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## Land Suitability Analysis of the Shire of Moorabool

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Grow West – Land Suitability Analysis of the Shire of Moorabool

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# Land Suitability Analysis of the Shire of Moorabool

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**2006**

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Many thanks also go to Jennifer Sheridan, Grow West Project Officer for her support during the development of the study.

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# EXECUTIVE SUMMARY

The Moorabool Shire Council occupies a strategic position in the Port Phillip and Corangamite Regions, State of Victoria, Australia, because of its community and enterprises, natural resources and environment, as well as its geographic location on the outskirts of metropolitan Melbourne. The "Moorabool Growth Management Strategy" (MGMS) provided a basis for the *Grow West Land Suitability Analysis of the Shire of Moorabool*, which updates the former document and incorporates two new land suitability models for the region – proteas and horses.

*Chapter 1* of this report presents an overview of the Moorabool Shire outlining characteristics of the region including its biophysical environment, transport and infrastructure and economic situation. The planning context for the region is also reviewed at a range of scales.

*Chapter 2* examines the Shire's economy with a focus on natural resource based industries, specifically agriculture which dominates the regions economy and land use activity.

*Chapter 3* outlines the innovative Land Suitability Analysis (LSA) method applied across Moorabool to evaluate the suitability of land for specific commodities. The method draws upon three ecosystem components of soil, climate, and landscape and integrates them using Multi-Criteria Evaluation Methods and Geographic Information Systems (GIS).

*Chapter 4* presents the land suitability overlays produced from both the MGMS and the current project. Land suitability maps are produced for ten groups of agricultural commodities: brassicas, potatoes, olives, pastures, pome fruits, lavender, buckwheat, winter wheat, radiata pine and proteas, as well as horses. Composite mapping also produced an index of suitability for the agricultural production of the broad range of commodities.

*Chapter 5* focuses on the biophysical analysis of Moorabool, which is illustrated with environmental overlays in order to highlight risks to resource use. This chapter examines key environmental characteristics of the region's ecological vegetation class (EVC) mapping, threatened flora and fauna; water quality and availability; salinity risk scenarios for the years 2020 and 2050; groundwater flows; floodways and flood extents; and soil erosion due to water.

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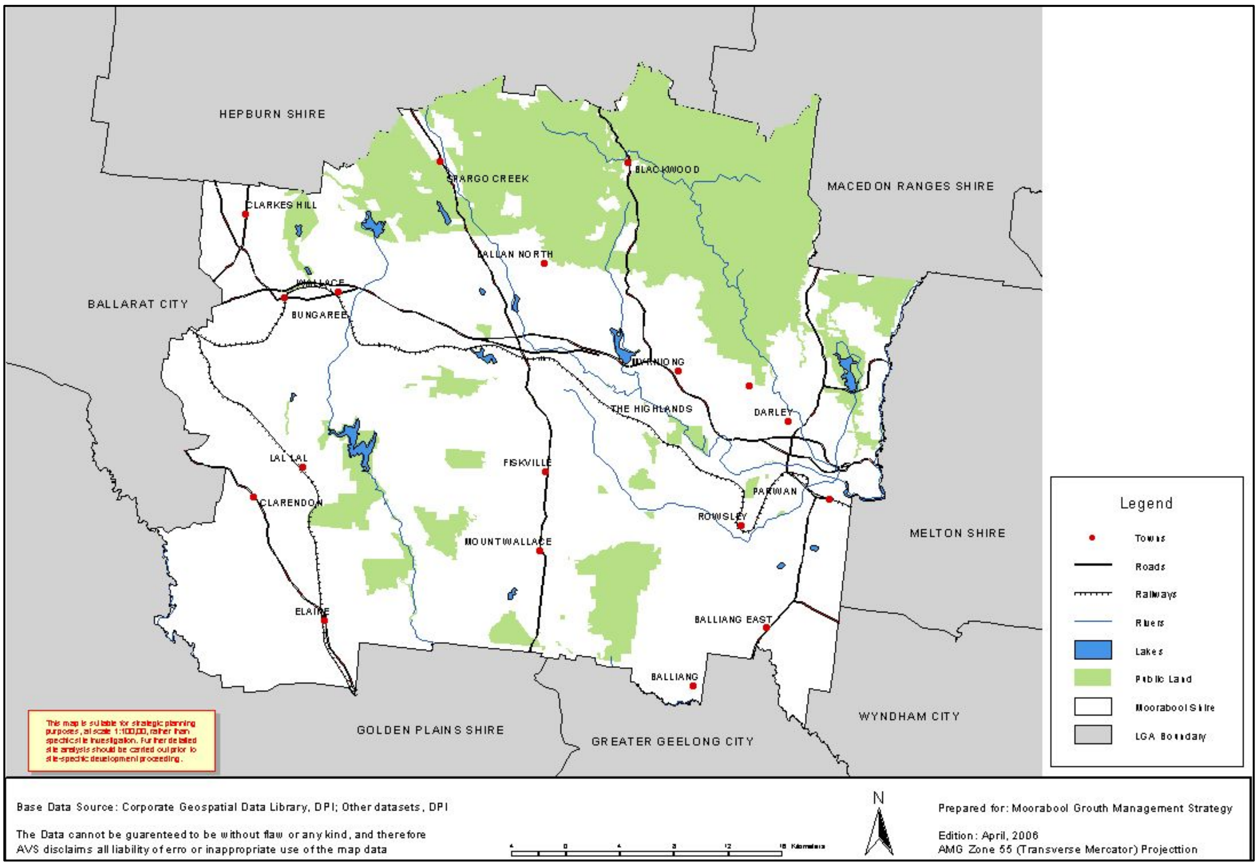
# 1. BACKGROUND AND PROJECT OBJECTIVES

The following *Land Suitability Analysis of the Shire of Moorabool* was undertaken as part of the *Grow West Project*, a landscape change project that aims to assist landholders to adopt sustainable land-use practices. The core Grow West project area is located within Moorabool Shire straddling the Western Freeway between Bacchus Marsh and Ballan, approximately 50 km from Melbourne. This study covers the entire Moorabool Shire Council Area (**Map 1.1**).

Map 1.1 Map of the Moorabool Shire Council Area




The analysis builds on previous work completed in the Shire in 2002 as part of the "*Moorabool Growth Management Strategy*" (MGMS). This report updates the MGMS report as well as providing an analysis of two new land suitability models for the region – proteas and horses. More specifically, the Land Suitability Analysis has the following key objectives:

- To run the land suitability analysis models, as described in the MGMS, for proteas and horses.
- To bring together and, where necessary update, information from the MGMS that is relevant to the management of the Shire's rural areas.
- To collate this information into a single bound document.

# 2. INTRODUCTION

## 2.1 The Moorabool Shire: An Overview[1]

The Moorabool Shire Council (hereafter 'Moorabool') was formed in 1994 through the amalgamation of the former Shires of Bacchus Marsh, Ballan, large parts of Buninyong, Bungaree and a small part of Werribee Council. A high growth, semi-rural municipality, Moorabool covers an area of 2,110 $km^2$ and is located approximately 50 km from the Melbourne CBD, on the western fringe of metropolitan Melbourne (**Map 2.1**).

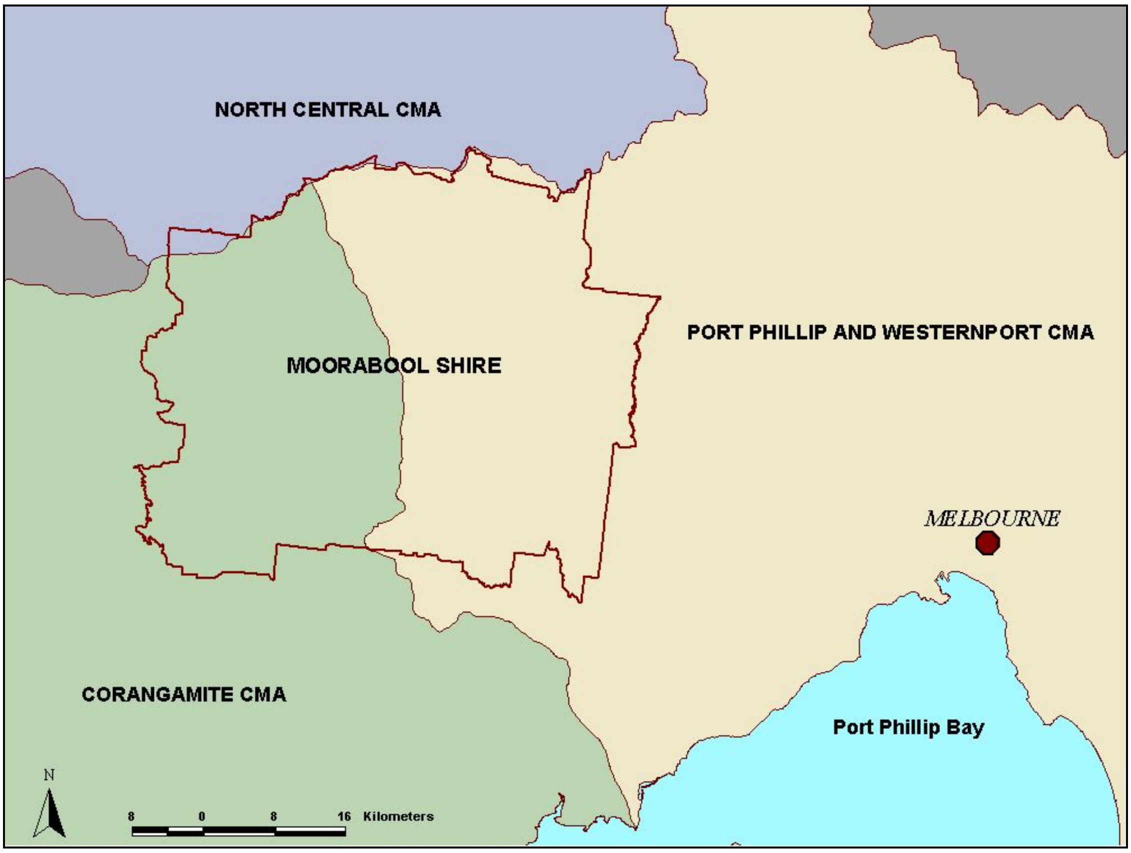
With 40% of residents commuting to work in Melbourne, it is unsurprising that urban settlement in the region is dominated by the influence of the Western Freeway, with the towns of Bacchus Marsh, Ballan and Gordon all located along this key transport route. It should be noted that there are a few exceptions to this rule, such as the small holidaying township of Blackwood, which is dominated by State Forest and bushland. With a population of 13,000, Bacchus Marsh is the largest town in the Shire representing more than half of the Shire's total population. This dominance has been reinforced by a pattern of population growth that has centred around the Bacchus Marsh and rural-residential areas in the eastern part of the Shire.

Moorabool's economy is highly diverse with residents employed in a range of agricultural, service, manufacturing and construction industries. This diversity can be attributed to a number of factors including high rates of population growth, the proximity of rural based industries and strong links to metropolitan Melbourne and regional centres such as Geelong and Ballarat. While the Shire's traditional links to Melbourne and Ballarat were based around manufacturing and agricultural industries, these links are now increasingly centred around the service industry, particularly professional services. The close proximity to Melbourne has also meant that the Shire has increasingly played a role in providing housing for Melbourne families seeking to live in rural and semi rural environments.

Moorabool falls within two Catchment Management Authority (CMA) regions. The Port Phillip and Westernport CMA roughly covers the eastern half of the Shire while the Corangamite CMA incorporates the western portion (**Map 2.1**). Moorabool is characterised by a great diversity of environments, from rolling plains to rugged river gorges and forests that provide spectacular scenery. The Shire encompasses significant areas of public land including the Brisbane Ranges National Park, the Lerderderg and Werribee Gorge State Parks as well as numerous reserves. These parks and reserves have a wide range of facilities which cater for activities such as camping, rock climbing, 4 wheel driving, walking, cycling, horse riding and fishing.

[1] Most of the information in this section has been extracted from the Moorabool Planning Scheme, particularly from the Municipal Strategic Statement (Section 21, Moorabool Shire Council, 2000).

Map 2.1 Location of Moorabool Shire Council Area in Relation to Victorian Catchment Management Authority Boundaries




## 2.2 National, Regional and Local Vision and Themes

When considering the strategic direction of rural areas in Moorabool it is essential to consider both the existing policy and planning framework at national, regional and local scales, and the major instruments of this policy at the local level.

National Action Plan for Salinity and Water Quality (NAP) and National Heritage Trust (NHT)

The National Action Plan for Salinity and Water Quality (NAP) and National Heritage Trust (NHT) are joint Federal and State Government initiatives to enable regional communities to achieve more coordinated and targeted investment in order to:

- conserve biodiversity
- encourage sustainable use of natural resources
- build community capacity
- implement institutional change

The State government contributes half of this funding, which in Victoria will account for $300 million until June 2008. The majority of NAP funding is delivered through regional Catchment Management Authorities. Although all of the CMA's may apply for funding through NHT, only the six NAP priority regions can access NAP funding. Only the western half of Moorabool, falling within the Corangamite CMA, is in a NAP priority region and hence able to access NAP funding.

