intersect around 350 ha of native vegetation with very high or high conservation significance potential, 220 ha of wetlands, 28 km of waterways and 20 km of roads. The vast majority occur along the lower Gellibrand River and associated coastal wetlands.
- Secondary salinity. Secondary salinity affects 35 ha of public land in the lower Gellibrand River, and 103 ha of native vegetation with very high or high conservation significance potential, 105 ha of wetlands, 114 ha within 50 m of a waterway and 6.6 ha within 50 m of a road. The majority occurs along the lower Gellibrand River, north of Princetown and as small outbreaks in the Kennedys Creek catchment.

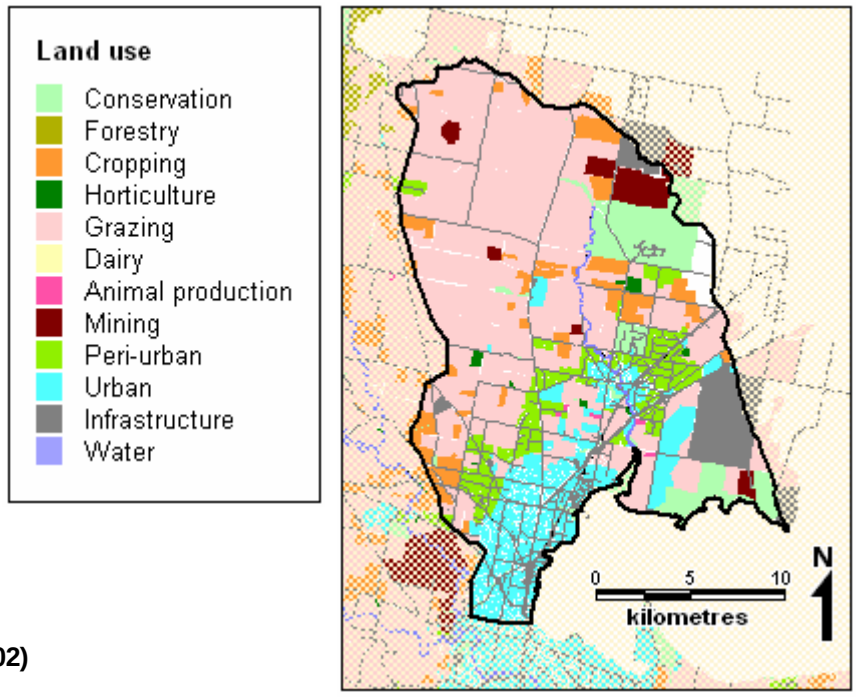
To private assets

- Susceptibility to soil structure decline. Approximately 86% (25,066 ha) of dairy land and 63% (7,370 ha) of grazing land is highly susceptible to soil structure decline, mostly by soil pugging of the wet soils in the Heytesbury Settlement.
- Susceptibility to soil waterlogging. Around 37% (10,920 ha) of dairy land is very highly susceptible to waterlogging, 30% (8,792 ha) is highly susceptible to waterlogging; and 16% (1891 ha) of grazing land is very highly susceptible to waterlogging, 15% (1761 ha) is highly susceptible to waterlogging. The most severe threats are in the areas east of Simpson, north of Kennedys Creek and around Princetown.
- Landslides. On land used for dairying, 129 landslides have been mapped, up to 200 ha in size. Most occur east of Simpson around Kennedys Creek and in the Princetown area. One dairy farm (house, dairy, sheds) is known to have been destroyed by a landslide. There are 80 landslides mapped on grazing land.
- Soil erosion by water. A few gully erosion sites and 11 sheet/rill sites have been mapped on dairy land, and 21 sheet/rill sites on grazing land. Although they cover a relatively small total area (~ 100 ha), they but may be underestimated by the mapping techniques.
- Secondary salinity. Approximately 60 ha of dairy and 60 ha of grazing land are affected on the eastern side of the Landscape Zone, bordering the Heytesbury Settlement.

Hovells Landscape Zone

36480 hectares or 2.7% of CCMA area

9.6% public land



Land use (2000 – 2002)

Land use	number of polygons mapped	total area hectares	total area percentage
Animal production	5	63.5	0.2
Conservation	202	3088.4	8.5
Cropping	49	2448.5	6.7
Forestry	2	0.0	0.0
Grazing	145	18442.0	50.6
Horticulture	10	176.4	0.5
Infrastructure	31	1815.3	5.0
Mining	8	972.5	2.7
Peri-urban	98	2730.0	7.5
Urban	1236	4493.0	12.3
Total	1786	34229.6	93.8

Assets

- 251 km of waterways with Hovells Creek and Limeburners Bay as the most significant.
- 44 wetlands (3.0% of area), includes Ramsar and significant wetlands around Point Lillias and Point Wilson.
- Native vegetation conservation significance potential: 16.1% of total Landscape Zone is Very High, 10.4% of total Landscape Zone is High.
- At least 694 km roads, not including many of the more recent suburban roads in Lara and Geelong.
- Portions of the major provincial City of Greater Geelong, including significant urban and industrial infrastructure.

- Cultural and heritage assets include aboriginal archaeological sites and historical sites associated with the early pastoral settlement of Victoria.

Threats

To public assets

- Soil erosion by water. There are 15 intersections (51 ha) of mapped gullies with waterways and 41 intersections (72 ha) of mapped sheet/rill erosion and waterways, all in the headwaters of Hovells Creek, especially on the flanks of the You Yang Ranges. These have the potential for sediment and nutrient export to Limeburners Bay, especially when added to the decreased water quality associated with the urban development of Lara (flooding and stormwater disposal). There are 8 intersections of mapped gully erosion (22 ha) and 31 intersections of mapped sheet/rill (29 ha) with native vegetation of very high conservation status and 2 gully intersections and 12 sheet/rill intersections with native vegetation of high conservation status potential. Most occur along the flanks of the You Yang Ranges and along the creek lines of tributaries to Hovells Creek. Roads intersect with 7 mapped gully erosion sites and 17 mapped sheet erosion sites with the largest along Sandy Creek Road and Granite Road. Seven sheet erosion sites (6 ha) have been mapped on public land.
- Secondary salinity. Secondary salinity has been mapped on 16 ha of public land (Avalon airport and Serendip sanctuary). Secondary salinity also intersects with nearly 40 ha of native vegetation with high and very high conservation significance potential, 46 ha of wetlands. Around 31 ha occur within 50 m of a waterway and 19 ha within 50 m of a road.
- Potential acid sulphate soils. Potential acid sulphate soils have been mapped on 201.7 ha of public land, the vast majority occurs in the coastal and estuarine wetlands around Limeburners Bay, Point Lillias and Point Wilson. Many of these are Ramsar and significant wetlands and rare species habitat (eg. Orange-bellied parrot). Approximately 250 ha of native vegetation with high and very high conservation significance potential, 535 ha of wetlands, 12.3 km of waterways and 14.5 km of roads also intersect with acid sulphate soils.

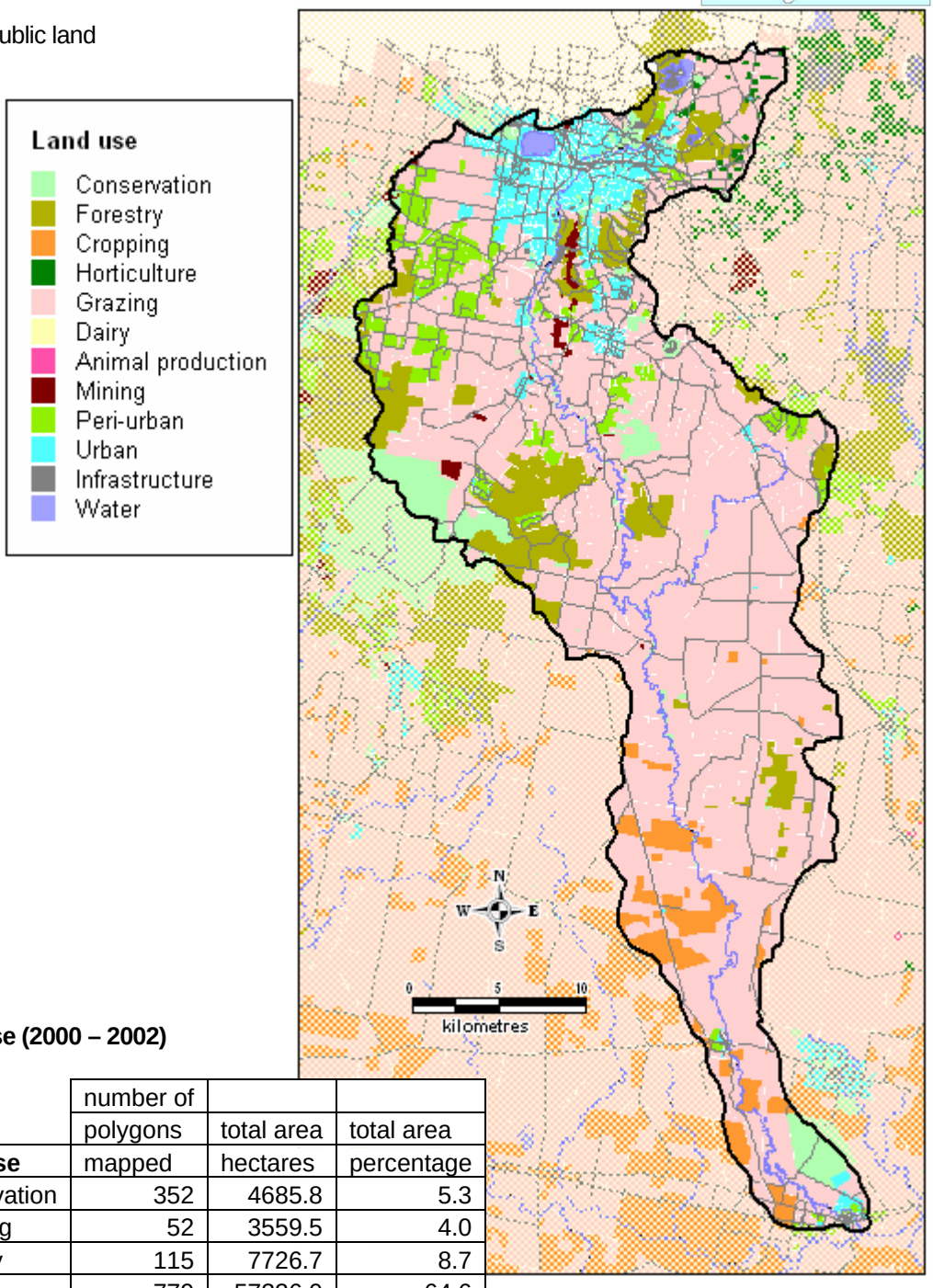
To private assets

- Soil erosion by water. There are 44 incidences (38ha) of sheet/rill erosion which have been mapped on grazing land along with 5 gullies (7 ha). Nineteen hectares of gully erosion at five sites threaten cropping land. Eroded mining/quarry land amounts to 29 ha.
- Susceptibility to soil nutrient decline. Over 370 ha of grazing land and 125 ha of cropping land are very highly susceptible and nearly 1600 ha of grazing land and 240 ha of cropping land are highly susceptible to soil nutrient decline. Most occurs along the sandy slopes of the granitic landscapes adjacent to the You Yang Ranges, and the sandy coastal plain on the edge of Corio Bay.
- Susceptibility to soil acidification. Soils of the sandy slopes of the granitic landscapes adjacent to the You Yang Ranges, and the sandy coastal plain on the edge of Corio Bay are also susceptible to soil acidification. The statistics are the same as for nutrient decline.
- Susceptibility to soil waterlogging. Approximately 15,846 ha of grazing land, 2,190 ha of cropping land and 164 ha of land used for horticulture are highly susceptible to soil waterlogging. This is nearly all of the volcanic soils in the Landscape Zone.
- Susceptibility to soil structure decline. Around 3,900 ha of grazing land, 1,040 ha of cropping land and 104 ha of land used for horticulture are highly susceptible to soil structure decline. The majority of the land is along the Hovells Creek valley from the You Yang Range to Limeburners Bay.