## CMA Regional Catchment Strategies

In Victoria, the Catchment and Land Protection Act (1994) requires CMA's to develop Regional Catchment Strategies which provide the basis of the NAP/NHT investment plan for dryland salinity, water quality and biodiversity initiatives in the region. The Corangamite CMA completed a review of its Regional Catchment Strategy (RCS) in December 2003, the Shire forming an important part of the RCS "review and renewal" process through the involvement of senior officers. The reviewed strategy will continue to drive investment under the NAP in the region until 2008. For the area of the Corangamite CMA that incorporates Moorabool the RCS identified five key assets that are considered a high priority for action:

1. Water use: impacted by reduced stream flow, sediments and nutrients.
2. Land use: facing threats from salinity, weeds and soil deterioration.
3. Surface water (streams, rivers, lakes, wetlands): subject to reduced stream flow, increasing nutrients and eutrophication, sedimentation and turbidity.
4. Vegetation: threatened by land clearing, poor maintenance and the spread of weeds.
5. Fauna: threatened by competition with pest animals and habitat loss associated with land use change and land clearing.

Developed over two years in cooperation with a wide range of government agencies, community groups and industry organisations from across the region, the *Port Phillip and Westernport RCS* was finalised in 2004. The Strategy identifies ninety-seven actions under the following four goals identified for the region:

- sustainable water use and healthy waterways, wetlands, estuaries, coasts and bays;
- healthy land used appropriately and productively;
- healthy and enduring ecosystems with a diversity of habitats and native species; and
- a community valuing, understanding and celebrating the region's catchment assets and working to achieve sustainability.

## Melbourne Metropolitan Strategy: Melbourne 2030

*Melbourne 2030 - Planning for sustainable growth* is the Victorian Government's strategic plan for the sustainable management of growth in the urban and non-urban areas of Metropolitan Melbourne and surrounds (DOI, 2002). It envisions a liveable, prosperous and sustainable Melbourne within a long-term timeframe of 30 years.

> *"The main thrust is to continue to protect the liveability of the established areas and to increasingly concentrate major change in strategic redevelopment sites such as activity centres and underdeveloped land. This will help prevent urban expansion into surrounding rural land."* (DOI, 2002)

The substance of *Melbourne 2030* is contained in nine key *directions* that embody the Government's aims of sustainability and providing a better future for all. DSE is the lead agency for the plan and is working with Local Councils, industry, and the community to implement the vision set out in *Melbourne 2030*. Six (draft) Implementation Plans directly support the metropolitan strategy through policy initiatives, planning measures, and new legislation. The first plan demarcated the (then interim) *Urban Growth Boundary* (UGB) which essentially places limits on urban expansion, directs future urban growth to existing urban settlements, and protects rural areas. Recently, the Government introduced legislation which adjusts the boundaries in some municipalities and ensures that a legislative process is followed to modify the UGB in future. Other implementation plans deal with growth areas, housing, activity centres, integrated transport, and green wedges.

Melbourne 2030 focuses on the greater metropolis of Melbourne and the importance of linkages to the regional centres. Moorabool forms the major proportion of the Western Growth Corridor with Bacchus Marsh and Ballan ideally placed as major linkage towns between Melbourne and Ballarat and therefore Melbourne 2030 has major implications for strategies developed in the following areas:

- Settlement
- Employment
- Leisure
- The Environment
- Travel
- Infrastructure

## Victorian Local Sustainability Accord

Launched in November 2005 the Victorian *Local Sustainability Accord* is a partnership agreement between Victorian, State and local governments which aims to support more consistent environmental policies and legislation. Five local governments, including Moorabool, have signed onto the Accord which forms a key element of the State Government's Environmental Sustainability Framework. These Councils will be involved in a pilot project led by DSE that will develop:

- Processes for local councils across Victoria to create local environmental sustainability priority statements.
- Improved funding criteria and processes for the Sustainability Fund.
- A Victorian Local Sustainability Advisory Committee.

## Werribee Plains: A Vision for Sustainable Growth

The State Government's Vision for the Werribee Plains was initially launched in 2002, with an Action Plan for the region released two years later. The Vision aims to "position the region as a world leader in sustainable development". Incorporating the Eastern portion of Moorabool, the Vision aims to provide support and coordination for a range of projects across the region. These projects address the sustainability issues being faced by infrastructure, environment and tourism, urban development and industry. A key driver identified in the Vision will be the opportunities presented by the continued development of the region's recycled water resources.

## Moorabool Municipal Strategic Statement

The Municipal Strategic Statement (MSS) in the Moorabool Planning Scheme provides the vision for the future of Moorabool. The vision is to be achieved through the development and implementation of a series of strategies relating to key issues. The MSS documents the main issues and provides background information on the Shire as well as objectives, strategies and policies, and actions designed to assist in achieving the vision.

Moorabool's Municipal Vision and Strategic Framework clause 21.06 "builds on the Corporate Plan in the context of the State Planning Policy Framework." The Corporate Plan of Moorabool is included as clause 21.05 in the Local Planning Policy Framework (LPPF). The Corporate Plan identifies five fundamental goals that set a context for the planning scheme. The five goals identified by the Corporate Plan are as follows:

- Infrastructure
- Economic development
- Environment
- Human services
- Good government

The Municipal Vision and Strategic Framework clause 21.06 also states that its vision seeks to "foster a cohesive community proud of its quality of life. This must recognise and value the individual qualities of the various communities, because in the broad sense, the Shire has two communities of interest, an eastern community with a strong focus to Melbourne and a western community with strong links to Ballarat. This broad diversity of community interest will remain a feature of the Shire."

The Strategic Framework identifies three principal qualities of the Shire.

**The natural and cultural assets**

The Shire's natural resources and environments and its cultural heritage and their contribution to the economic and social well being of the Shire will continue to be integral to the quality of life. The quality of the environment is an important factor that has led to continuing population growth in the Shire. Urban growth and residential development will be managed to protect these natural and cultural assets for lifestyle as well as for biodiversity protection, environmental sustainability and lifestyle qualities.

**The values and assets of the townships and settlements**

The range of living environments and lifestyle opportunities will be maintained. Urban growth will be focussed within the major centres of Bacchus Marsh and Ballan supported by limited development within the capacity range of smaller settlements that have their own rural and environmental settings. Limited development will occur in smaller centres and will be related to the provision of infrastructure. The visual qualities, function, convenience and vitality of the Shire's urban centres will be improved and the rural landscape and forest setting of centres will be protected.

**The opportunities to build a stronger and more economically vibrant Shire**

The Shire has a diverse economic base centred on its strategic location, excellent transport infrastructure, agricultural productivity, tourism development opportunities, natural resources, local industries and services. The opportunities to increase the level of local employment need to be realised.

### Council Plan for Moorabool Shire: 2005-2009

The principles laid out the in the Council's MSS are dealt with in more detail in the more recent 2005-2009 Council Plan. The development of this plan involved a review of the Council's strategic direction, the identification of key result areas and the development of a new vision and mission. The Council's revised vision states that, by 2009 Moorabool Shire will:

- be characterised by viable and vibrant communities and towns forming an integrated Shire with strong identity. They will be communities of choice attracting growth;
- have water resources secured and management strategies implemented to ensure agricultural development and town development continues;
- see the services and infrastructure supporting this growth reflect community needs and underpinned by:
    - o long-term financial forecasting,
    - o sound financial and resources management,
    - o performance based land use planning,
    - o key external partnerships; and
- be led by a respectful, balanced and committed group of Councillors.

## 2.3 Economic Situation

The economic and social data collected through the Australian Bureau of Statistics (ABS) census can be presented at a range of scales. Alongside, the Local Government Areas (LGA) and Statistical Sub-divisions (SSD), information is also presented at Statistical Local Area (SLA) level (**Figure 2.1**). SLA boundaries follow Shire boundaries and are subsets of LGAs. Moorabool encompasses three SLAs - Bacchus Marsh in the east of Moorabool, Ballan in the centre of Moorabool and West SLA in the west of Moorabool (**Map 2.2**).

Map 2.2 Statistical Local Areas (SLAs) of Moorabool Shire

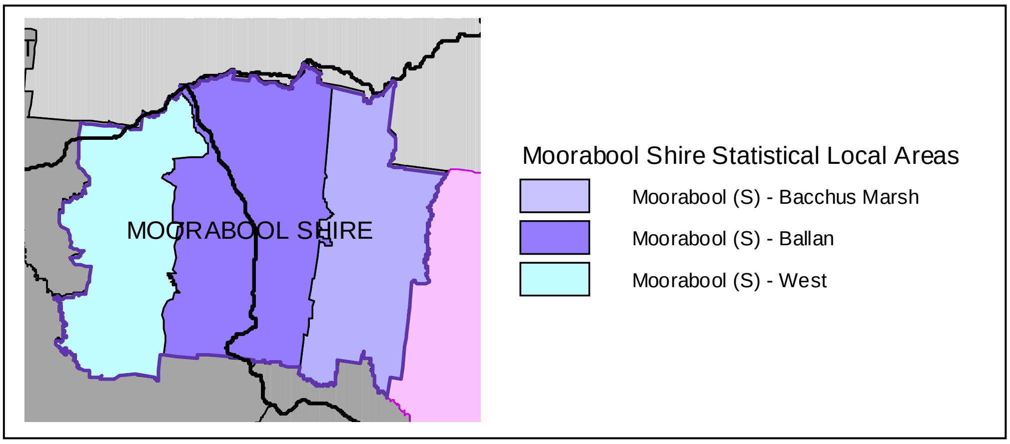
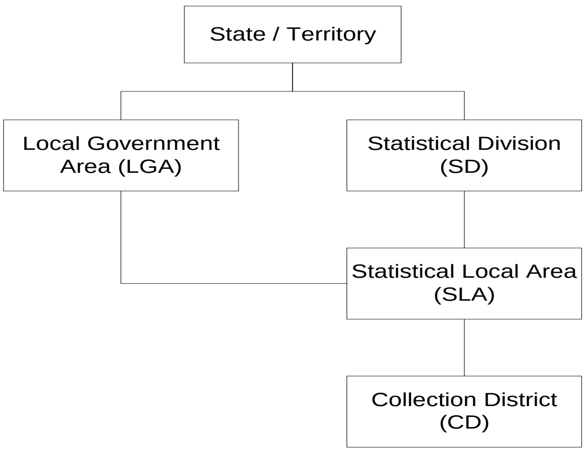



Figure 2.1 ABS Defined Boundaries

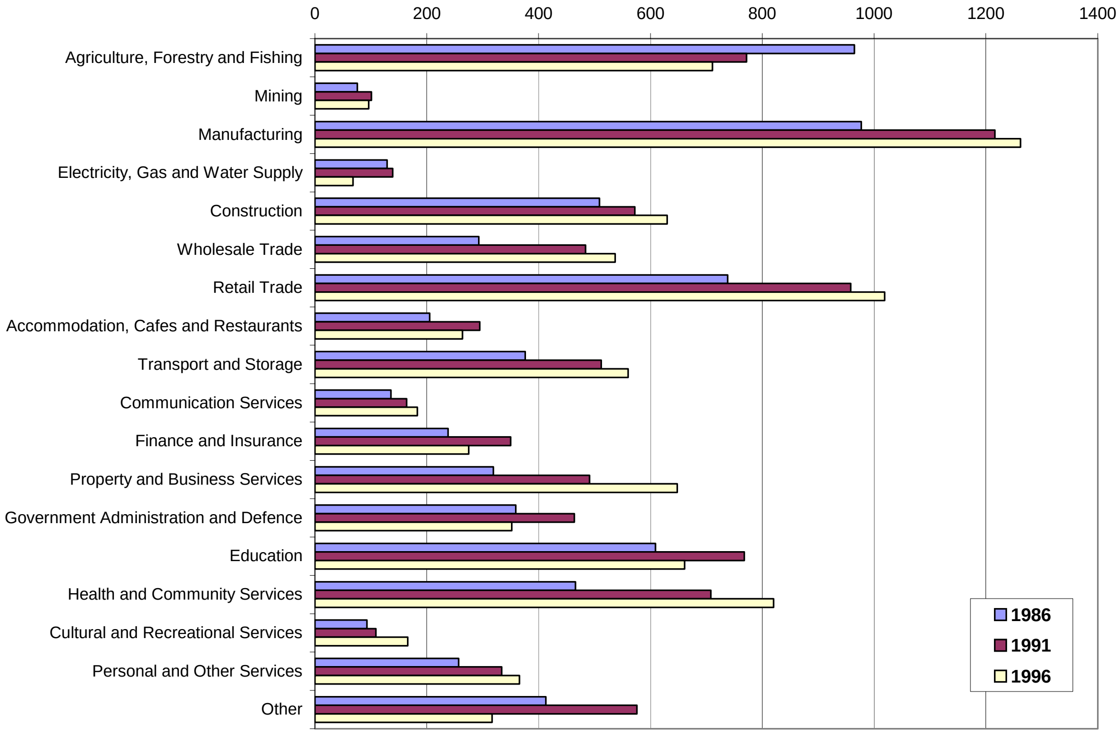



(**Source:** Adapted from CData96 User Manual, ABS, 1997)

### Employment in Agriculture, Forestry and Fishing

Over the last ten years, a notable decline can be observed in the number of Moorabool residents employed in Agriculture, Forestry and Fishing (**Figure 2.2**). In 1986, 965 residents were recorded as employed in Agriculture, Forestry and Fishing, by 1996 this number had declined by 26%. (ABS, 1996). This decline in agricultural employment can be attributed to changes in the global economy, where commodities command lower prices and are subject to greater fluctuations. As a result, Australian agriculture is increasingly under pressure to add-value to goods, increase mechanisation and utilise scientific and technological advantages in order to compete with developing countries and trading blocs.

Figure 2.2 Comparison of the number of Moorabool Residents Employed by Industry in 1986, 1991 & 1996

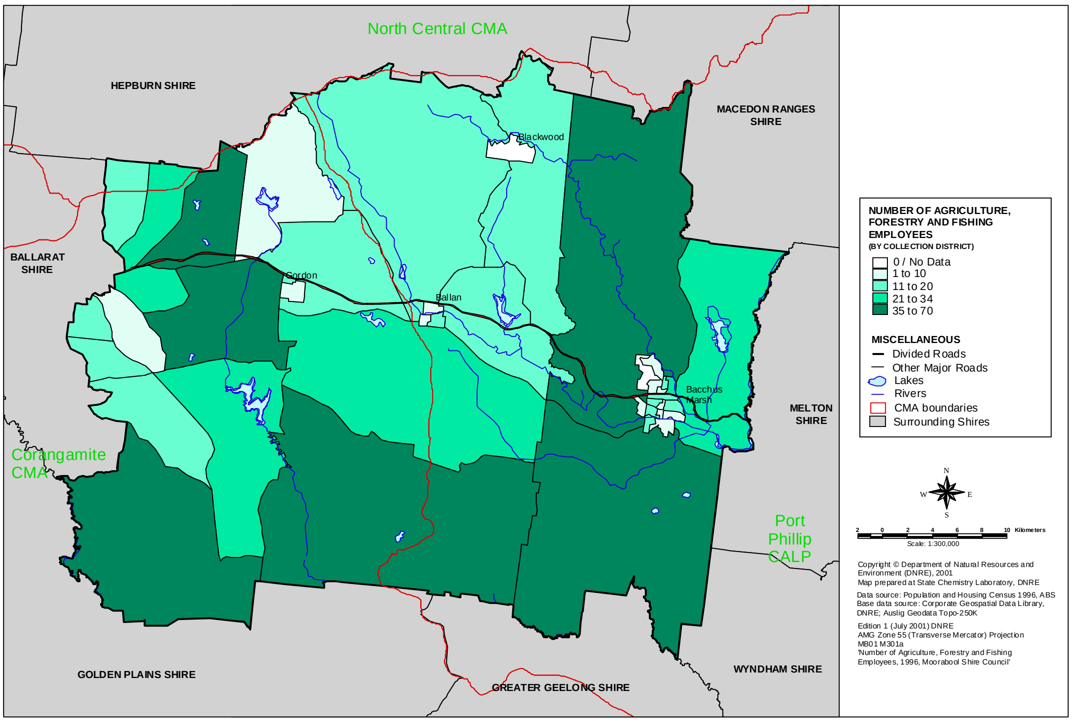



Source: CData96, ABS Graphic prepared at SRP AV-Werribee, DNRE.

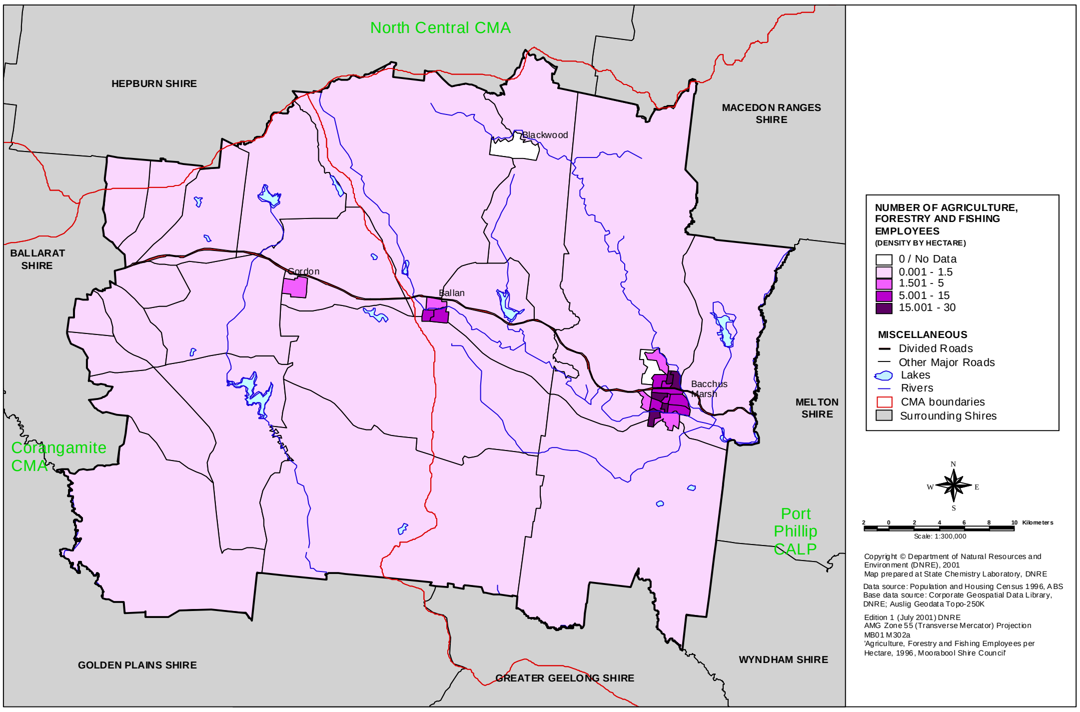
Importantly the impact of the decline in agricultural employment has not been consistent across the region, the West SLA, for example, employed almost 446 people in 1986, however this figure had almost halved to 281 by 1996. Declines in agricultural employment, however, may not necessarily imply a decline in agriculture per se, if this is accompanied by improved efficiencies in the mechanisation of farming. In fact, in the case of Moorabool, the high concentration of primary industry support services in Melbourne, Ballarat and Geelong may present producers in this region with a competitive advantage.

**Maps 2.3a** and **2.3b** provide a picture of how employment in this sector is distributed across the municipality. As would be expected the concentration of employment in Agriculture, Forestry and Fishing is generally located away from major towns.

Map 2.3a) Number of Agriculture, Forestry and Fishing employees 1996
Moorabool Shire Council




Map 2.3b) Agriculture, Forestry and Fishing Employees (per hectare) 1996
Moorabool Shire Council



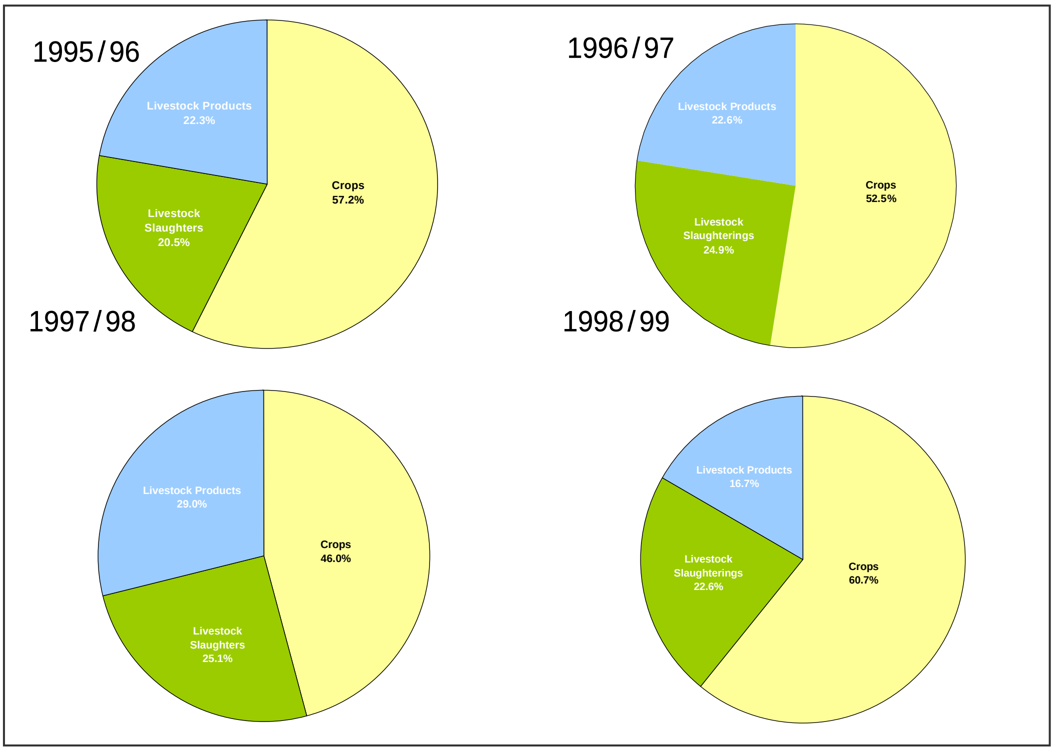
## Economic Contribution of Primary Industries

The following section provides an outline of the economic contribution of agriculture and mining and extractive industries to the local economy. The trends observed for a number of the Shire's key agricultural commodities are considered in more detail.

### Agriculture

In 1998/99, Agriculture contributed almost $50 million in gross income to Moorabool Shire. This income came from three sources: crops (including horticulture, turf, pasture and broadacre crops), livestock products (diary, wool and eggs) and livestock for slaughter. **Figure 2.3** shows how the contribution of each of these sectors to the Value of Agricultural Commodity Production[2] (VACP) has changed between 1995 and 1999. Up until 1998/1999 livestock products and slaughters were gradually displacing crops as the dominant source of VCAP. This trend can be observed to change in 1998/99, however, with crops expanding to make up 60.7% of the Value of Agricultural Commodity Production[3] (VACP). An examination of these trends shows that they can largely explained by macroeconomic shifts in cash receipts, technological changes (i.e. raised bed cropping) and by decreasing area under agriculture.

Figure 2.3 Major Agricultural Groupings, 1995/96 to 1998/99 for Moorabool Shire Council




(**Source:** Agricultural Surveys, 1995/96, 1996/97, 1997/98, 1998/99, via NRE StatsWeb, ABS)

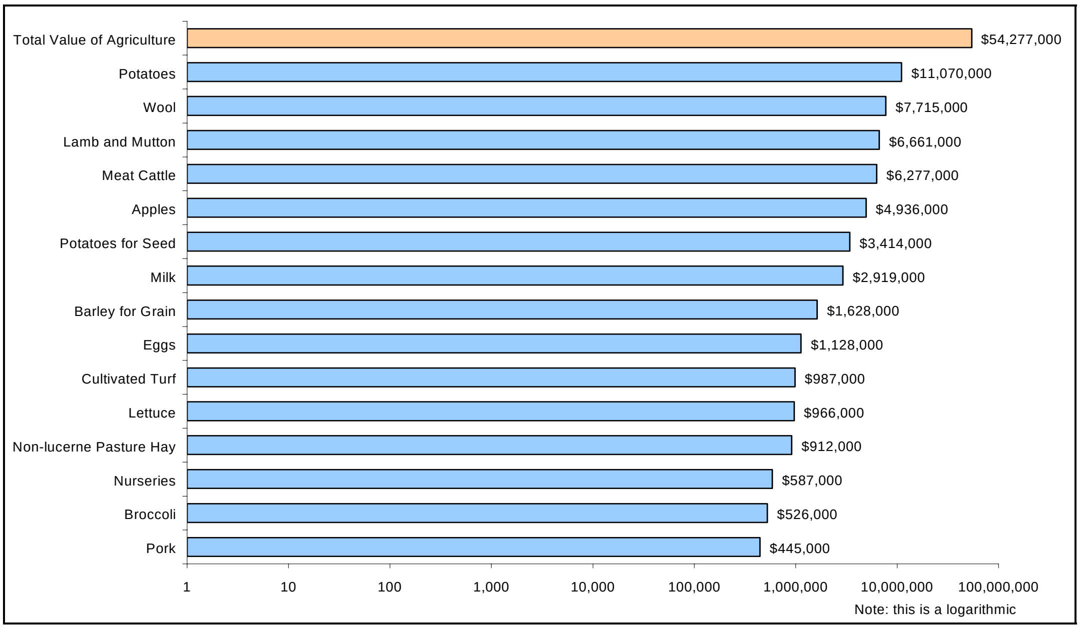
**Figure 2.4** shows the top 15 commodities according to their contribution to VACP in 1996/97. Potatoes contributed around 23% of Moorabool's VACP and, when

[2] VACP = Value of Agricultural Commodities Produced (VACP) is an estimate derived by ABS, a component of which is Gross Value of Production (GVP). While not a farm receipts/turnover/sales figure, GVAP can be used as an indicator of agriculture value.