Leigh Landscape Zone

88765 hectares or 6.7% of CCMA region

16.7% public land



Land use (2000 – 2002)

Land use	number of polygons mapped	total area hectares	total area percentage
Conservation	352	4685.8	5.3
Cropping	52	3559.5	4.0
Forestry	115	7726.7	8.7
Grazing	779	57326.0	64.6
Horticulture	37	354.0	0.4
Infrastructure	132	517.2	0.6
Mining	29	506.9	0.6
Peri-urban	162	4358.2	4.9
Urban	1276	4779.9	5.4
Water	13	382.1	0.4
Total	**2947**	**84196.2**	**94.9**

Assets

- 1689 km of waterways, including the Leigh River and Leigh River Gorge.
- 74 wetlands (0.8% of area), including Lake Wendouree which has high recreational value.
- Native vegetation conservation significance potential: 5.2% of total Landscape Zone is Very High, 11.7% of total Landscape Zone is High.
- 1224 km roads, not including the more recently constructed urban roads in Ballarat.
- A portion of the provincial City of Ballarat, which includes significant educational facilities, industry, mining, transport corridors and heritage assets.

Threats

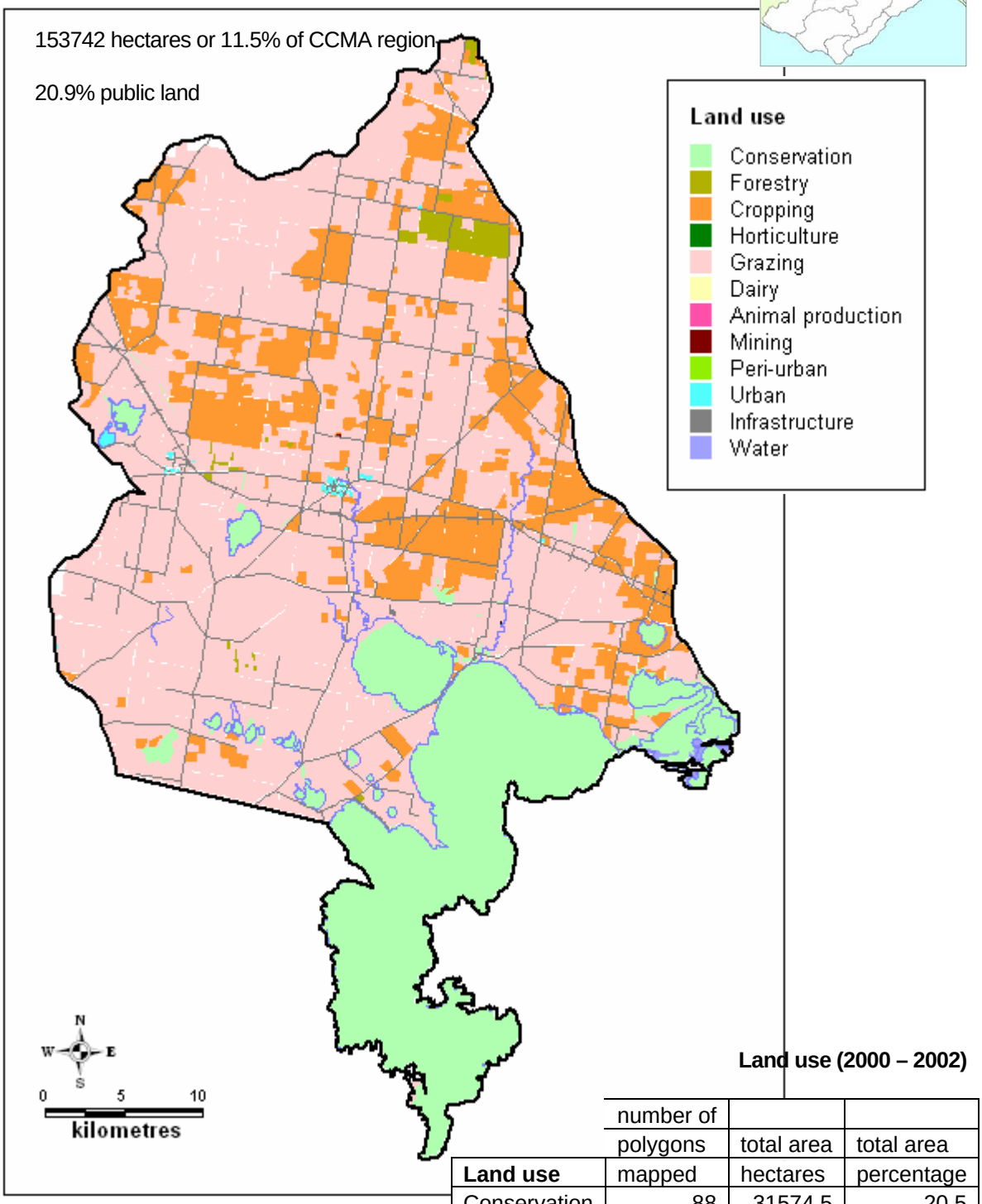
To public assets

- Soil erosion by water. There are 178 mapped gullies (260 ha) and 128 mapped sheet/rill erosion sites (197 ha) that intersect with waterways (50 m buffer). Most extensive occurrences are along Woodbourne Creek, lower Williamson Creek, the Yarrowee River downstream of Grenville, and the Leigh River. Fifty-five mapped gully sites (85 ha) and 47 mapped sheet/rill sites (59 ha) intersect with native vegetation with very high and high conservation significance potential. Thirteen road intersections with gullies (15 ha) and 10 with sheet/rill (12 ha) include the Mount Mercer – Meredith Road (at Woodbourne Creek), Bamganie Road and minor rural roads in the Grenville, Bamganie and Woodbourne districts. Fifteen gullies (77 ha) and 27 sheet/rill (69 ha) are mapped on public land.
- Secondary salinity. Secondary salinity has been mapped on 3.8 ha of public land (on or near the Buninyong Dredge Reserve). Nearly 300 ha of land within 50 m of a waterway, 31 ha of land within 50 m of a road and 66 ha of native vegetation with very high and high conservation significance potential intersect with the mapped secondary salinity.
- Potential acid sulphate soils. Potential acid sulphate soils intersect with 9 km of waterways, 2 km of road and 42 ha of high value native vegetation, mostly along the Yarrowee River.

To private assets

- Soil erosion by water. There are 162 gullies (240 ha) mapped on grazing land along with 127 mapped sheet/rill sites (203 ha). Almost all are in the Garabaldi, Grenville, Woodbourne and Bamganie districts. Other land uses (e.g. cropping, peri-urban, urban) record minor incidences (< 5 ha total).
- Susceptibility to soil waterlogging. Approximately 3100 ha of grazing land and 600 ha of cropping land are very highly susceptible to soil waterlogging, all of which occurs in the river flats of the lower Leigh River valley. Approximately 3600 ha of grazing land, 4500 ha of forestry land and 650 ha of cropping land are highly susceptible to soil waterlogging.
- Susceptibility to soil nutrient decline. The granitic landscapes north of Warrenheip include over 200 ha of grazing land and 145 ha of forestry land which is very highly susceptible to soil nutrient decline. The sedimentary hills and gravel caps in the northern and central eastern parts of the Landscape Zone comprise over 25,000 ha of grazing land, 8,500 ha of forestry land and 285 ha of cropping land which is highly susceptible to soil nutrient decline.
- Susceptibility to soil acidification. Much of the same country which is susceptible to soil nutrient decline is also susceptible to soil acidification. The only variation is that about half the area of soil (181 ha) is very highly susceptible (but the same area is highly susceptible).
- Susceptibility to soil structure decline. Nearly all of the agricultural land in the Landscape Zone - over 42,000 ha of grazing country, 7,000 ha of forest land and 1,000 ha of cropping country - is highly susceptible to soil structure decline.
- Susceptibility to soil erosion by wind. About 11,000 ha of grazing land on the sandier soils in the middle of the Landscape Zone are highly susceptible to wind erosion.

Lismore Landscape Zone



Land use (2000 – 2002)

Land use	number of polygons mapped	total area hectares	total area percentage
Conservation	88	31574.5	20.5
Cropping	229	26016.9	16.9
Forestry	24	1530.9	1.0
Grazing	402	90332.4	58.8
Infrastructure	23	163.5	0.1
Mining	1	5.6	0.0
Urban	55	308.3	0.2
Water	2	405.4	0.3
Total	**824**	**150337.4**	**97.8**

Assets

- 736 km of waterways and 187 wetlands (22.5% of area), including Ramsar and significant wetlands, such as Lake Corangamite.
- Native vegetation conservation significance potential: 0.9% of total Landscape Zone is Very High, 3.9% of total Landscape Zone is High.
- 622 km roads, including highways. Other infrastructure includes significant railway and power lines.
- Cultural and heritage assets, especially aboriginal archaeological sites associated with the lakes, waterways and wetlands.

Threats

To public assets

- Secondary salinity. Eighty-six sites totalling 1,973 ha of secondary salinity are mapped in the Landscape Zone. About 580 ha of secondary salinity occur on public land, almost all of which are around Lake Martin. Over 100 ha of native vegetation with very high and 160 ha with high conservation significance potential intersects with secondary salinity, with a scattered distribution. Over 345 ha of land within 50 m of a waterway and 43.5 ha of land within 50 m of a road are affected by secondary salinity.
- Potential acid sulphate soils. Potential inland acid sulphate soils intersect 100 ha of high value native vegetation, 215 ha of wetlands, 18 km of waterways, and 2 km of roads. All areas are associated with the margins of the wetlands in the southern portion of the Landscape Zone.