[3] VACP = Value of Agricultural Commodities Produced (VACP) is an estimate derived by ABS, a component of which is Gross Value of Production (GVP). While not a farm receipts/turnover/sales figure, GVAP can be used as an indicator of agriculture value.

considered with potatoes grown for seed, represents almost 30%. Apples also constitute a significant proportion VACP, contributing some 8.5%. The Shire's other significant agricultural commodities centre around livestock products, such as wool (14%) and dairy (5%), sheep for slaughter (12%) and cattle (12%).

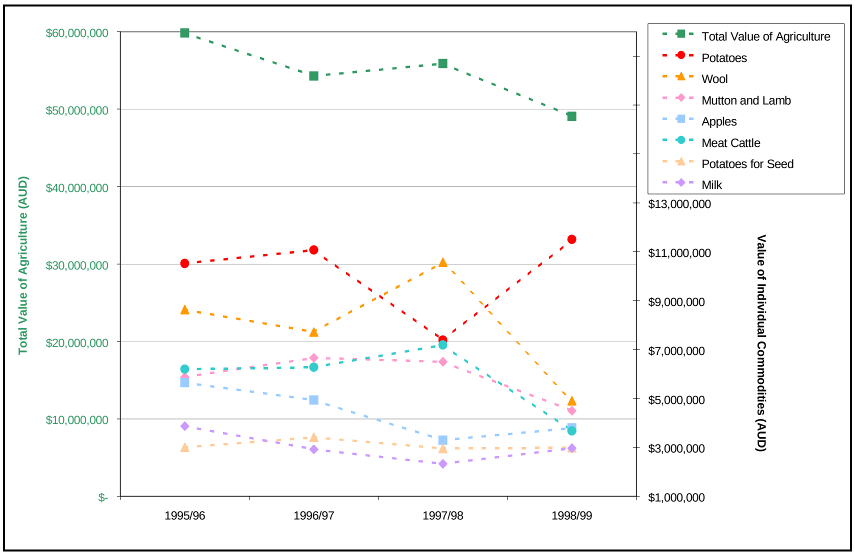
Figure 2.4 Value of Agricultural Commodity Production for Major Commodities, 1996/97 Moorabool Shire Council




(**Source:** Agricultural Survey 1996/97, ABS)

When the shifts in this contribution are considered over time several agricultural commodities can be seen to be making a consistent contribution to the Shire's VACP (**Figure 2.5**), the most significant of these are considered in more detail below.

Figure 2.5 Trends in VACP for Major Commodities (1995 – 1999) Moorabool Shire Council

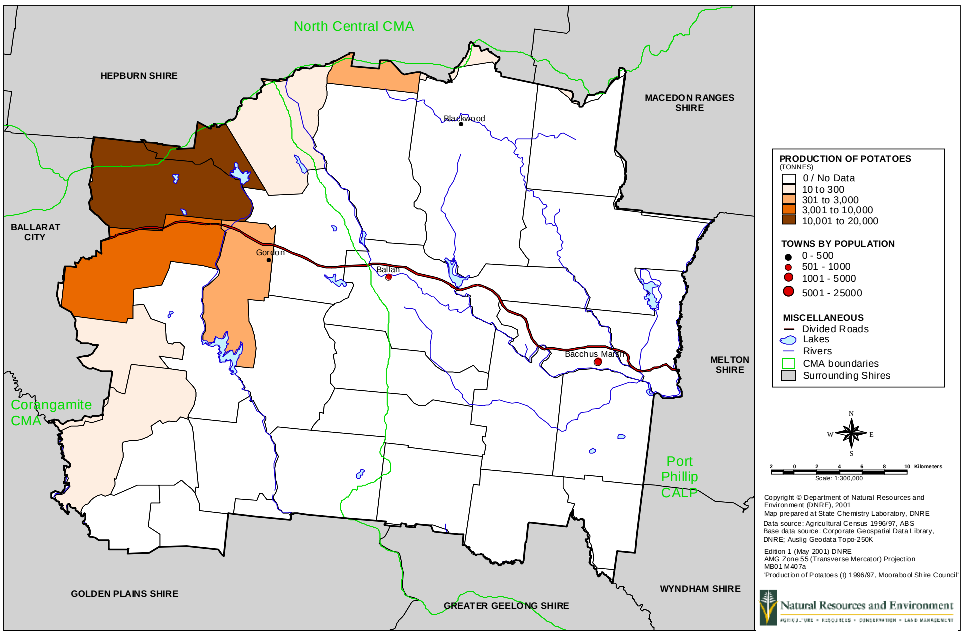



(**Source:** Agricultural Surveys, 1995/96, 1996/97, 1997/98, 1998/99, ABS; accessed via NRE StatsWeb)

## *Potatoes*

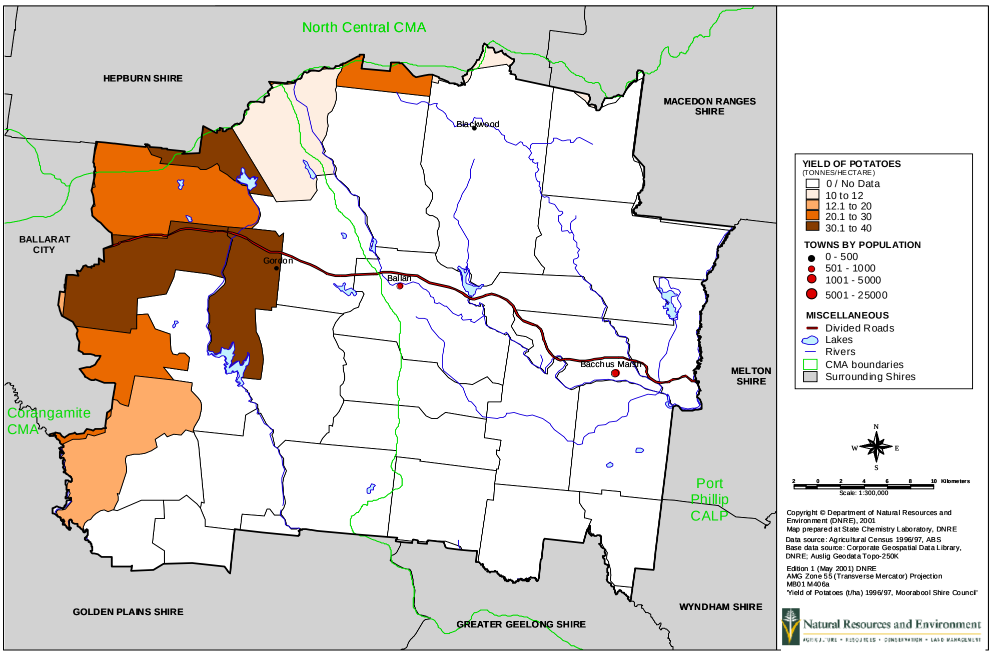
Representing over 23% of the Shire's VACP in 1998/99 (or $11.5 million), potatoes have been amongst the most valuable crops to the Shire over time, contributing both a greater proportion of VACP, and a larger absolute dollar amount than any other commodity. Potatoes are predominantly grown close to the Western Freeway along the Shire's western border (**Map 2.4a**).

Map 2.4a) Potato Production – 1996/97 (tonnes)




A comparison of the overall production (tonnes) vs. the yield (tonnes/ha) produced in these areas, however, shows that although the areas to the south of the Western freeway do not produce as large quantities of potatoes, they generally achieve higher yields per hectare, as defined by ABS (**Map 2.4b**).

Map 2.4b) Yield of Potatoes 1996/97 (tonnes/ha)



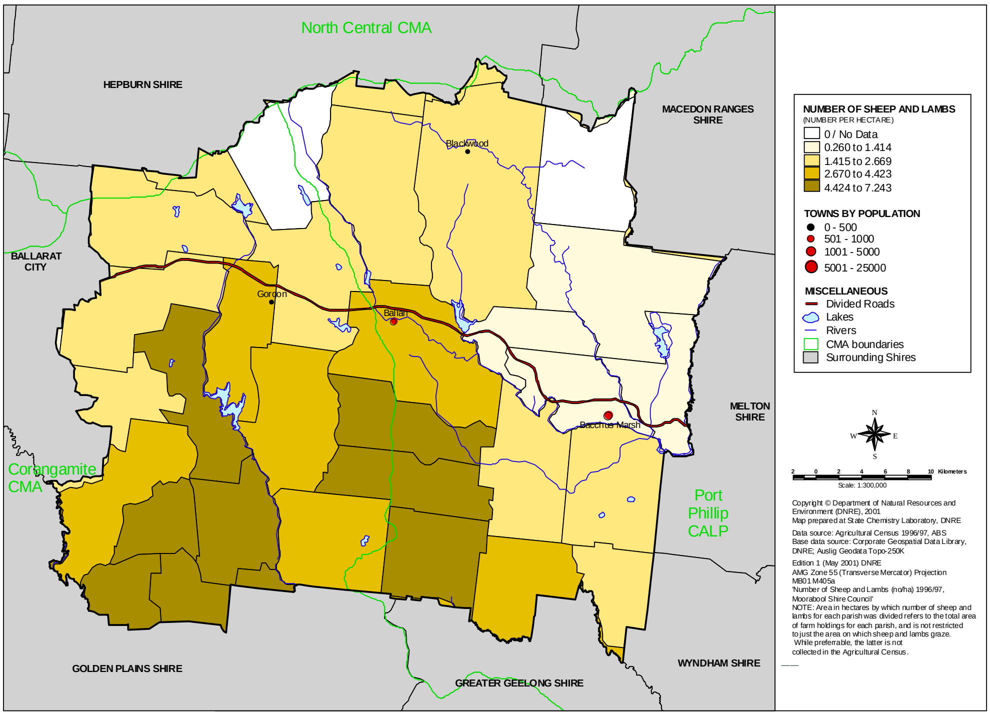
### *Sheep for Wool & Meat*

Over the time period in question, wool has consistently made the second largest, or largest, contribution to Moorabool's VACP (**Figure 2.4**). In absolute terms, however, the value of wool has fluctuated, peaking at $10.6 million in 1997/98 and briefly displacing potatoes as the most valuable enterprise before being subject to a sharp decrease to $4.9 million in 1998/99 (**Figure 2.5**).

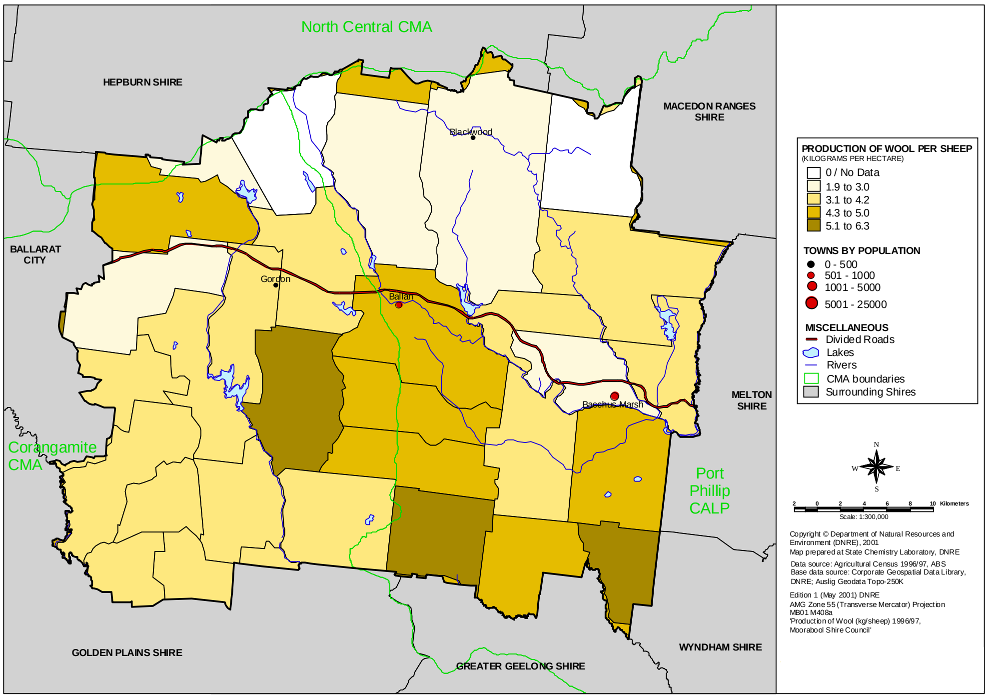
A similar trend can be observed with sheep and lambs grown for meat with VACP peaking at $6.7 million in 1996/97 before declining to $4.5 million in 1998/99. Across Victoria and Australia, the number of sheep sold increased between 1994/95 and 1997/98. Despite declines in cash costs between 1996/97 and 1997/98, larger declines in cash receipts resulted in reduced farm cash income (ABARE 1999, pp108-113). Wool receipts likewise were expected to decrease in 1998/99 (ABARE, 1999, p2)

While sheep and lambs grown for meat can be found right across the Shire, **Map 2.5** shows that the highest concentration per hectare is found south of the Freeway. Wool production follows a similar pattern, although it is more highly concentrated across the south-eastern portion of the Shire (**Map 2.6**).