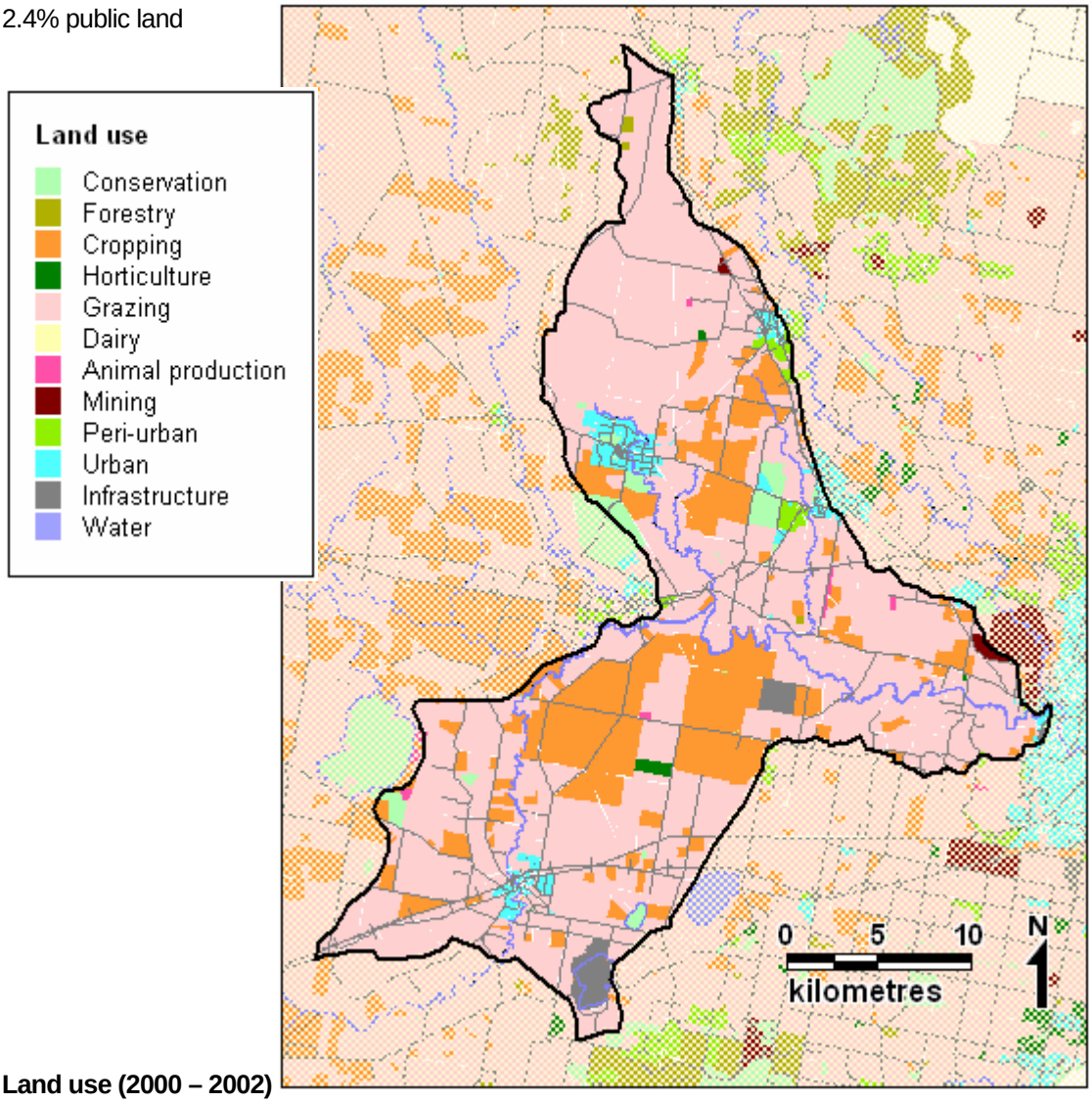
To private assets

- Secondary salinity. About 983 ha of grazing land and 85 ha of cropping land are affected by secondary salinity. Many areas fringing primary saline areas including wetlands are affected, especially around Lake Martin and Derrinallum.
- Susceptibility to soil structure decline. About 10% (2,723 ha) of cropping land and 24% (21,750 ha) of grazing land is highly susceptible to soil structure decline, especially around Leslie Manor, Lismore and Derrinallum.
- Susceptibility to soil waterlogging. Around 5% (1,379 ha) of cropping land and 12% (11,056 ha) of grazing land is very highly susceptible to waterlogging, mostly south of Lismore, Derrinallum and Cressy. Approximately 69% (17,980 ha) of cropping land and 59% (53,210 ha) of grazing land is highly susceptible to waterlogging, in widespread locations north west of Berrybank and west of Leslie Manor.
- Susceptibility to soil nutrient decline. Approximately 1133 ha of grazing country, 715 ha of cropping country and 100 ha of forest country are very high susceptible to soil nutrient decline, being almost all the granitic landscapes around Lismore and north west of Lismore. The sandy soils around Leslie Manor and Lake Gnarpurt are highly susceptible, including 13,640 ha of grazing land and 2158 ha of cropping land.
- Susceptibility to soil acidification. The soils susceptible to soil nutrient decline are also susceptible to soil acidification, with the same regions and statistics as above.
- Susceptibility to soil erosion by wind. The soils of 14,466 ha of grazing country and 1084 ha of cropping country are highly susceptible to wind erosion. These include the sandy soil plains around Leslie Manor and the alluvial clay pans associated with low-lying poorly drained areas such as ephemeral wetlands.

Mid Barwon Landscape Zone

70618 hectares or 5.3% of the CCMA area

2.4% public land



Land use (2000 – 2002)

Land use	number of polygons mapped	total area hectares	total area percentage
Animal production	7	167.2	0.2
Conservation	87	1483.4	2.1
Cropping	144	13979.8	19.8
Forestry	3	93.5	0.1
Grazing	238	49431.6	70.0
Horticulture	3	168.4	0.2
Infrastructure	57	1203.2	1.7
Mining	3	170.9	0.2
Peri-urban	28	444.0	0.6
Urban	189	1692.1	2.4
Total	**759**	**68834.1**	**97.5**

Assets

- 703 km of waterways including the Barwon River.
- 104 wetlands (1.8% of area), mostly very small (Wurdiboluc Reservoir and Lake Gherang are exceptions)
- Native vegetation conservation significance potential: 14.8% of total Landscape Zone is Very High, 9.2% of total Landscape Zone is High.
- Infrastructure assets including 458 km roads, along with main railway and power lines. Parts of the urban City of Greater Geelong and peri-urban fringe.

Threats

To public assets

- Soil erosion by water. Waterways intersect with 14 mapped gully sites (24 ha) and 52 mapped sheet/rill site (61 ha). There are 23 intersections of mapped erosion with native vegetation of very high and high conservation significance potential, the vast majority being small patches of sheet/rill erosion along drainage lines. Roads intersect with 2 gully erosion sites and 4 sheet/rill erosion sites.
- Landslides. Thirteen landslides are mapped with 50 m of a waterway, almost all along the Barwon River east of Inverleigh. They are mapped on public land and 8 intersect with native vegetation with very high or high conservation significance potential.
- Secondary salinity. Nearly 122 ha of secondary salinity sites are mapped within 50 m of a waterway, and 11.5 ha within 50 m of a road. Most occur on the volcanic landscapes north and west of Winchelsea, with some in the valleys of the Barrabool Hills. Secondary salinity intersects with 35 ha of native vegetation with very high conservation significance potential and 57 ha of high conservation significance potential.
- Potential acid sulphate soils. Approximately 11 km of waterways and 74 ha of high value native vegetation intersect with potential inland acid sulphate soils, in scattered locations on the volcanic plains east of Lake Murdeduke and north of Winchelsea.

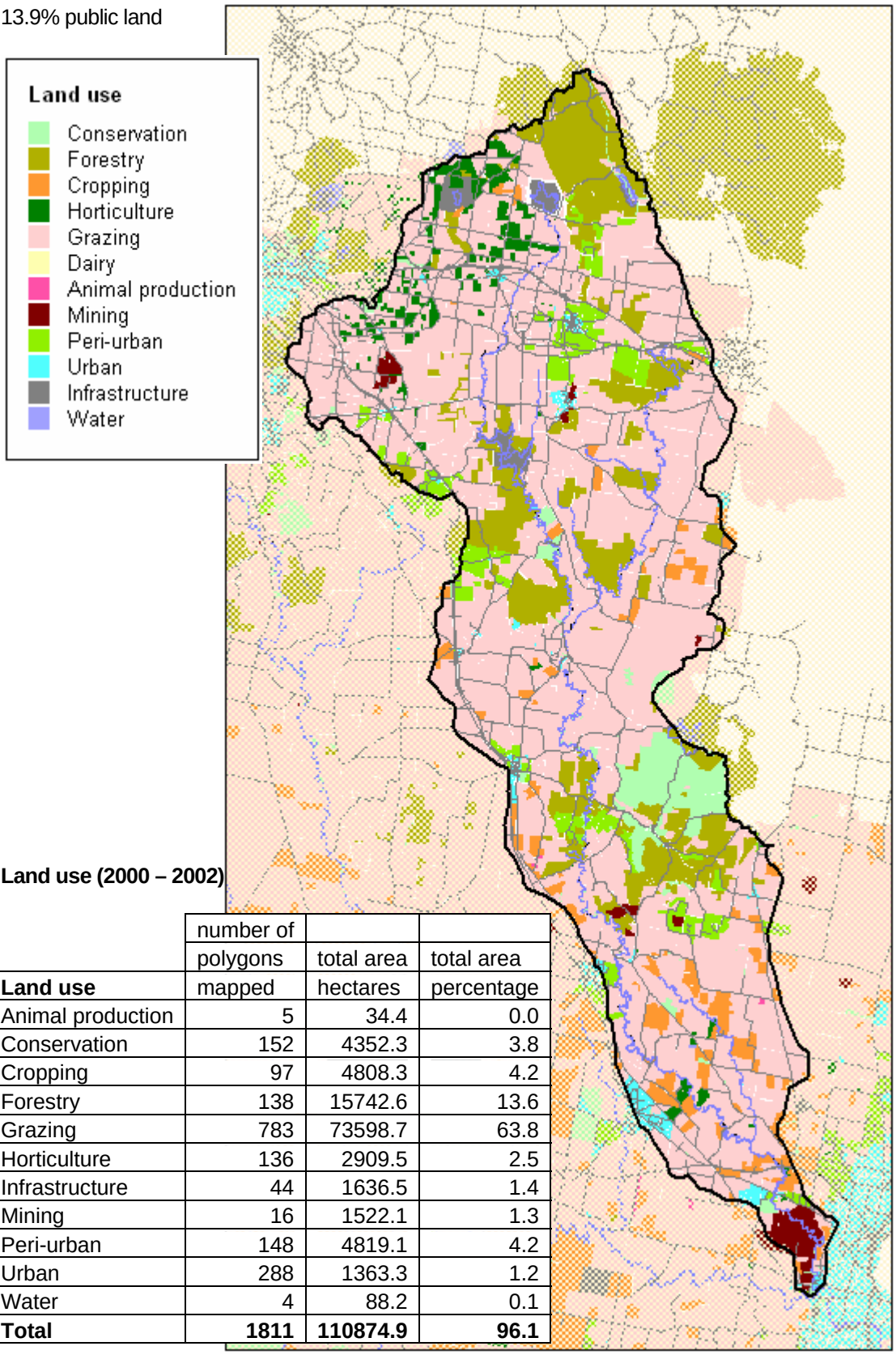
To private assets

- Susceptibility to soil waterlogging. Around 4% (561 ha) of cropping land and 6% (3,133 ha) of grazing land is very highly susceptible to waterlogging, mostly along the floodplain of the Barwon River. About 61% (8,453 ha) of cropping land and 64% (31,524 ha) of grazing land is highly susceptible to waterlogging, in widespread locations. Cropping land is most threatened in the Winchelsea - Inverleigh district, and grazing land north of Teesdale to Meredith.
- Susceptibility to soil structure decline. Nearly 18,500 ha of grazing land and 5,250 ha of cropping land are highly susceptible to soil structure decline.
- Susceptibility to soil nutrient decline. The sandy soils just south of Wurdiboluc Reservoir include 550 ha of soils used for grazing and 18 ha of soils used for cropping which are very highly susceptible to nutrient decline. Approximately 7,200 ha of grazing land and 2,900 ha of cropping land are highly susceptible to soil nutrient decline. These include the sandy soils south of Winchelsea, west and north of Lake Modewarre, and a large area south of Lethbridge to Murgheboluc.
- Susceptibility to soil acidification. In general, the same soils that are susceptible to soil nutrient decline is also susceptible to soil acidification. These are described above.
- Susceptibility to soil erosion by wind. The soils of 3,100 ha of grazing land and 2,000 ha of cropping land are susceptible to wind erosion. These include the sandy and alluvial soils of the area west and north of Lake Modewarre, and the Sandy Creek catchment, east of Teesdale.

Moorabool Landscape Zone

115407 hectares or 8.7% of CCMA region

13.9% public land



Land use (2000 – 2002)

Land use	number of polygons mapped	total area hectares	total area percentage
Animal production	5	34.4	0.0
Conservation	152	4352.3	3.8
Cropping	97	4808.3	4.2
Forestry	138	15742.6	13.6
Grazing	783	73598.7	63.8
Horticulture	136	2909.5	2.5
Infrastructure	44	1636.5	1.4
Mining	16	1522.1	1.3
Peri-urban	148	4819.1	4.2
Urban	288	1363.3	1.2
Water	4	88.2	0.1
Total	**1811**	**110874.9**	**96.1**

Assets

- Urban water supply catchments for the City of Ballarat, City of Greater Geelong and other urban centres (e.g. Meredith & Bannockburn).
- 2151 km of waterways, including the Moorabool River and tributaries. 132 wetlands (1.1% of area). High value groundwater resources (Bungaree GMA).
- Native vegetation conservation significance potential: 9.3% of total Landscape Zone is Very High, 16.6% of total Landscape Zone is High.
- 978 km roads excluding the more recently constructed urban and peri-urban roads of newer subdivisions around Geelong and Ballarat. Extensive peri-urban development.

Threats

To public assets

- Soil erosion due to water. Waterways intersect with 145 mapped gully sites (226 ha) and 169 mapped sheet/rill site (272 ha). Most severe are Eclipse Creek, Tea Tree Creek, Anakie Creek, and Deadman Gully. There are 9 intersections (24 ha) of mapped gully erosion with native vegetation of very high conservation significance potential, and 40 intersections (48 ha) with native vegetation of high conservation significance potential. Similarly, 18 intersections (22ha) of mapped sheet/rill erosion with native vegetation of very high conservation significance potential, and 48 intersections (94 ha) with native vegetation of high conservation significance potential. The vast majority of these are associated with drainage lines in the area between Morrisons and Gheringhap. 15 intersections of roads with gully erosion and 24 intersections with sheet/rill erosion.
- Landslides. Eighteen landslides intersect with waterways, mostly along the Moorabool River. Recently remediation has been necessary to protect a main water supply pipeline.