Map 2.5 Number of Sheep and Lambs



Map 2.6 Production of Wool – 1996/97

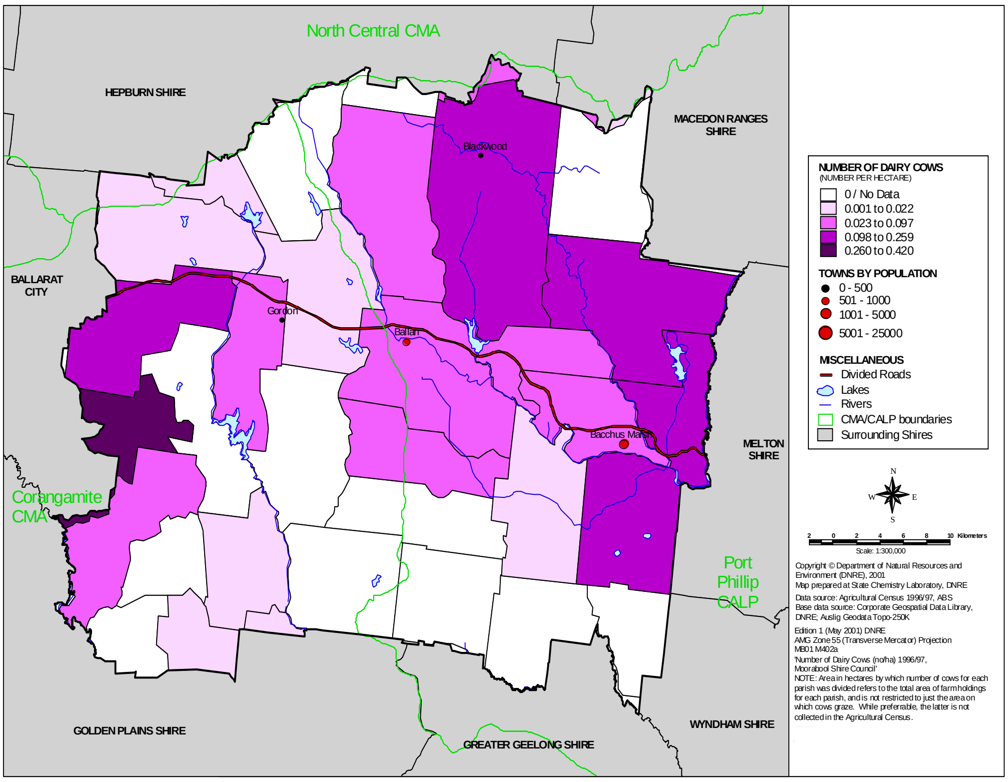



### *Cattle for Dairy and Meat*

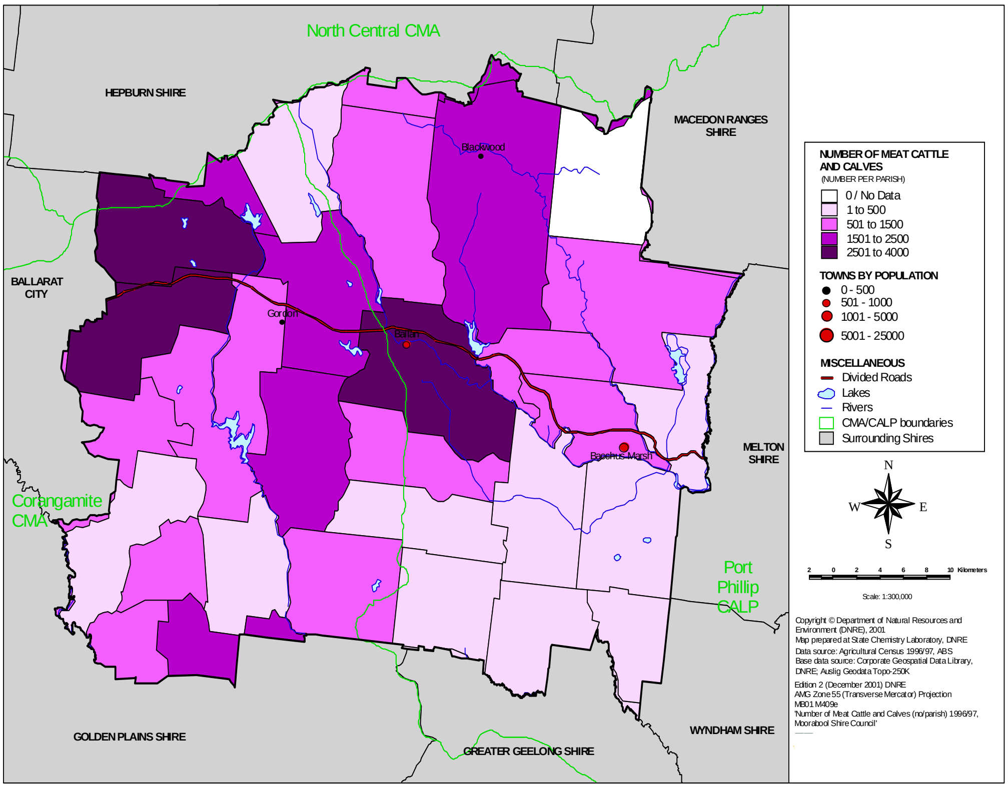
Cattle and calves for meat have been the third or forth most significant contributors to Moorabool's VACP over the time period in question (**Figure 2.5**). Its value has also fluctuated increasing by $1 million from 1995/96 to 1997/98, before declining sharply by almost 50% to $3.7 million. Contrary to this and other trends already discussed, the value of milk to the Shire displayed the opposite trend decreasing between1995/96 and 1997/98, before increasing to $3.0 million by 1998/99. Like sheep, the number of beef cattle sold between 1994/95 and 1997/98 increased (ABARE, 1999, pp88-91; ABARE, 1998, pp84-87; ABARE, 1997, pp84-87). However, large declines in cash costs between 1997/98 and 1998/99 were insufficient to offset larger declines in cash receipts (ABARE 1999, pp108-113) with the result being lower farm business profits to farms in this industry.

Both dairy and beef cattle are raised across the Shire (**Maps 2.7a & b**). While it is clear that dairy farms are not as widely distributed as beef cattle, the corse nature of the data does not allow a firm distinction between their distributions.

Map 2.7a) Distribution of Dairy Cattle per hectare (1996/97)



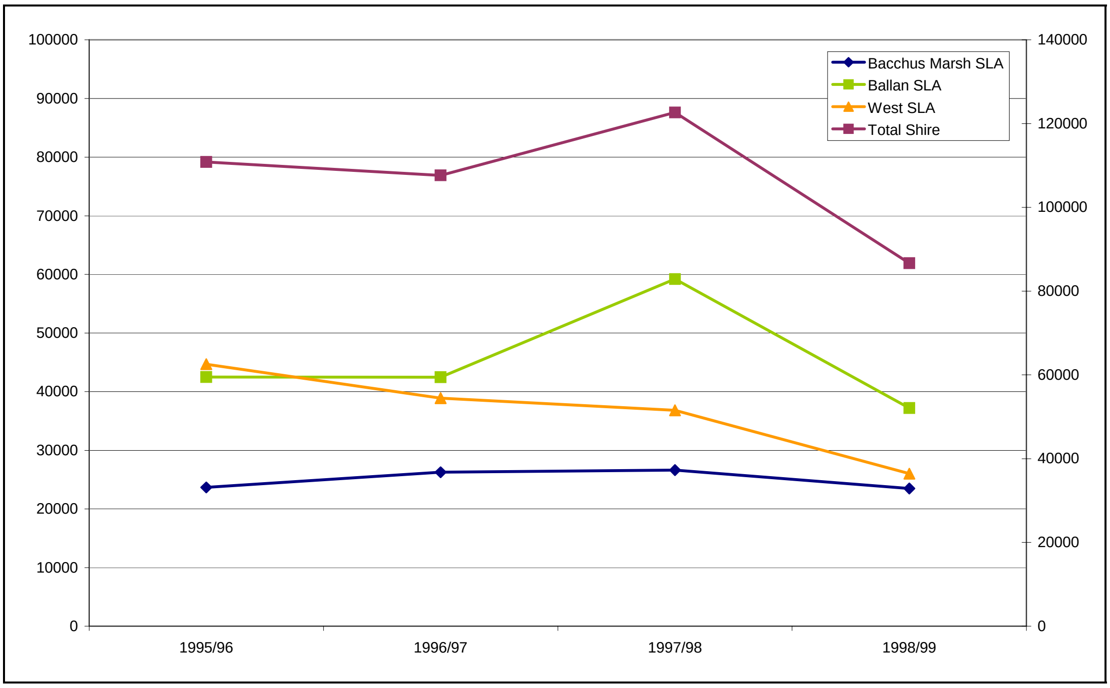

Map 2.7b) Distribution of Beef Cattle and Calves per hectare (1996/97)




### *Less Land Under Agriculture*

Aside from macro-scale agricultural prices and costs, another contributing factor to the Shire's decreasing VACP may be the decreasing amount of land under agriculture. In 1995/96 some 111,000 hectares was under agriculture, the majority of which land was located in the central region of the Shire around the township of Ballan (**Figure 2.6**). By 1997/98, the total area increased before falling quite substantially to 87,000 hectares in 1998/99. When individual statistical local areas (SLA) are considered, it is clear that most of this change was the result of fluctuations in the amount of land used for agriculture in this central region, with land in the east showing a steady decline.

Figure 2.6 Area under Agriculture, 1995/96 to 1998/99
Moorabool Shire Council




**Source:** Agricultural Surveys 1995/96, 1996/97, 1997/98 and 1998/99, ABS

These fluctuations help to explain some of the variation seen in Moorabool's VACP (see **Figure 2.5**). Further investigation would be expected to show that these changes are the result of land being converted from agriculture to forestry and urban development.

## 2.4 Transport and Infrastructure

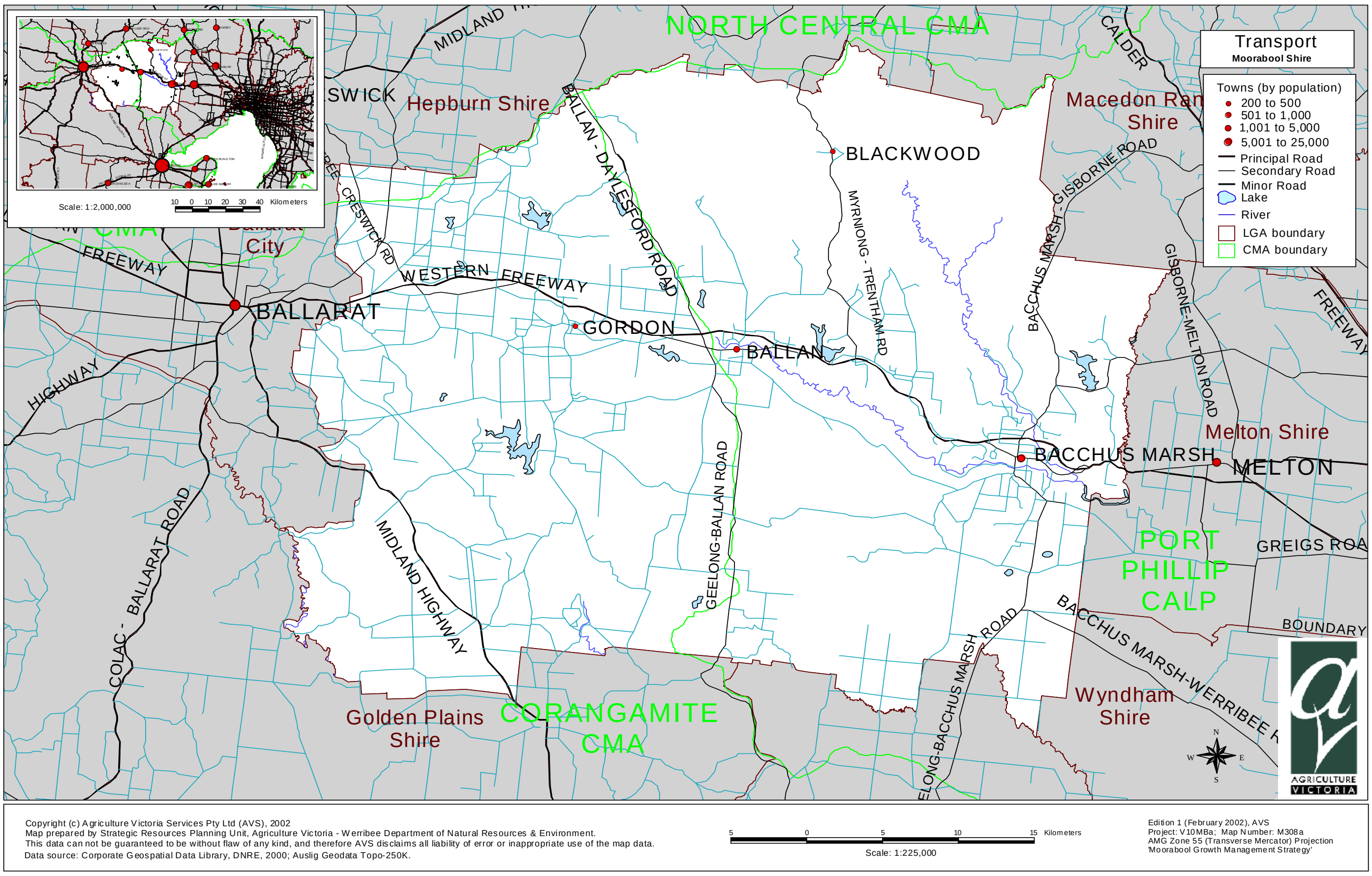
Future growth of Moorabool is highly dependent on its accessibility. The proximity of Melbourne to the east of Moorabool has already seen a huge growth disparity across the Shire. The development of transport and infrastructure would be of enormous benefit to the west in order to curb the disparity in jobs, income and future migration, but would also support the industries that are important to the future growth. The Western Highway, the main arterial connecting Melbourne and Western Victoria, roughly transects Moorabool Shire (**Map 2.7**). A comprehensive rail system also enables travel between Melbourne, Melton, Bacchus Marsh, Ballan and beyond to Ballarat (**Map 2.8**).