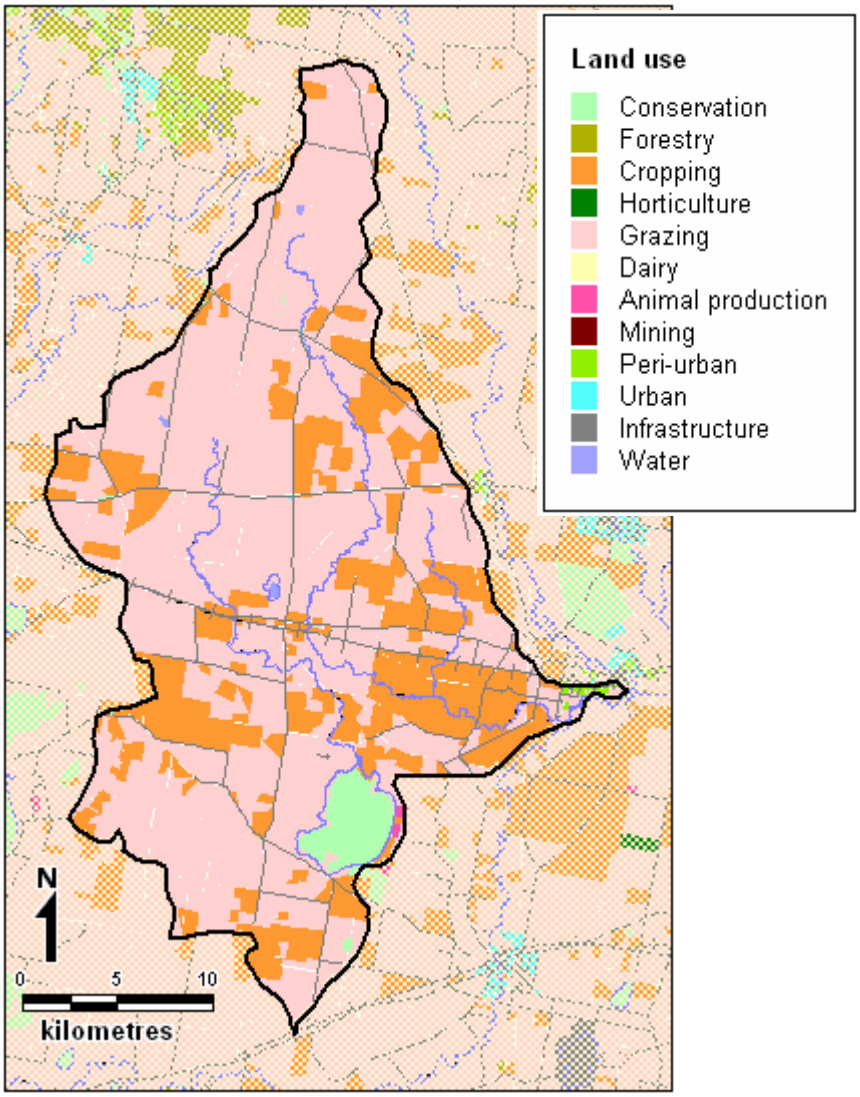
To private assets

- Soil erosion due to water. Around 138 gullies, totalling 216 ha, have been mapped on grazing land, along with 180 sheet/rill erosion sites (206 ha). Some minor (< 10 ha) occurrences on cropping land and approximately 50 ha of forestry land. The vast majority of the land is in the Morrisons, Durdidwarrah, Sheoaks, Steiglitz, Maude and Anakie areas.
- Susceptibility to soil waterlogging. Extensive areas of river flats are very highly susceptible to soil waterlogging, which includes 12,330 ha of grazing land, 1,134 ha of cropping land, 1,358 ha of forestry land and 232 ha of horticultural land. Widespread areas that include 38,137 ha of soils used for grazing, 2,580 ha of soils used for cropping and 2,600 ha of soils used for forestry are highly susceptible to waterlogging.
- Susceptibility to soil structure decline. Almost all of the soils with the exception of the volcanic soils (krasozems) east of Ballarat are highly susceptible to soil structure decline. This includes 50,290 ha of soils used for grazing, 2,568 ha of soils used for cropping, 14,130 ha of soils used for forestry and 400 ha of soils used for horticulture.
- Susceptibility to soil nutrient decline. Approximately 4,250 ha of grazing land on soils developed on granitic rocks, and soils developed on sands and gravel caps are very highly susceptible to soil nutrient decline. Widespread areas of non-volcanic soils which include 21,670 ha of grazing land, and 12,480 ha of forestry land are highly susceptible to soil nutrient decline.
- Susceptibility to soil acidification. Similar areas to those mentioned above (soil nutrient decline) are susceptible to soil acidification. Around 3,340 ha of grazing land in the granitic soil landscapes are very highly susceptible and 22,585 ha of grazing land on the non-volcanic soils are highly susceptible to soil acidification.

Murdeduke Landscape Zone

68316 hectares or 5.1% of CCMA region

2.8% public land



Land use (2000 – 2002)

Land use	number of polygons mapped	total area hectares	total area percentage
Animal production	3	53.7	0.1
Conservation	14	1717.5	2.5
Cropping	118	16968.2	24.8
Grazing	139	48110.4	70.4
Infrastructure	14	81.7	0.1
Peri-urban	8	114.5	0.2
Urban	5	5.8	0.0
Water	3	71.0	0.1
Total	**304**	**67122.8**	**98.3**

Assets

- 460 km of waterways, including Warrambine Creek and Mia Mia Creek.
- 65 wetlands (4.1% of area), including Ramsar and significant wetlands (Lake Murdeduke).
- Native vegetation conservation significance potential: 9.1% of total Landscape Zone is Very High, 6.9% of total Landscape Zone is High.
- 236 km roads, rail line and minor rural infrastructure.
- Cultural and heritage assets including aboriginal archaeological sites.

Threats

To public assets

- Secondary salinity. Secondary salinity intersects with over 375 ha of native vegetation with very high and high conservation significance potential, and 235 ha of wetlands. These occur along Mia Mia Creek, along Warrambine Creek north of Wingeel Swamp, and in groups of small wetlands east of Eurack (near Hesse Rd) and north east of Lake Murdeduke (near McIntyre Rd & Flemings Rd). There are 32 intersections (~300 ha) within 50 m of a waterway and 9 sites mapped within 50 m of a road (8 ha).
- Potential acid sulphate soils. Seventy potential acid sulphate soils are mapped within a 50 m buffer of a waterway (77.5 ha), and 11 within a 50 m buffer of roads (8 km). Around 85 ha of high value native vegetation and 9 ha of public land are also intersected. The sites are scattered with a widespread distribution along low-lying poorly-drained areas.
- Soil erosion due to water. Small incidences (17 in number) of sheet/rill erosion amounting to approximately 16 ha total (0.02% of total area) includes 12 intersections with waterways (4.5 ha), 3 intersections with roads (0.3 ha) and 8 intersections with high value native vegetation (7 ha).

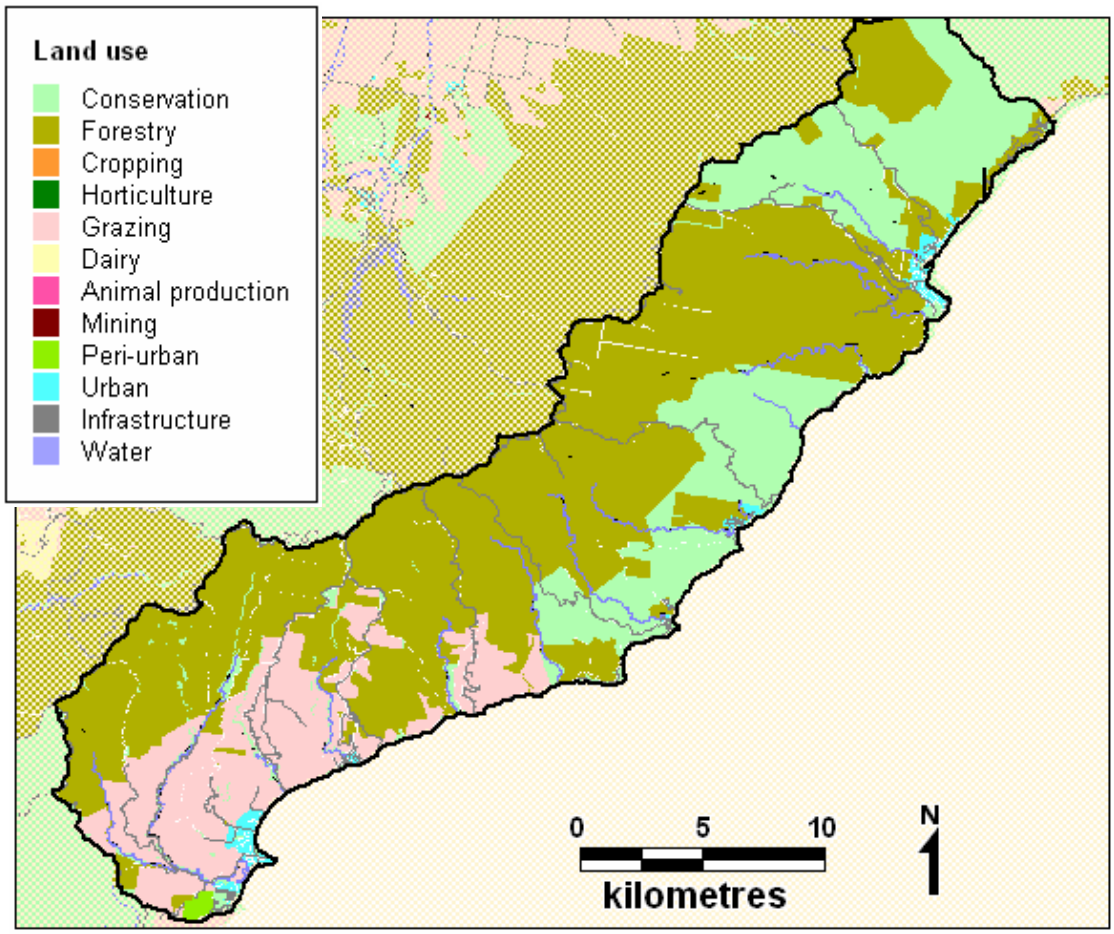
To private assets

- Susceptibility to soil structure decline. Around 7% (1,127 ha) of cropping land and 6% (2,734 ha) of grazing land is highly susceptible to soil structure decline, especially east of Eurack, south of Inverleigh and south east of Wingeel.
- Susceptibility to soil waterlogging. Similarly, 7% (1,127 ha) of cropping land and 5% (2,618 ha) of grazing land is very highly susceptible to waterlogging, mostly east of Eurack, south of Inverleigh and south east of Wingeel.. About 17% (2,885 ha) of cropping land and 6% (2,695 ha) of grazing land is highly susceptible to waterlogging, all in one soil-landform unit north of Warrambine Creek, from Inverleigh to Wingeel.
- Susceptibility to soil erosion by wind. Over 2250 ha of grazing land and nearly 950 ha of cropping land is highly susceptible to wind erosion. These are mostly scattered alluvial soils associated with low-lying poorly-drained areas which are subject to wind erosion when dried.
- Susceptibility to soil nutrient decline. Very little area (~560 ha or <1% of the total area) is highly susceptible to soil nutrient decline.
- Susceptibility to soil acidification. Similarly to nutrient decline, less than <1% of the total area is highly susceptible to soil acidification.

Otway Coast Landscape Zone

46091 hectares or 3.5% of the CCMA region

33.5% public land



Land use (2000 – 2002)

Land use	number of polygons mapped	total area hectares	total area percentage
Conservation	168	11109.0	24.1
Forestry	98	26634.5	57.8
Grazing	81	6556.2	14.2
Infrastructure	8	73.9	0.2
Mining	1	0.8	0.0
Peri-urban	2	117.3	0.3
Urban	146	481.5	1.0
Total	**504**	**44973.3**	**97.6**

Assets

- 1282 km of waterways, mostly mountain streams. Barham River is the largest catchment.
- 3 wetlands (<0.1% area).
- Native vegetation conservation significance potential: 7.8% of total Landscape Zone is Very High, 2.5% of total Landscape Zone is High. A significant proportion of the native vegetation is in the Otway National Park.
- 284 km roads including the Great Ocean Road.
- Cultural and heritage assets, and high value tourist sites.

Threats

To public assets

- Landslides. There are 280 landslide intersections mapped within a 50 m buffer of waterways, with Wild Dog Creek, Barham River and Smythe Creek recording the most. Around 109 landslides mapped on public land, affecting at least 205 ha. Landslides threaten roads, utilities and urban infrastructure of small coastal towns, especially Wye River, Separation Creek, Kennett River, Lorne and the hinterland of Apollo Bay. Landslides have periodically closed the Great Ocean Road, Turton's Track, Wild Dog Road and other scenic tourist routes in recent years.
- Susceptibility to soil waterlogging. Waterlogged soils result from high rainfall combined with septic tank effluent disposal in shallow stony soils within coastal towns. The resultant runoff of poorly-treated effluent threatens the ecological integrity of waterways, estuarine and coastal environments.
- Potential acid sulphate soils. Approximately 8 km of waterways and 5 km of roads intersect with potential acid sulphate soils. Around 22 ha of high value native vegetation and 49 ha of public land are also intersected. The most extensive areas are in the coastal plains around Apollo Bay.