### Road Transport

The Western Highway is a declared national highway, originating in metropolitan Melbourne and forming a central access route to Western Victoria. The Western Highway has recently been duplicated as far as the Sunraysia Highway at Ballarat. A number of other key road transport routes are present within Moorabool. The Midland Highway, a state road, crosses through the south western corner of

Moorabool Shire on the way to Ballarat. While two key C class roads run in a north to south direction: the Bacchus Marsh-Gisborne Road, which becomes the Geelong-Bacchus Marsh Road, and the Geelong-Ballan Road. C class roads are generally defined as two-laned, undivided roads.

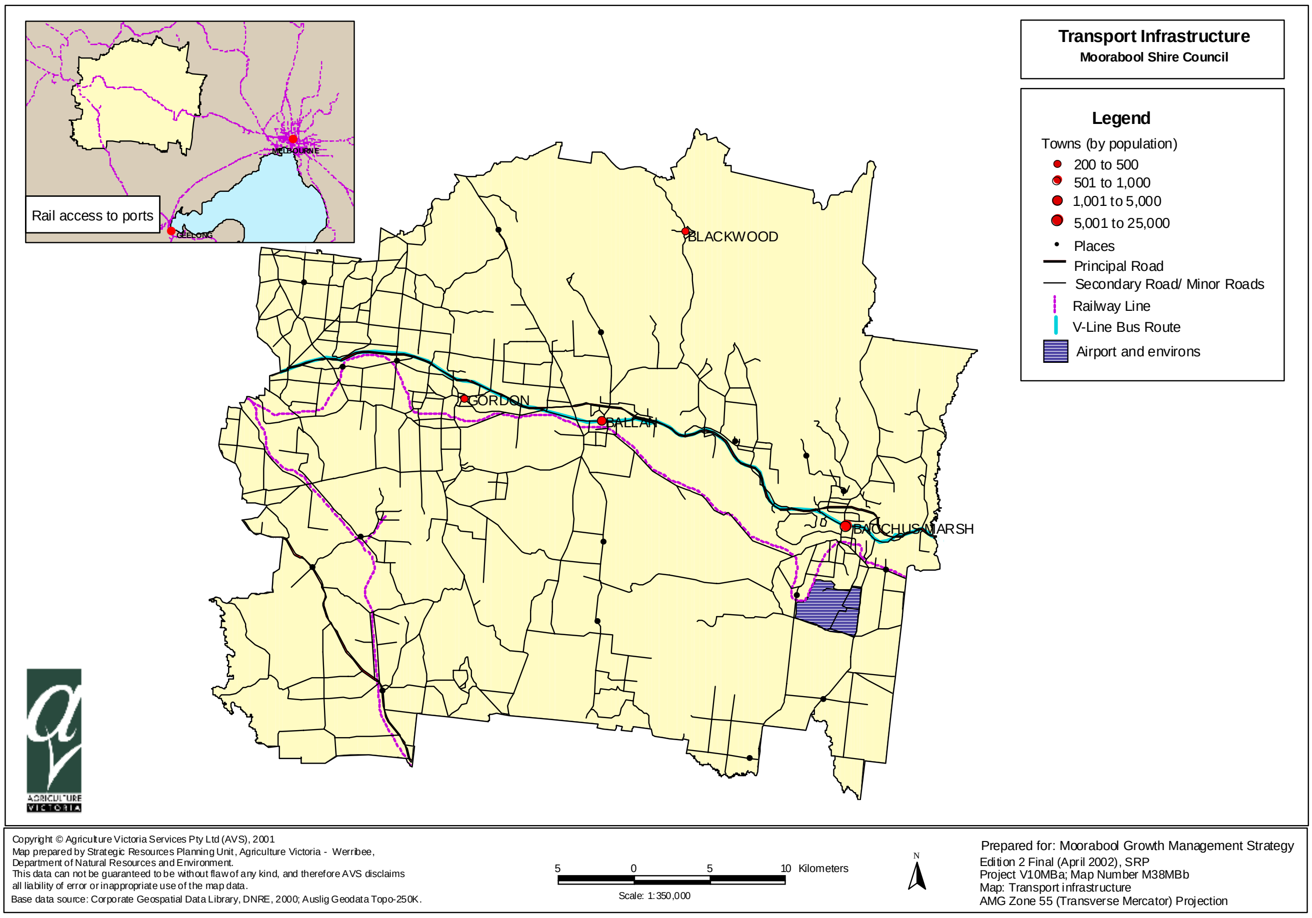
Map 2.8 Road Network for the Shire of Moorabool




## Bus Transport

The bus transport system in Moorabool is run by private bus companies. The bus in Bacchus Marsh is run by Bacchus Marsh Coaches on behalf of V-Line. Buses pick up passengers with the arrival of trains and stop at various locations within the town. A bus service runs between Ballarat and Tullamarine airport stopping at Bacchus Marsh, Melton and Ballan. Bacchus Marsh Coaches also operate in Darley, while Ballarat Coaches operate buses in Melton and Bacchus Marsh (see **Map 2.9**).

Map 2.9 Transport Infrastructure for the Shire of Moorabool




**Source:** Moorabool Shire Council

## Rail Transport

A broad gauge freight railway runs between Ballarat and Melbourne, through Moorabool Shire. Passenger services operate between Melbourne and Ballarat stopping at Bacchus Marsh and Ballan. Metropolitan train services operate a service from Melton into Melbourne. Growth rates for demand for rail services has increased by 38% since 1993/94 in the Ballarat Corridor. Currently, travel time between Bacchus Marsh and Melbourne is 65 minutes and in 1998/99 1,343 people boarded trains in the Ballarat Corridor.

## Airports

The nearest local airport to Moorabool is at Ballarat, and the nearest international and scheduled airport to Moorabool is Tullamarine in Melbourne. The long debated future of Essendon Airport in Melbourne's North West is another important issue in the region. Essendon currently records 72, 000 movements a year, with a capacity of double that.

A report commissioned by the State Government, 'Capacity of Aviation Facilities in the Port Phillip Region', September 2000, finds a case for Essendon Airport's closure. The overriding concern about the airports operations has been a safety issue due to close proximity to residential developments. It has been proposed that if land at Essendon Airport became available for development then a mixed use development would be the most likely outcome, with industrial, commercial and large residential components. An increase in employment in the northern and western suburbs of Melbourne from the redevelopment of the airport would encourage more people to possibly choose to commute to work from places such as Moorabool. However, the

'Moorabool Industrial Areas Strategy' 2001, found that due to the extent of industrial land availability in the inner northern and western suburbs, this makes Moorabool a less attractive location for industrial investment. The redevelopment of the Essendon Airport site would further reaffirm this disadvantage.

### Ports

Moorabool Shire is bordered by the Macedon Ranges Shire, the Shire of Melton, City of Wyndham, City of Greater Geelong, Golden Plains Shire and the City of Ballarat. The ports of Geelong and Melbourne are the closest ports to Moorabool Shire.

# 3. LAND SUITABILITY ANALYSIS

Determining the optimal use of particular types of land is a complex process involving multiple decisions that relate to a range of biophysical, socio-economic and institutional/organisational aspects (Ahern, 1999). A structured and consistent approach to Land Resource Assessment (LRA) is thus essential. Ensuring that land use is compatible with the intrinsic characteristics of the Australian environment is fundamental to improving natural resource management and contributing to the sustainability of resources (Lovering and Crabb, 1997; NLWRA, 2001a). This chapter discusses the decision support systems applied to Land Suitability Analysis (LSA), a component of LRA.

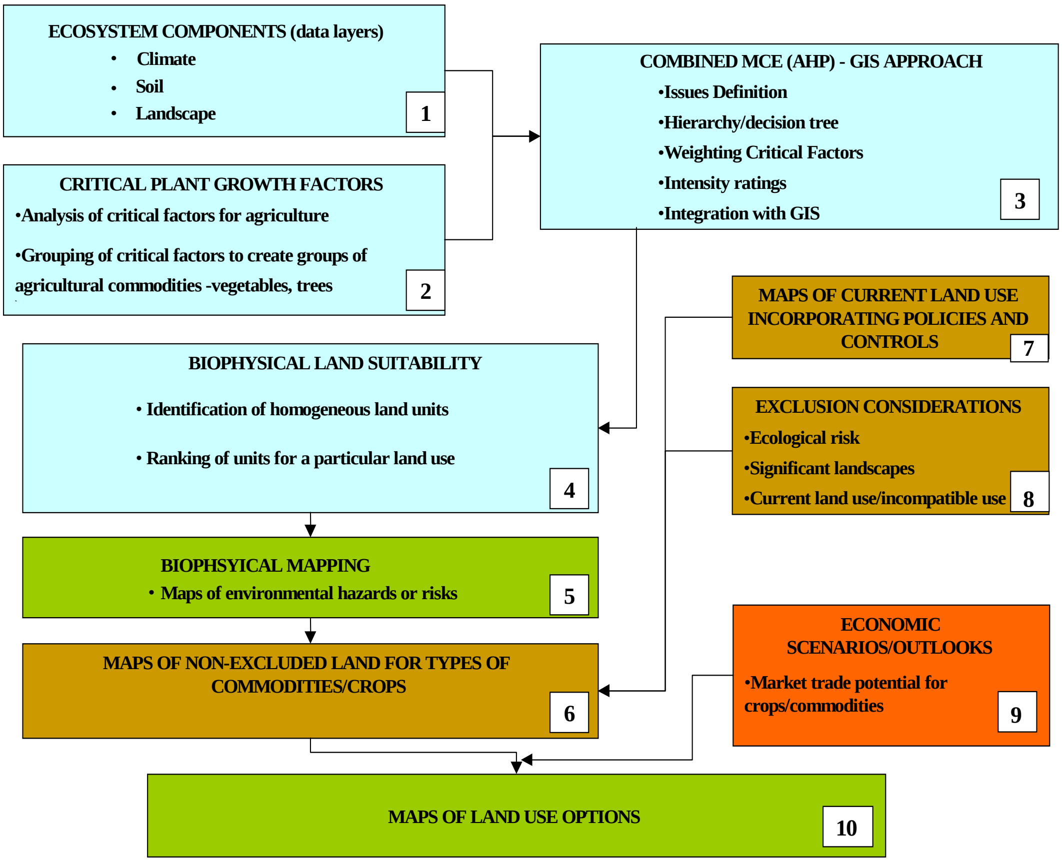
## 3.1 Land Suitability Analysis Methodology

The methodology applied to LSA integrates a *Multiple Criteria Evaluation* (MCE) method in a GIS environment (Malczewski, 1999). MCE is an effective decision-making tool for complex issues that uses both qualitative and quantitative information.

In order to define the natural suitability of an area for a specific agricultural purpose, several criteria must be evaluated based on the specific growth requirements of each commodity. These criteria can be characterised through soil, climate, and landscape components. It should be noted that the land suitability models do not take management or infrastructure factors, such as the location of irrigation areas, into account as there is little reliable data available and it was felt these factors are highly dynamic. The critical factors necessary to grow specific commodities are determined in expert panel workshops and are developed as commodity growth models. These factors are then ordered into a hierarchy of importance or decision tree using the *Analytic Hierarchy Process* (AHP), a well known MCE method (Saaty, 1994/2000; 1980). Specific values for each criterion are detailed and ranked according to the most to least preferred conditions for growth. Each criterion is then weighted according to relative importance to the growth of the commodity. The commodity growth model is then run in the GIS platform, which simultaneously calculates and combines all the necessary data (**Figure 3.1**).