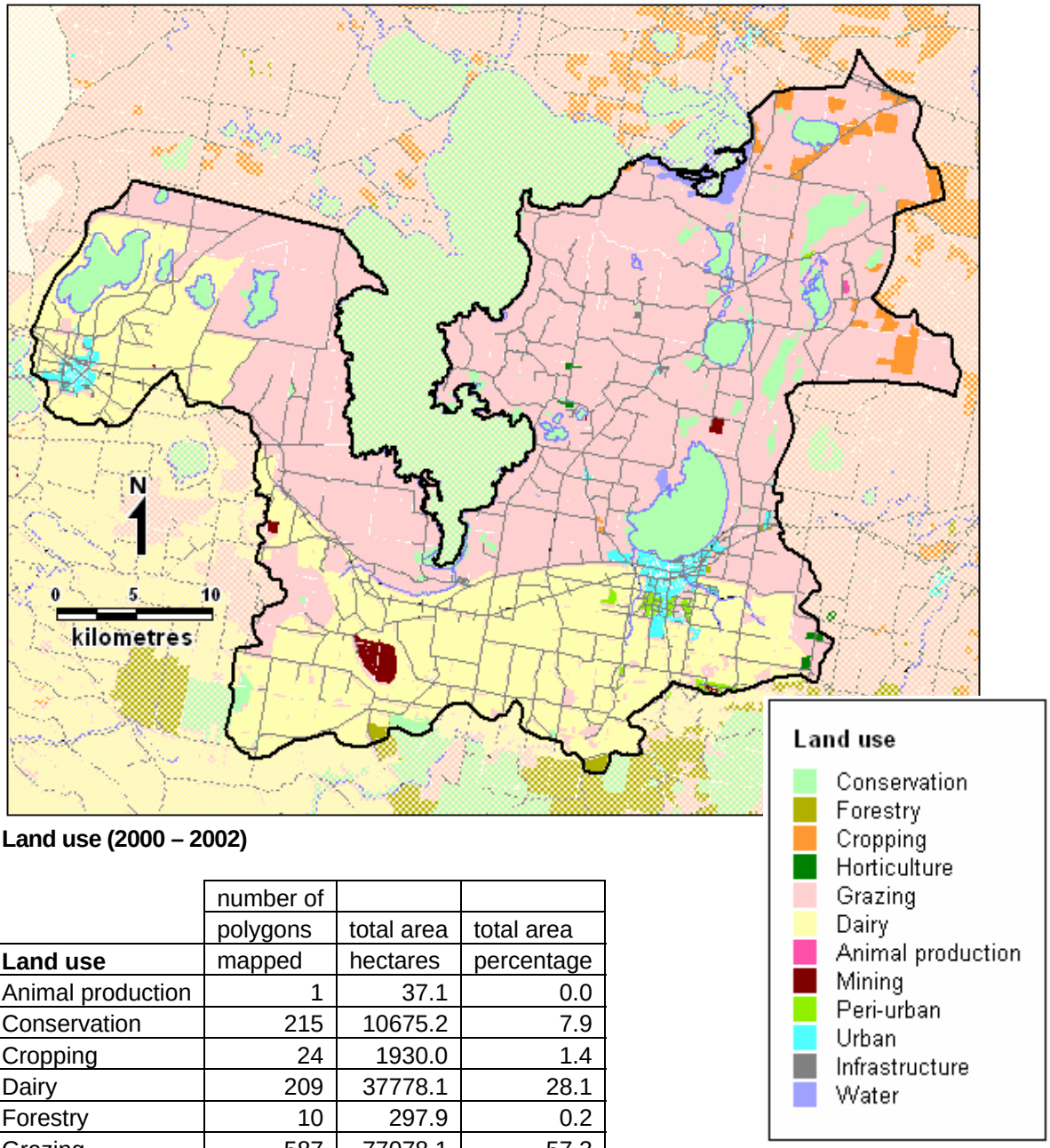
To private assets

- Landslides. There are 232 landslides mapped on grazing land and 65 on land used for forestry. The areas most affected are Wongarra, Wild Dog Creek valley, Tanybryn, Barham River valley and Paradise.
- Susceptibility to soil structure decline. Around 83% (22,000 ha) of land used for forestry and 95% (6,200 ha) of land used for grazing is highly susceptible to soil structure decline. This covers the entire Landscape Zone with the exception of the gently undulating landscapes near the crest of the Otway Ranges.
- Susceptibility to soil waterlogging. Nearly 177 ha of grazing country in the lower Barham River valley are highly susceptible to soil waterlogging.
- Susceptibility to soil nutrient decline. Nearly 200 ha of land used for forestry and over 300 ha of land used for grazing are very highly susceptible to soil nutrient decline, in the area around Lorne.
- Susceptibility to soil acidification. The same area as above (i.e. very high nutrient decline) is highly susceptible to soil acidification.
- Susceptibility to soil erosion by wind. Around 300 ha of grazing land near Apollo Bay have been identified as highly susceptible to wind erosion.

Stony Rises Landscape Zone

134466 hectares or 10.1% of CCMA region

8.6% public land



Land use (2000 – 2002)

Land use	number of polygons mapped	total area hectares	total area percentage
Animal production	1	37.1	0.0
Conservation	215	10675.2	7.9
Cropping	24	1930.0	1.4
Dairy	209	37778.1	28.1
Forestry	10	297.9	0.2
Grazing	587	77078.1	57.3
Horticulture	8	155.7	0.1
Infrastructure	44	143.3	0.1
Mining	13	684.2	0.5
Peri-urban	37	436.4	0.3
Urban	363	1684.3	1.3
Water	9	803.7	0.6
Total	**1520**	**131704.1**	**97.9**

Assets

- 946 km of waterways and 535 wetlands (9.2% of area), including Ramsar and significant wetlands such as Lake Beeac and Lake Cundare.
- Native vegetation conservation significance potential: 6.4% of total Landscape Zone is Very High, 10.0% of total Landscape Zone is High.
- 1054 km roads, excluding the more recently subdivided areas around Colac and Camperdown.
- Cultural and heritage assets include aboriginal archaeological sites and buildings associated with the early pastoral settlement.
- Urban centres of Colac and Camperdown, including manufacturing and service industries.

Threats

To public assets

- Secondary salinity. Around 1,544 ha of secondary salinity have been mapped in the Landscape Zone, which includes 235 ha on public land. Within a 50 m buffer of waterways there are 81 sites amounting to 300 ha, within 50 m of wetlands there are nearly 1000 ha, and around 39 ha in 57 sites mapped within 50 m of a road. Although widely scattered, the largest areas are around Lake Martin, The Sanctuary, and the upper reaches of Barongarook Creek.
- Potential acid sulphate soils. Potential acid sulphate soils have been mapped at 118 sites (124 ha) within 50 m of a waterway and 35 sites (20 ha) within 50 m of a road. About 35 ha of high value native vegetation and 40 ha of wetlands are also intersected. The sites are very fragmented and scattered, with the majority in low-lying and poorly-drained areas of the volcanic landscapes.

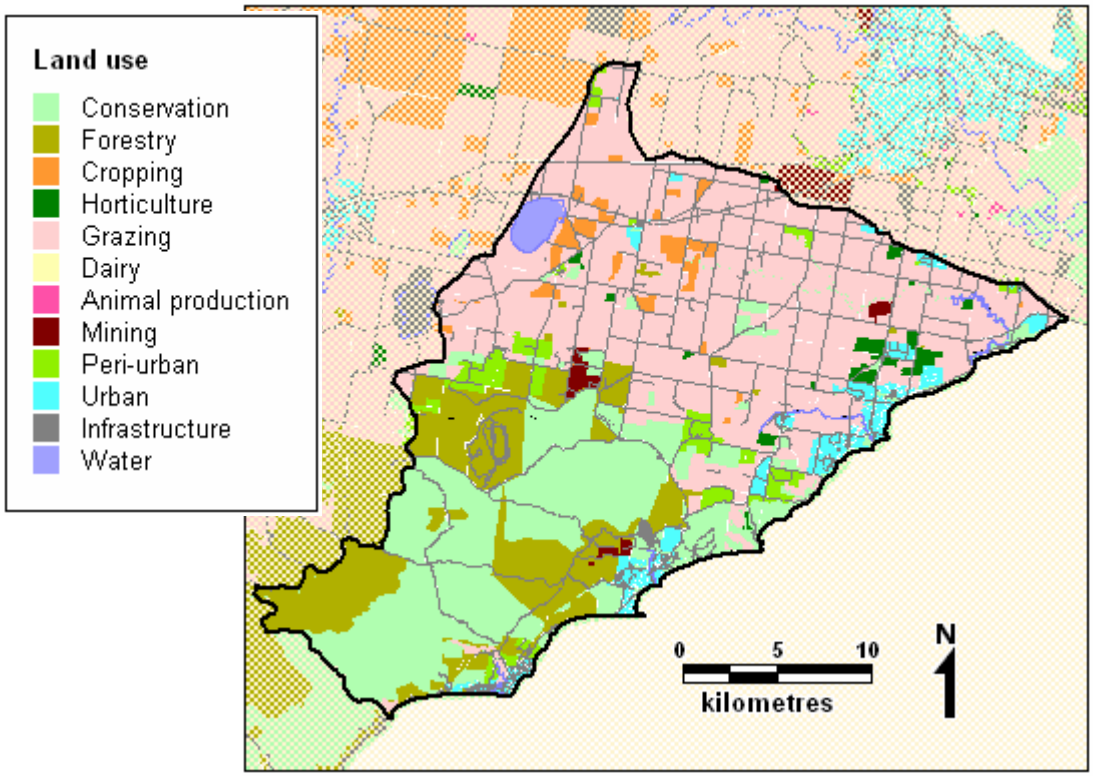
To private assets

- Susceptibility to soil structure decline. Around 7% (2,728 ha) of dairy land is very highly susceptible to soil structure decline, in the Swan Marsh, Pirron Yallock and Larpent areas. A further 58% (21,951 ha) of dairy land, 34% (651 ha) of cropping land and 60% (46,321 ha) of grazing land is highly susceptible to soil structure decline. The dairy land around Bungador, Swan Marsh and Barongarook; the cropping land around Barpinba; and the grazing land in the Eurack, Lough Calvert, Beeac, Dreeite and Wool Wool areas are mapped in this category.
- Susceptibility to soil waterlogging. Soils very highly susceptible to soil waterlogging include 12% (4,609 ha) of dairy land, 32% (623 ha) of cropping land and 25% (18,885 ha) of grazing land. The largest areas are the grazing lands north of Lake Colac through Lough Calvert to Eurack. Around 54% (20,585 ha) of dairy land, and 37% (28,439 ha) of grazing land is highly susceptible to waterlogging, including nearly all the land between the Colac – Cressy Road and Lake Corangamite.
- Secondary salinity. Secondary salinity has been mapped on 52 ha of dairy land and 402 ha of grazing land. The largest extents of salt-affected grazing lands are those fringing Lake Martin.
- Susceptibility to soil nutrient decline. Soils very highly susceptible to soil nutrient decline include 13,460 ha of dairy land and 3,876 ha of grazing land. A further 10,829 ha of dairy country, 2,900 ha of grazing country and 292 ha of forestry country are highly susceptible to soil nutrient decline. These include all of the soils developed on the undulating sandy landscapes in the southern section of the Landscape Zone (i.e. south of the volcanic plains).
- Susceptibility to soil acidification. Around 24,289 ha of dairy country, 6,777ha of grazing country and 300 ha of forest country in the same areas as described above, are highly susceptible to soil acidification.

Thompson Landscape Zone

62626 hectares or 4.7% of CCMA region

33.3% public land



Land use (2000 – 2002)

Land use	number of polygons mapped	total area hectares	total area percentage
Conservation	174	16334.9	26.1
Cropping	41	1326.0	2.1
Forestry	68	9348.2	14.9
Grazing	185	27499.9	43.9
Horticulture	27	771.3	1.2
Infrastructure	29	182.0	0.3
Mining	7	455.8	0.7
Peri-urban	59	2049.2	3.3
Urban	381	2258.2	3.6
Water	1	532.6	0.9
Total	**972**	**60758.0**	**97.0**

Assets

- 1048 km of waterways and 56 wetlands (1.9% of area)
- Native vegetation conservation significance potential: 4.6% of total Landscape Zone is Very High, 25.6% of total Landscape Zone is High.