The modelling generates a spatial map with a single composite index which depicts the probability of the key ecosystem components being suitable for commercial commodity production with respect to plant growth. The evaluation index broadly classifies the landscape into four categories: low, moderate, high, and restricted. Restricted refers to land that is considered to be completely unsuitable for production due to the values of one or more factors such as slope, soil or rainfall. In addition, area statements (in hectares) are tabled for each commodity, specifying the amount of available land according to each category of suitability, ranging from low to high.

Figure 3.1 Land Suitability Analysis Method




(**Source:** DNRE, 1999)

## 3.2 Biophysical Suitability of Selected Crops

The method described in the previous section can be used for single commodities or, where the growth requirements are similar, for groups of commodities. The formation of groups of vegetables and fruits was based on a literature review which identified important growth characteristics and significant distinguishing features of the various commodities. The list was discussed with agronomists, soil scientists and other relevant crop experts in the Moorabool Region to ensure that maximum benefit was gained from local experience. It is considered that the groups selected are representative of a broad range of crops and commodities, thus permitting a strategic evaluation of the suitability of land for agriculture in the region.

### Selection of Commodities

The following eleven commodities (and 'other' – horses) were selected for the Moorabool Shire, based on an assessment of the:

(i) commodities currently produced in Moorabool;
(ii) new commodities that could be introduced in the region according to potential market (both domestic and export) demand;
(iii) advice from agronomists and other relevant experts; and
(iv) discussion with senior officers of the Moorabool Shire and Grow West.

| | | |
|---|---|---|
| *Vegetable grouping* | • | Brassica and Artichokes - broccoli, Brussel sprouts, cabbages, cauliflowers, kales, mustard, Jerusalem artichoke, Chinese cabbage, Chinese broccoli |
| | • | Potato |
| *Fruit grouping* | • | Pome Fruits - apples, pears, quinces |
| | • | Olive |
| *Crop grouping* | • | Buckwheat |
| | • | Winter Wheats (red) |
| *Pastures* | • | Perennial Ryegrass/White Clover |
| | • | Phalaris/Sub-Clover |
| *Flower grouping* | • | Lavender |
| | • | Proteas |
| *Plantation Grouping* | • | Radiata Pine |
| *Other* | • | Horses |

## Source Data: Layers for the Application of the AHP

Three essential data sources were utilised in the land suitability mapping: soils, landscape and climate data. The soil data was mapped at a scale of 1:100,000; climate data at a scale of 1:250,000; and the landscape data at a scale of 1:25,000. The combined resolution of the analysis is a 10 m grid cell size, therefore, the maps of land suitability are presented at a geographic scale of 1:100,000. This is appropriate for strategic planning purposes at the regional level, but is not appropriate for specific site investigations. It is advisable, therefore, that further detailed site investigations or soil sampling be carried out (for instance, at 1:25,000 or 1:5,000 scales) prior to new site development proceeding.

### Soil

The soil mapping of Moorabool outlines a range of physical and chemical attributes which are assigned to each soil type and are defined according to standard field assessments. The soil data used in the project was adapted from mapping carried out by Maher and Martin (1987) and existing point data contained within the Victorian Soils Database (previous Land System Studies).

The attributes used within the land suitability model include:

- pH surface soil and subsoil
- Sodicity surface soil and subsurface
- Dilatence[4]
- Permeability
- Depth to B horizon
- Internal drainage (surface soil and subsurface)
- EC surface soil and subsurface
- Texture surface soil and subsoil
- Coarse Fragments
- Depth to Bedrock
- Useable soil depth
- Impedance of B horizon

### Landscape

The generation of a high resolution landform layer to describe landscape characteristics involves the creation of a digital elevation model (DEM). DEM's are used to generate other information about landscape position. This includes slope, aspect, curvature, and elevation. The DEM layer used was generated by the (former) DPI Centre for Land Protection and Research (CLPR)-AV, using ANUDEM 4.6 with corrected hydrology and 1:25 000 topographic information which included 10 metre contours and all available spot height information. The resolution of the DEM is 25m.

[4] Dilatence refers to the ease with which water moves out of a saturated soil, which is dependant on the proportion of sand and/or silt present.

### Climate

Climate characteristics used were generated through the analysis of data received from the Bureau of Meteorology (BOM). The BOM recommends the climate information below be used at a scale of 1:250,000. The data includes:

- Temperature (ºC)
- Rainfall (mm), monthly
- Extreme heat days (2 datasets of days/month above 30ºC and above 40ºC)
- Branas Index[5]
- Heat Degree Days (HDD)[6]
- Solar radiation.
- Wind strength
- frost below 2ºC or below 0ºC

### Other Data Overlays

#### *Complex Soils*

The areas identified as 'Complex Soils' represent an Alluvial Plain soil-geomorphic unit. The alluvial plain unit is comprised of black cracking clays on alluvial plains and yellow duplex soils on gently undulating plains that have at the regional (1:100,000) level been grouped together. Due to the variation contained within the soil unit it has been identified as complex, and different soils within the unit will have a higher or lower suitability for agriculture depending on the soil type and their inherent properties.

#### *Restrictive Soils*

Restrictive soils have been identified based on soil types. These include swamps, lakes, silts and river flats. These units have one or more factors such as high salinity and poor drainage, which make them unsuitable for agricultural production.

#### *Poor Winter Trafficability*

Areas marked as 'Poor Winter Trafficability' generally have soils which are either i) low lying landscape and/or with impeded drainage or ii) have a conspicuously bleached subsurface (A2) horizon which becomes unstable when wet and therefore impedes the traffic of farm machinery and/or cultivation. In the first situation, the installation of external and/or internal drains may allow these soils to be utilised for cropping purposes for most of the year. In the second situation, internal drains (where they can be suitably installed) may be of assistance but cultivation should still be restricted to 'moist' and not 'wet' conditions. As well as becoming unstable when wet, bleached subsurface (A2) horizons generally become extremely hardset when dry and cultivation in this state can lead to clodding or pulverisation/powdering. In some soils the subsurface (A2) horizon becomes unstable with only a small amount of water (i.e. the rest of the profile may be well drained) and as such, they should probably be restricted to summer cropping only, and if irrigated, low flow systems should be used.

[5] The *Branas Index* is a generalised index to gain an understanding of the potential for grapes to develop fungal infections that lead to sub-optimal yields and quality in the crop. It can be made specific to each type of infection such as powdery mildew and botrytis. The index is calculated by multiplying mean monthly temperature by mean monthly rainfall and summing the totals for the period October to March inclusive. It provides a rough estimate of the humidity and wetness of the growing area – wet, warm humid conditions most often lead to the development of fungal infections.

[6] Heat Degree Days are a summation of mean temperatures >10ºC during Oct-Apr.

# 4. LAND SUITABILITY MAPS

## 4.1 Brassica and Artichoke

**Broccoli, Brussel Sprouts, Cabbages, Cauliflowers, Kales, Mustard, Chinese Cabbage, Chinese Broccoli and Jerusalem Artichokes**

Broccoli, cauliflower, cabbage, and Brussel sprouts are all varieties of *Brassica oleracea*; Chinese cabbage is a variety of *Brassica campestris*. Worldwide Broccoli has created new interest as a vegetable, the growing demand resulting in an improvement in product quality in Australia. Brassicas can be grown all year round in Victoria as they are able to withstand a wide range of conditions and are particularly tolerant of cold. In most situations Brassica will require additional water through irrigation; therefore detailed suitability assessment should include further collection of information about existing irrigation

Brassica and Artichoke: Criteria for Growth

| | | | Optimal | Least Desirable |
|---|---|---|---|---|
| **Soil** | pH | Surface<br>Sub-surface | 6.5 to 7.5<br>6.5 to 7.5 | <5<br><5 |
| | Sodicity | Surface<br>Sub-surface | Non-sodic<br>Non-sodic | Sodic<br>Sodic |
| | Texture | Surface | L, SL, ZL, SCL | MHC, HC |
| | Useable Depth | | >750 mm | <300 mm |
| | Drainage | Surface<br>Sub-surface | Moderately well, well drained<br>Moderately well, well drained | Poorly, very poorly drained<br>Poorly, very poorly drained |
| **Climate** | Temperature | Mean monthly maximum<br>Mean monthly minimum | 18 to 24ºC<br>10 to 15ºC | <13 and >18ºC<br><0ºC |
| | Rainfall | Average annual<br>Average monthly in growing season (Oct to April) | >1000 mm<br>>50 mm | <400 mm<br><25 mm |
| **Landscape** | Slope | | 0 to 3% | >15% |

Soil: The ideal soils for the production of Brassicas are alluvial soils, loams and clay loams that have a high content of organic matter, good structure and are well drained. Brassica species do not flourish under strongly acidic conditions. More specifically, desirable soils should be slightly acidic (i.e. pH ~6.5, in water) as most nutrients are readily available at this pH (Dimsey, 1995).

Brassica species have a high demand for major nutrients and trace elements. Generally a base fertiliser and one or two side dressings are required. The amount and frequency of fertiliser applied depends on the soil type. Soils with a medium to high clay content and high organic matter retain nutrients more strongly and are not as readily leached as lighter soils. Sandy loams will need higher rates of fertiliser and more frequent watering under dry conditions.

Climate: Brassica species can be grown all year round across most of Victoria, however, extreme heat in summer and frosts in winter can restrict production. The growing season for Brassica and Artichoke is from May to September, as the rainfall during this period (i.e. <50mm/month) is considered optimal for production.

Cabbages require more irrigation when grown on beds than those grown on the flat (Dimsey, 1995)

Landscape: Landform units that are unsuitable for the production of Brassica species, comprise elevated and dissected steep mountains and hills, coastal dunes, wetland complexes, high siliceous dune fields and stony undulating plains.

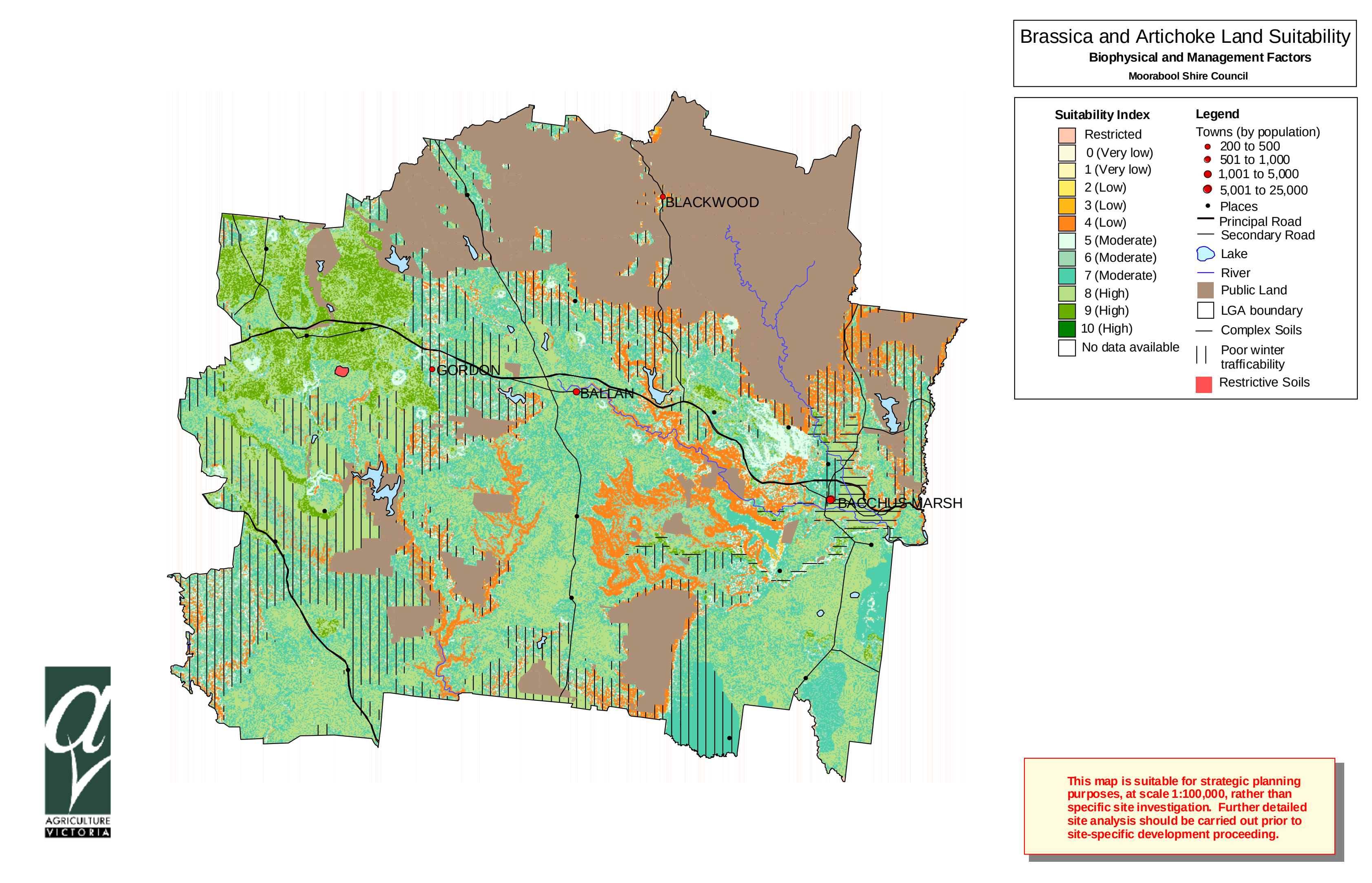
## Brassica and Artichoke Suitability Across Moorabool Shire

| Suitability | Hectares within the Shire |
|---|---|
| Low | 17,440 |
| Moderate | 68,750 |
| High | 67,360 |

**Note:** The suitability area calculations have been approximated to the nearest ten hectares. Public land, totalling more than 57,510 hectares, is excluded from the calculations. The total private land area mapped is estimated at over 150,690 hectares in the Moorabool Shire.