- 713 km roads, not including the more recently subdivided areas of Torquay and other coastal towns.
- Coastal assets including beaches, cliffs and shore platforms, which are highly valued as tourist assets. Cultural and heritage assets including aboriginal archaeological sites are associated with the coast.

Threats

To public assets

- Potential acid sulphate soils. In both inland and coastal locations the mapped potential for acid sulphate soils intersects with nearly 36 km of waterways and 13 km of roads. About 470 ha of native vegetation with high or very high conservation significance potential is intersected, along with 277 ha of public land and 243 ha of wetlands. The largest sites are the Breamlea wetlands and lower Thompson Creek, followed by the wetlands of Marshy Creek and Salt Creek (lower Anglesea River), and lower Painkalac Creek.
- Landslides. There are 17 intersections of landslides and waterways, and 129 landslides on public land. Almost all occur along the coastline south of Jan Juc, with Point Addis and Eastern View areas as the recording the most.
- Erosion by water. Nine gully erosion sites (10 ha) and 46 (34 ha) sheet/rill erosion sites occur within 50m of waterways, with Thompson Creek and Spring Creek recording the most. Approximately 25 ha of native vegetation of very high and high conservation significance threatened by erosion, along the coast and along waterways. There are 11 intersections of roads with erosion, mostly sheet/rill erosion (57 ha) and 51 sheet/rill erosion sites (1075 ha) are mapped on public land.

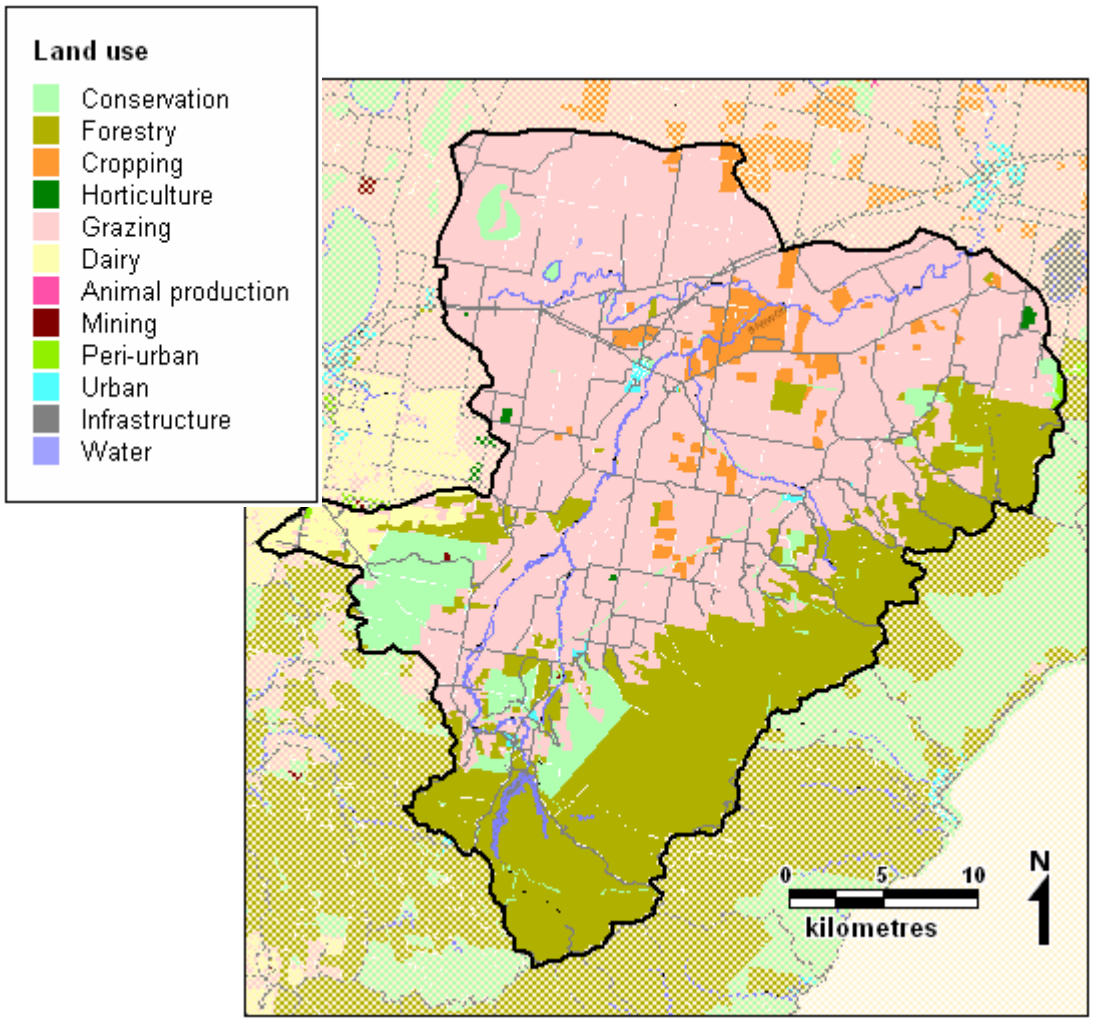
To private assets

- Susceptibility to soil waterlogging. Alluvial soils in the low-lying poorly-drained landscape positions are very highly susceptible to waterlogging and include 1037 ha of grazing land. Around 76% (20,948 ha) of grazing land, 47% (4,400 ha) of forest land and 73% (973 ha) of cropping land is highly susceptible. These occur in widespread areas across the northern portion of the Landscape Zone.
- Susceptibility to soil structure decline. Almost all of the agricultural land (95%) is highly susceptible to soil nutrient decline. This includes 26,061 ha of grazing land and 1127 ha of cropping land. Similarly, 77% (7,168 ha) of forest land is highly susceptible to soil structure decline.
- Susceptibility to soil nutrient decline. Around 4,100 ha of forest country and 755 ha of grazing country is very highly susceptible to soil nutrient decline. This includes the sandy and gravely soils of the Anglesea hinterland, in the southern portion of the Landscape Zone. The sandy soils of the northern portion (i.e. north of Point Addis to Moriac) include 14,268 ha of grazing country, 2,595 ha of forest country and 495 ha of cropping country which are highly susceptible to soil nutrient decline.
- Susceptibility to soil acidification. The areas described above as susceptible to nutrient deficiency are also susceptible to soil acidification. These include around 15,000 ha of grazing land, 6,700 ha of forest land and 500 ha of cropping land.
- Susceptibility to soil erosion by wind. The soils of around 4365 ha of grazing land east of Paraparap and in the area west of Mt Moriac are highly susceptible to wind erosion.
- Erosion by water. There are 28 sheet/rill erosion sites (28 ha) and 8 gully erosion sites (10 ha) mapped on grazing land, mostly south of Connewarre and north of Torquay.

Upper Barwon Landscape Zone

97590 hectares or 7.3% of CCMA region

28.1% public land.



Land use (2000 – 2002)

Land use	number of polygons mapped	total area hectares	total area hectares
Conservation	212	6546.8	6.7
Cropping	59	3602.2	3.7
Dairy	24	1614.5	1.7
Forestry	248	27590.1	28.3
Grazing	369	55200.9	56.6
Horticulture	6	141.0	0.1
Infrastructure	24	397.4	0.4
Mining	4	16.0	0.0
Peri-urban	5	111.3	0.1
Urban	68	253.1	0.3
Water	3	22.6	0.0
Total	**1022**	**95495.8**	**97.9**

Assets

- 1822 km of waterways including the Barwon River.
- 53 wetlands (1.0% of area) including The Sanctuary (Lake Thurrumbong).
- Native vegetation conservation significance potential: 3.2% of total Landscape Zone is Very High, 15.9% of total Landscape Zone is High. Most are included in the Otway Ranges.
- 533 km roads and rural infrastructure. Birregurra is the main urban centre.

Threats

To public assets

- Erosion by water. There are 28 (124 ha) gully erosion sites and 40 (141 ha) sheet/rill erosion sites mapped within 50 m of waterways, with Wormbete Creek, Yan Yan Gurt Creek and the Barwon River recording the most. Approximately 43 ha of native vegetation of high conservation significance threatened by erosion, mostly along the waterways. There are 10 intersections of roads with erosion, with gully sites and sheet/rill sites covering approximately 43 ha each. Examples occur along Cape Otway Road and Coalmine Road. Eight erosion sites (163 ha) are mapped on public land.
- Landslides. There are 148 landslides mapped within 50 m of a waterway, including several larger slides which have occurred along the western flanks of the Barwon River valley, south of Birregurra. Around 34 landslides intersect with high value native vegetation and 56 occur on public land, almost all are on the flanks of the Otway Ranges.
- Secondary salinity. Around 265 ha of secondary salinity have been mapped within 50 metres of a waterway and 46 ha within 50 m of a road. Most occurs in a widespread distribution along drainage lines and landscape depressions from Gerangamete in the south to Warncoort in the west to near Bambra in the east.

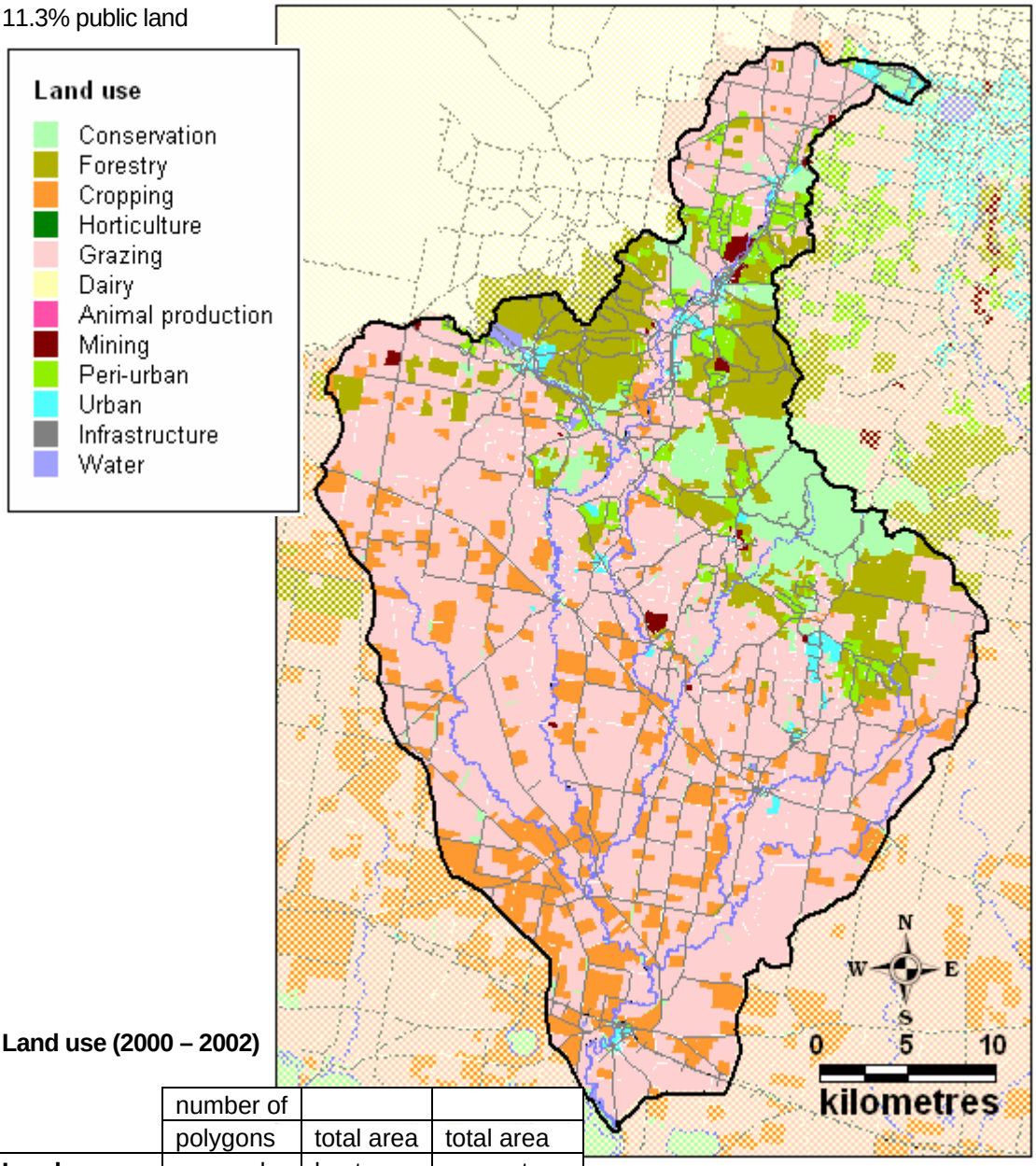
To private assets

- Susceptibility to soil waterlogging. Around 9% (4,755 ha) of grazing land has a very high susceptibility to waterlogging, most occurs in the Gerangamete – Barwon Downs area. Approximately 60% (33,256 ha) of grazing land, 84% (3,035 ha) of cropping land and 39% (623 ha) of dairy land has a high susceptibility to waterlogging. This constitutes almost all of the landscapes north of the Otway Ranges to Birregurra Creek and the Barwon River.
- Erosion by water. There are 23 gully erosion sites (68 ha) and 42 sheet/rill erosion sites (99 ha) mapped on grazing land, mostly in the Bambra, Wensleydale and Wormbete areas. Some relatively small-scale sheet/rill erosion sites mapped on cropping land and dairy land.
- Susceptibility to soil structure decline. Nearly 83% (45,617 ha) of grazing land, 89% (24,577 ha) of forest land, 84% (3,013 ha) of cropping land and 39% (622.8 ha) of dairy land are highly susceptible to soil structure decline.
- Susceptibility to soil nutrient decline. About 20% (11284 ha) of grazing land, 68% (1095 ha) of dairy land and 13% (3,537 ha) of forestry land is very highly susceptible to soil nutrient decline. The area occurs as a broad band of sandy soils from north of the West Barwon Reservoir to Barongarook and across to Whoorel, excluding the river flats of the Barwon River valley. Smaller scattered areas of sandy soil (4856 ha grazing, 596 ha forest, 272 ha cropping) are highly susceptible.
- Susceptibility to soil acidification. The soils susceptible to nutrient deficiency are also highly susceptible to acidification. These include 16,139 ha grazing land, 4132 ha forestry land and 1095 ha of dairy land.
- Susceptibility to soil erosion by wind. Around 5,400 ha of grazing land and 973 ha of dairy land are highly susceptible to wind erosion. These areas are north west of Warncoort and the general area from Yeodene to Barongarook.

Woady Yaloak Landscape Zone

122943 hectares or 9.2% of CCMA region

11.3% public land



Land use (2000 – 2002)

Land use	number of polygons mapped	total area hectares	total area percentage
Conservation	415	9566.9	7.8
Cropping	260	15437.3	12.6
Forestry	201	13214.5	10.7
Grazing	830	73887.9	60.1
Horticulture	1	1.6	0.0
Infrastructure	30	74.1	0.1
Mining	36	629.9	0.5
Peri-urban	143	3757.2	3.1
Urban	274	1560.2	1.3
Water	22	414.2	0.3
Total	**2212**	**118543.8**	**96.4**

Assets

- 2117 km of waterways including the Woady Yaloak River, Naringhil Creek, Misery and Moonlight Creeks, Kuruc-a-ruc Creek and Ferrars Creek.
- 91 wetlands (0.8% of area)
- Native vegetation conservation significance potential: 5.5% of total Landscape Zone is Very High, 6.7% of total Landscape Zone is High.
- 1000 km roads, excluding the more recently subdivided areas west of Ballarat.

Threats

To public assets

- Erosion by water. There are 320 (637 ha) gully erosion sites and 166 (526 ha) sheet/rill erosion sites within 50 m of waterways, with Mount Misery Creek, Moonlight Creek and the Woady Yaloak River recording the most. Thirty-two mapped gully erosion sites (69 ha) and 25 mapped sheet/rill erosion sites (50 ha) intersect with native vegetation of very high conservation significance, and 34 gully erosion (82 ha) and 20 sheet/rill erosion sites (64 ha) intersect with native vegetation of high conservation significance potential. The vast majority of these intersections occur along the waterways and drainage lines along a broad zone from Mount Mercer to Pittong. There are 48 gully erosion sites and 32 sheet/rill erosion sites within 50 m of roads, mostly on minor rural roads north of the Rokewood - Skipton Road. Ninety seven gully erosion sites (330 ha) and 79 sheet/rill erosion sites (329 ha) are mapped on public land.
- Salinity. Secondary salinity occurs along waterways and drainage lines contributing salt load to the Woady Yaloak River, with 1,237 ha of secondary salinity mapped in the Landscape Zone. Sixty-four hectares of secondary salinity occurs on public land, 702 ha within 50 m of waterways, 60 ha within 50 m of roads, and 171 ha within 50 m of wetlands. Over 170 ha of very high and 150 ha of high conservation significance potential native vegetation are also intersected. Although secondary salinity is widespread, there are much larger areas in the granitic landscapes south of Pittong and on the sand soils from Mt Mercer to Cape Clear.

To private assets

- Susceptibility to soil structure decline. About 52% (7,992 ha) of cropping land, 98% (13,000 ha) of forestry land and 67% (49,626 ha) of grazing land is highly susceptible to soil structure decline. This constitutes almost all the north and east sections of the Landscape Zone.
- Susceptibility to soil waterlogging. Around 14% (2133 ha) of cropping land and 10% (7,298 ha) of grazing land has a very high susceptibility to waterlogging in the southern portion of the Landscape Zone along the Woady Yaloak River flood plain and in the Rokewood area. Another 42% (6,441 ha) of cropping land and 50% (37,293 ha) of grazing land has a high susceptibility to waterlogging. This constitutes almost all of the volcanic landscapes in the southern half of the Landscape Zone and the area around Haddon.
- Susceptibility to soil nutrient decline. Soils of the granitic landscapes south of Pittong and in the Mount Kinross locality are very highly susceptible to soil nutrient decline. These include 4,156 ha of grazing land, 804 ha of forestry land and 459 ha of cropping land. Another 21,347 ha of grazing land, 9,478 ha of forest land and 2,030 ha of cropping land are highly susceptible to soil nutrient decline. This includes the majority of the highlands from Rokewood to Pittong and north to Haddon.
- Susceptibility to soil acidification. The same area that is susceptible to soil nutrient decline is also susceptible to soil acidification, with 3,985 ha of grazing land, 746 ha of forestry land and 459 ha of cropping land very highly susceptible. Another 21,518 ha of grazing country, 9,536 ha of forestry country and 2030 ha of cropping country are highly susceptible.
- Susceptibility to soil erosion by wind. About 9,820 ha of grazing land and 1018 ha of cropping land are highly susceptible to wind erosion in the Mt Mercer – Cape Clear area.

4 Calculating the risk to assets

The priorities for investment in soil health management were established using the statistics generated in the GIS analysis to identify the relative risk to the assets potentially threatened by soil processes. The size of the potential threat to the asset was determined using the GIS and quantified in terms of area (hectares) or number of incidences. A relative value was assigned to the assets and combined with a relative severity of the threatening process to provide a relative impact of the threat to the asset. These relative values were assigned with the participation of the Soil Health Strategy Steering Committee. The relative risk to the asset was then calculated by the product of the size of the potential threat and the relative impact on the asset (Figure 4.1).

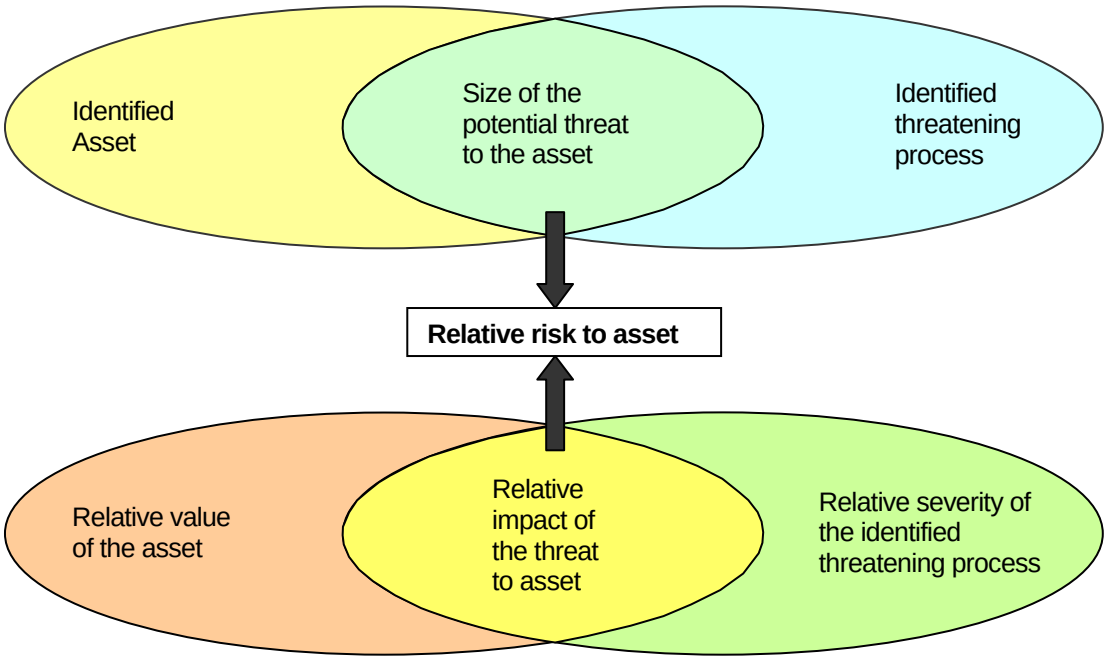


Figure 4.1 General process for ascertaining the relative risk to assets.

4.1 Relative value of assets and relative severity of threats

The relative value of any asset relates to the Corangamite community's perception of the relative worth of that particular asset for the public benefit. Relative asset values (RAV) were determined by the Soil Health Strategy Steering Committee (as representatives of the Corangamite communities) using a scale from 1 to 10, where 10 was the highest value. Water quality, biodiversity, cultural and heritage, public land for conservation and infrastructure assets all scored the highest values (10). The lowest RAVs were assigned to private land used for grazing (2), cropping (3) and forestry (3). The values are listed in Table 4.1

The relative severity of threatening processes has a much greater range to account for the variation in the types of data used. Some threats such as a landslide or gully erosion site have been mapped to a high resolution and are represented by discrete polygons which have a relatively small area of intersection with an asset, such as a road or stream. By contrast, the area of land with a high susceptibility to soil structure decline is mapped at a very small scale (i.e. a large polygon), and the area of intersection with an asset such as the land used for cropping is generally quite a large number. A gully erosion site has been assigned a relative severity factor (RSF) of 5, whereas the high threat of soil structure decline has been assigned a RSF of 100 (Table 4.2).

Primary Asset	Secondary Asset	Relative asset value (RAV))	Comment
Land	Urban	9	Urban areas support the major communities and include secondary and tertiary industries
	Peri-urban	7	Significant sized peri-urban communities support the urban centres
	Mining	8	Mining includes gold, coal and clay resources, quarrying includes sand, gravel and stone resources
	Animal production	7	Intensive animal production is expanding, and has high gross margins
	Horticulture	5	Gross margins for potatoes in 2005/06 was $8,070/ha
	Dairy	4	Gross margins for dairy for 2004/05 was $1,323/ha
	Cropping	3	Average gross margins for cropping for 2004/05 was $291/ha
	Forestry	3	In 2001/02 softwood plantations contributed $160M, hardwood plantations contributed $4M and native forests contributed $68M to the region's economy.
	Grazing	2	Average gross margins for grazing for 2004/05 was $275/ha
	Public land (non-conservation use)	7	Public land used for recreation, infrastructure and utilities.
	Public land (conservation use)	10	This includes the Otway National Park, Angahook-Lorne State Park and other terrestrial, aquatic and marine conservation areas.
Biodiversity	Wetlands	10	13 Ramsar-listed wetlands and 345 significant wetlands are listed in the region
	Significant flora and fauna	10	Regional AROTS include 19 fauna and 50 flora, and over 300 VROTS
Cultural and heritage	Heritage sites	10	The region has significant numbers of Aboriginal archaeological sites and Victoria's earliest pastoral settlements
Infrastructure	Roads	10	Over 10,600 km of roads service the region
	Utilities and services	10	Regional electrical power, gas, telecommunication conduits and transportation corridors are extensive
Water quality	Water resource areas	10	Major urban and agricultural water supply resources
	Waterways	10	At least 19,630 km of waterways including some of the most intact in the state (Otway Ranges).

Table 4.1 Relative asset value (RAV) assigned to each of the assets

Factual Data	
Threatening process	**Relative severity factor (RSF)**
Gully erosion sites	5
Sheet/rill erosion sites	5
Landslides	3
Secondary salinity sites	10

Interpreted data		
Threatening process	**Relative severity factor (RSF)**	
Susceptibility to soil structure decline	Very High	50
	High	100
	Moderate	150
Susceptibility to soil waterlogging	Very High	50
	High	100
	Moderate	150
Susceptibility to soil nutrient decline	Very High	50
	High	100
	Moderate	150
Susceptibility to soil acidification	Very High	50
	High	100
	Moderate	150
Susceptibility to soil erosion by wind	Very High	50
	High	100
	Moderate	150
Potential acid sulphate soils		25

Table 4.2 Relative severity factor (RSF) assigned to threatening processes

4.2 Example calculation of relative risk

As an example, the relative risk to assets for the threatening process of soil waterlogging in the Upper Barwon Landscape Zone was calculated (using the interpretative data) as tabulated below.

Asset	RAV	Very high susceptibility (hectares)	RSF	High susceptibility (hectares)	RSF	Moderate susceptibility (hectares)	RSF	Total
Land-use								
Conservation	0	966	50	1903	100	2926	150	0
Urban	0	19	50	167	100	66	150	0
Peri Urban	0	0	50	96	100	14	150	0
Horticulture	5	0	50	141	100	0	150	7
Dairy	4	0	50	1903	100	2926	150	154
Cropping	3	0	50	3035	100	563	150	102
Grazing	2	4755	50	33255	100	15865	150	1067
Forestry	3	200	50	1741	100	15367	150	372
Animal Production	7	0	50	0	100	0	150	0
Raw Total								1702
Normalised to CCMA region (the raw total is multiplied by 7.3%, which is the proportional area of the Corangamite CMA region covered by the Upper Barwon Landscape Zone)							Final total	**233**

Table 4.3 Calculation of relative risk from soil waterlogging in Upper Barwon

By contrast, the relative risk to assets for the threatening process of gully erosion in the Upper Barwon Landscape Zone was calculated (using the factual data) as shown in Table 4.4.

Asset	RAV	Actual area under threat (hectares)	RSF	Relative risk value
Land - use				
Water supply	10	0	5	0
Conservation	10	7	5	13
Urban	9	0	5	0
Peri Urban	7	0	5	0
Infrastructure	10	0	5	0
Horticulture	5	0	5	0
Dairy	4	0	5	0
Cropping	3	0	5	0
Grazing	2	68	5	27
Forestry	3	40	5	24
Animal Production	7	0	5	0
Mining	8	0	5	0
Public				
Public Land	7	82	5	114
Conservation	10	31	5	62
Wetlands	10	85	5	170
Waterways	10	124	5	249
Roads	10	42	5	85
			Total	**743**

Table 4.4 Calculation of relative risk from gully erosion in Upper Barwon

The combined relative risk for each threatening process is illustrated in Figure 4.2, showing that landslides present the greatest relative risk to assets, and wind erosion the least relative risk. It is stressed that **the risk values are relative, and not absolute values**.

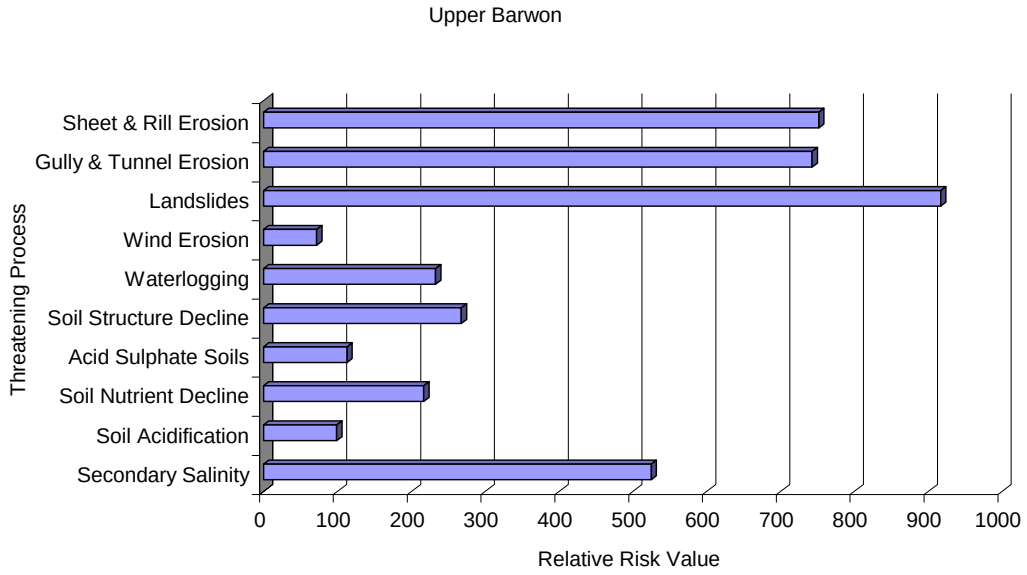


Figure 4.2 Relative risk values for the Upper Barwon

4.2.1 Sensitivity analysis

Since the ranking of the relative risk is dependent on both the RAV chosen for assets and the RSF assigned to the threatening processes, an analysis was undertaken to determine the sensitivity of the calculations. A series of tests were conducted where the RAV and/or the RSF were significantly changed (eg. doubled) and the final results compared.

Overall, the outcomes were much the same, indicating that relative insensitivity of the calculations to the RAV and RSF. Even though the values were significantly changed in the sensitivity analysis, the final ranking of the threatening processes within a Landscape Zone and between the Landscape Zones remained virtually unchanged.

4.3 Summary of the relative risk to assets

The calculated relative risk values for each threatening process across the Landscape Zones of the Corangamite region were sorted from highest to lowest.

The highest 20 values are listed in Table 4.5, and the full ranking details are included in the Excel spreadsheets of Appendix C.

Landscape Zone	Threatening process	Relative Risk Value	Rank
Gellibrand	Landslides	3167	1
Lismore	Secondary salinisation	2886	2
Bellarine	Potential acid sulphate soils	2748	3
Woady Yaloak	Gully/tunnel erosion	2501	4
Woady Yaloak	Sheet/rill erosion	2317	5
Stony Rises	Secondary salinisation	1925	6
Curdies	Landslides	1903	7
Otway Coast	Landslides	1872	8
Thompson	Sheet/rill erosion	1804	9
Woady Yaloak	Secondary salinisation	1646	10
Moorabool	Sheet/rill erosion	1154	11
Murdeduke	Secondary salinisation	1090	12
Leigh	Gully/tunnel erosion	938	13
Upper Barwon	Landslides	917	14
Moorabool	Gully/tunnel erosion	893	15
Upper Barwon	Sheet/rill erosion	752	16
Upper Barwon	Gully/tunnel erosion	743	17
Leigh	Sheet/rill erosion	734	18
Thompson	Potential acid sulphate soils	557	19
Aire	Landslides	548	20

Table 4.5 Summary of the 20 greatest relative risks in the Corangamite region

5 Setting priorities

The threatening processes which pose the highest relative risk to assets (Table 4.5) area should guide the investment on soil health in the Corangamite region. However, the relative benefit-cost of that investment, measured in economic, environmental and social terms, should also be considered in the priority given to the investment.

In the development of the Corangamite Soil Health Strategy, a limited economic analysis was completed by URS (2005) to help guide the process. The analysis calculated the public and private benefit gained from various proposed soil health management actions and compared that to the costs of implementing the actions (i.e. the with-plan and without-plan scenarios). At the time of the analysis, the relative risk values for each Landscape Zone had not been determined, which makes it difficult to link the results of the economic analysis to this study. Nevertheless, the analysis provided some limited information which was used in setting priorities (Table 5.1).

Threatening process	**Benefit - Cost Ratio**	**Management actions costed in the economic analysis.**	**Benefits considered in the economic analysis**	**Benefits <u>not</u> considered in the economic analysis**
Landslides	7.89	Development of tools and pollices through the municipal planning schemes.	Reduction in catastrophic damage to environmental and infrastructure assets, loss of life, damage to infrastructure.	Reduction of sediments into waterways and wetlands. Preservation of biodiversity areas and heritage sites.
Secondary salinisation	4.04	On-ground works including vegetation, fencing & drainage.	Reduction in damage to infrastructure and utilities, and agriculture production.	Reduction of salinity in waterways, wetlands and significant biodiversity areas.
Sheet/rill erosion	0.48	On-ground works including earthworks, fencing, revegetation.	Reclaiming agricultural production and preventing the loss of production land.	Reduction of sediments into waterways and wetlands.
Gully/tunnel erosion	0.04	On-ground works including earthworks, fencing, revegetation, engineering works.	Retaining land from erosion, reclaimed production, better farm access.	Reduction of sediments into waterways and wetlands. Preservation of biodiversity areas, infrastructure, buildings, utilities and heritage sites.
Potential acid sulphate soils	5.88	Mapping occurrences and informing relevant stakeholders.	Avoiding damage to housing, building and infrastructure.	Maintaining water quality, fish numbers, aquatic ecosystems, human health

Table 5.1 Summary of the costs and benefits considered in the economic analysis

In general, the majority of the benefits without a market value were not considered in the analysis, which greatly undervalues the public benefit derived from investment in management actions to improve soil health. For example, the investment of one dollar in on-ground works to address gully erosion is calculated to return four cents in the reclaimed agricultural production and improved farm access. However, the benefit of improved water quality in waterways and wetlands, the preservation of significant flora or fauna species, the protection of property, utilities, roads, heritage sites, etc., were not calculated.

The true benefit of soil health management actions depends on the effectiveness of the action in reducing the risk of a threat to a specific asset. For example, on-ground works to reduce or stop active gully erosion in an urban water-supply catchment will have a greater benefit than on-ground works to reclaim an inactive gully outside of an urban water supply catchment. Similarly, in the relative risk assessment outlined in Section 4, the RAV does not discriminate between the relative values of the same asset class. In other words, the RAV for a wetland is 10, regardless of the fact some wetlands have international status (those listed under the Ramsar Convention, or under migratory bird treaties) and others have only local status.

For each Landscape Zone the relative risk has been reviewed with consideration of the type of asset at risk (taken from the summaries provided in Section 3) and the final priority ranking is presented in Table 5.2. This priority ranking takes into account the relative risk, the benefit cost values and the significance of the assets at risk. The final evaluation was endorsed by the Soil Health Strategy Steering Committee at a meeting on May 3rd 2006.

Priority	Threatening process	Landscape Zone
1	Landslides	Gellibrand
2	Secondary salinisation	Lismore
3	Potential acid sulphate soils	Bellarine
4	Sheet/rill erosion	Woady Yaloak
5	Gully/tunnel erosion	Woady Yaloak
6	Secondary salinisation	Stony Rises
7	Landslides	Curdies
8	Landslides	Otway Coast
9	Secondary salinisation	Woady Yaloak
10	Sheet/rill erosion	Thompson
11	Sheet/rill erosion	Moorabool
12	Landslides	Upper Barwon
13	Secondary salinisation	Murdeduke
14	Sheet/rill erosion	Upper Barwon
15	Gully/tunnel erosion	Moorabool
16	Gully/tunnel erosion	Upper Barwon
17	Gully/tunnel erosion	Leigh
18	Landslides	Aire
19	Potential acid sulphate soils	Thompson
20	Sheet/rill erosion	Leigh

Table 5.2 Priority for investment in soil health management actions

Naturally, it is beyond the scope of this study to individually assess the RAV or the RSF for each identified intersection of an asset with a potential threat. However, the intersections of assets with each threatening process have been mapped within each Landscape Zone listed Table 5.2 and these maps are presented in electronic form on CD in Appendix D. It is suggested that the intersections be verified on-ground so that the specific priorities for actions can be assessed for the development of Soil Health Action Plans for each Landscape Zone.

6 Conclusions

The assessment of the relative risk to assets from soil-related threatening processes presented in this report is the limited by the accuracy, resolution and types of available data. However, the asset-based framework is based on that recommended by DSE (2006) and the methods are repeatable when new or improved data is made available. Sensitivity testing demonstrates that the priority setting method is robust, as the identified priorities do not significantly change when the weightings are altered. Within the limits of the data, the process provides an objective assessment of priorities for investment in soil health management in the Corangamite region.

References

CCMA 2003. *Corangamite Regional Catchment Strategy 2003-2008*. Corangamite Catchment Management Authority, 232p.

DSE 2006 (draft). *Decision making processes for investment in land management: The asset based approach.* Discussion paper Department of sustainability and Environment. Melbourne.

MACEWAN R.J. 2003. *Soil Health Strategy for Corangamite Region. Discussion paper.* Centre for Land Protection Research, Bendigo. 27p.

URS 2005. Economic Analysis of the Corangamite Soil Health Strategy. Draft final report prepared for the Department of Primary Industries. URS Australia Pty Ltd., October 7th 2005. 123p.

Appendices