Brassica species are relatively easy to grow and tolerate a wide range of soil and climate conditions. In the case of Moorabool, the climatic conditions are generally favourable for Brassica growth, with the suitability of soil and landscape factors causing most of the variation across the Shire (**Map 4.1**). A significant amount of land was identified as being highly suitable, the majority of which is located in the west of the Shire around the towns of Wallace, Bungaree, and Elaine. The higher suitability areas are generally characterised by more suitable soils, that are deep, moderately to well drained and non sodic.

## Map 4.1 Land Suitability for Brassica and Artichoke Production





Map prepared by Strategic Resources Planning Unit, Agriculture Victoria - Werribee, Department of Natural Resources and Environment.
This data can not be guaranteed to be without flaw of any kind, and therefore AVS disclaims all liability of error or inappropriate use of the map data.

Data source: Soils and DEM data from Agriculture Victoria, DNRE, 2001/02; Climate data from CLPR, DNRE and Bureau of Meterology, 2000/01
Base data source: Corporate Geospatial Data Library, DNRE, 2000; Auslig Geodata Topo-250K.

Prepared for: Moorabool Growth Management Strategy
Edition 2 Final (February 2002), SRP
Project V10MBa; Map Number M02MBb
Model No. BrassicaBioMng
AMG Zone 55 (Transverse Mercator) Projection

## 4.2 Pome Fruit

**Apples, Pears, and Quinces**

Pome fruit are grown commercially over a wide range of climate and soil types. The chilling requirements of pome fruit growth make them most suited to climates with cool winters. Major pome fruit growing regions in Victoria include the eastern metropolitan area of Melbourne, Harcourt, Bacchus Marsh, Gippsland, Mornington Peninsula and Goulburn Valley.

Pome Fruit: Criteria for Growth

| | | | **Optimal** | **Least Desirable** |
|---|---|---|---|---|
| **Soil** | PH | Surface<br>Sub-surface | 6.0 to 7.5<br>6.0 to 7.5 | <4.5 or >8.5<br><4.5 or >8.5 |
| | Sodicity | Surface<br>Sub-surface | Not sodic (<6 Na% ECEC)<br>Not sodic (<6 Na% ECEC) | Sodic (>15 Na% ECEC)<br>Sodic (>15 Na% ECEC) |
| | Texture | Surface<br>Sub-surface | CL<br>CL | HC<br>HC |
| | Useable Depth | | 500 to 1000 mm | <150 mm |
| | Drainage | | Well drained | Very poorly drained |
| | Electrical Conductivity (EC) | Surface<br>Sub-surface | Very low <0.15 dS/m<br>Very low <0.15 dS/m | High >0.55 dS/m<br>High >0.55 dS/m |
| **Climate** | Temperature | Peak fruit growth<br>Early fruit/ flowering<br>Bud burst/ maturity | 20 to 25°<br>16 to 25°C<br>14 to 25°C | <16 or >28°C<br><14°C<br><14 or >25°C |
| | Chilling | | >800 hours below 7°C | <600 hours below 7°C |
| | Rainfall | | 40 to 60 mm monthly average | <15 mm monthly average |
| | Frost | | No frost from flowering (mid-Sept onwards) | Frost after mid-September |
| | Wind Strength | | Low (infrequent or light) | High (strong and regular) |
| **Landscape** | Aspect | | Northerly 350 to 10° | Southerly |
| | Slope | | 0 to 2° | >15° |

Soil: Pome fruits are intolerant of high soil salinity levels but are otherwise more tolerant of soil variation than many other fruit trees. Despite this, deep, well structured soils with good drainage are preferred.

Climate: Pome fruits prefer temperate climates, with moderate to warm temperatures during the growing season and cooler temperatures during maturation. Mean January temperatures of between 16°C and 23°C are optimal. Frosts are harmful once buds begin to open, so late flowering varieties are sometimes favoured.

Landscape: Gentle slopes facing north are preferable for the growth of pome fruits. Steeper and south-facing slopes are unsuitable because of the lack of sunlight.

## Pome Fruit Suitability Across Moorabool Shire

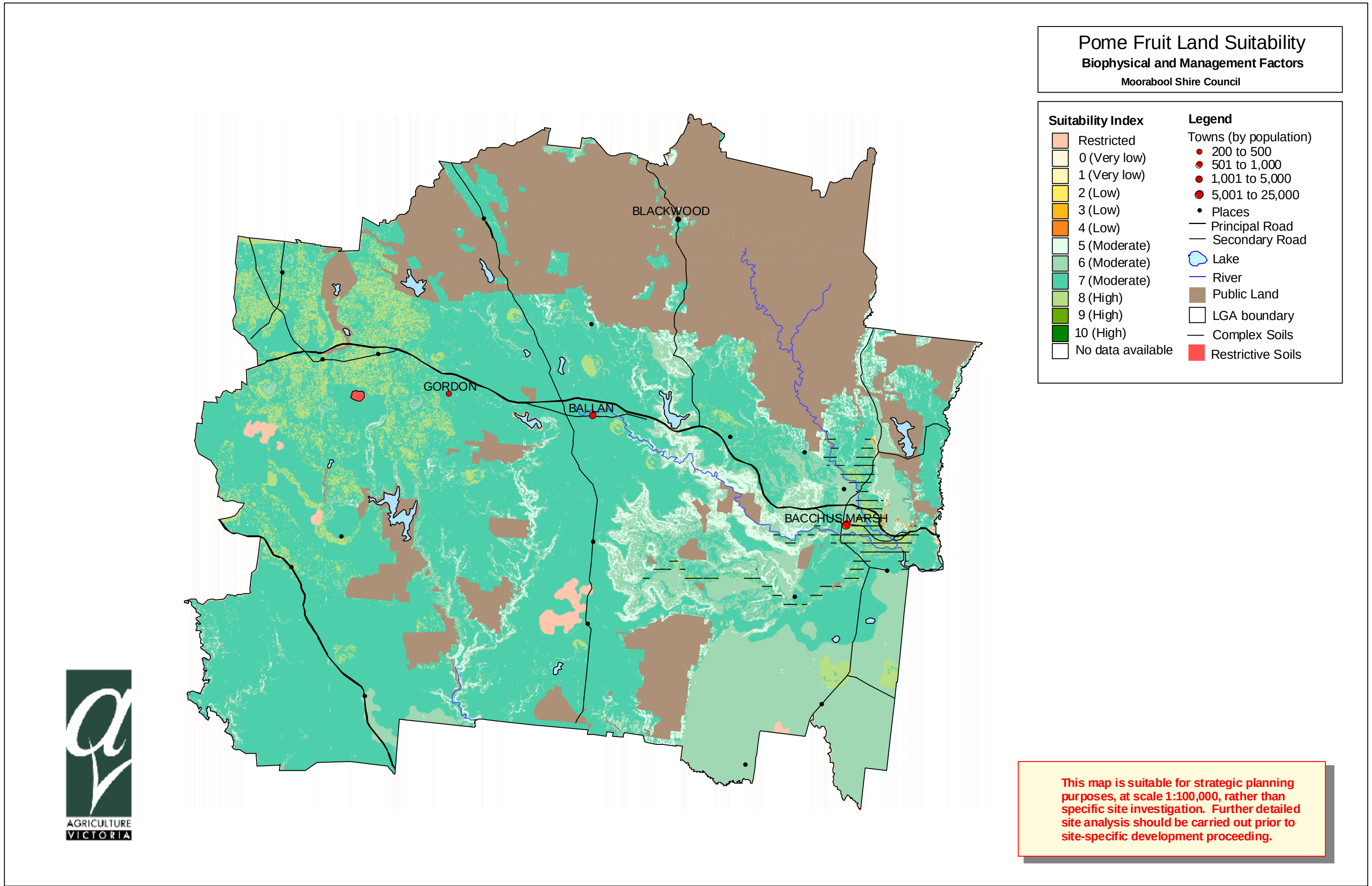
| Suitability | Hectares within the Shire |
|---|---|
| Low | 110 |
| Moderate | 141,210 |
| High | 11,100 |

**Note:** The suitability area calculations have been approximated to the nearest ten hectares. Public land, totally more than 57,510 hectares, is excluded from the calculations. The total private land area mapped is estimated at over 150,690 hectares in the Moorabool Shire.

The majority of the Shire has been mapped as moderately suitable for the production of pome fruit (**Map 4.2**). The widespread occurrence of frosts during the growing season, September to April, had a significant impact on the suitability of the area for production. Frosts during this period can damage growing fruit and result in reduced quality and yield.

The moderate suitability areas to the south-east are associated with sodic sub-soils, the sodicity of which can result in a deterioration of the soils physical condition resulting in waterlogging, crusting and increased risk of erosion (Peverill *et. al.*, 1999). Slightly sodic soils can be ameliorated through the use of gypsum. An area to the south of Ballan has been mapped as restricted; this is due to the very poor soil drainage in the area. Some areas to the west of Gordon and to the east of Bacchus Marsh are classified as being highly suitable to the growth of pome fruits. These areas are associated with soils that are non-sodic, have a useable depth greater than 40 centimetres and are imperfectly to moderately well drained.

# Map 4.2 Land Suitability for Pome Fruit Production





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Base data source: Corporate Geospatial Data Library, DNRE, 2000; Auslig Geodata Topo-250K.

5 0 5 10 15 Kilometers
Scale: 1:250,000

N

Prepared for: Moorabool Growth Management Strategy

Edition 2 Final (February 2002), SRP
Project V10MBa; Map Number M04MBb
Model No. Pomefruit
AMG Zone 55 (Transverse Mercator) Projection

## 4.3 Potato

Potatoes in Victoria are predominantly grown in the sandy and sandy loam areas of the Bellarine Peninsula, the Mornington Peninsula and the market garden areas around Dandenong, Frankston, Clyde, Cranbourne and Werribee South. Potato production in Moorabool Shire is significant, with an estimated value of $11.5 million for the year ending 31st March 1999 (ABS, 2000).

### Potato: Criteria for Growth

| | | | Optimal | Least Desirable |
|---|---|---|---|---|
| **Soil** | pH | Sub-surface | 5.5 to 6 | <4.5 or >9 |
| | Texture | Topsoil | LS, SL | SCL, MC |
| | Useable Depth | | >50cm | <20cm |
| | Coarse Fragments | | no coarse fragments | >30% |
| **Climate** | Temperature | Daily Maximum | 16 to 20ºC | <10ºC in a month or >30ºC |
| | Rainfall (monthly) | During planting | <50 mm | >50 mm |
| | | During tuber initiation | 70 to 80 mm | 0 mm |
| | | During bulking | >80 mm | <50 mm |
| | | Before and during harvest | <40 mm per month | >70 mm per month |
| | Light Intensity | | >2500 MJ/m$^2$ | 1000-1200 MJ/m$^2$ |
| **Landscape** | Slope | percent | 0 - 2% | >10% |

Soil: Soil type has considerable impact on potato production, in particular soil properties such as soil texture and permeability. Potatoes are intolerant of waterlogged conditions and therefore deep well drained soils are preferred; however careful management of irrigation scheduling on moderately or imperfectly drained soils can be successful. Soil salinity results in restricted growth or death of the plant, hence all land systems affected by salinity are considered unsuitable for potato production.

Soil pH can limit plant growth particularly where soil conditions become excessively acidic or alkaline. Highly acidic or alkaline soils require a higher level of management to maintain production.

Climate: Potatoes are shallow rooted plants with finely branched root systems and are highly sensitive to small deficiencies of water in the root zone. Whenever the plant is subjected to small moisture deficiencies the growth rate is reduced and the moisture stress on the plant will affect both the quality and yield. The summer growing season in southern Victoria is between November and March. During this time potatoes are sensitive to soil moisture deficits that are frequent during extended periods of weather over 35ºC and are also frost sensitive requiring a minimum frost free period of 120 days. In order to account for this frost sensitivity in the model areas with mean November and March temperatures greater than 10ºC have been assumed to have few or no frosts.

Landscape: Certain landform features can restrict the development of potato cropping, these landforms include areas subject to flooding and steep mountain terrain that would prohibit machinery access.

## Potato Suitability for Moorabool Shire

| Suitability | Hectares within the Shire |
|---|---|
| Low | 0 |
| Moderate | 95,180 |
| High | 58,370 |

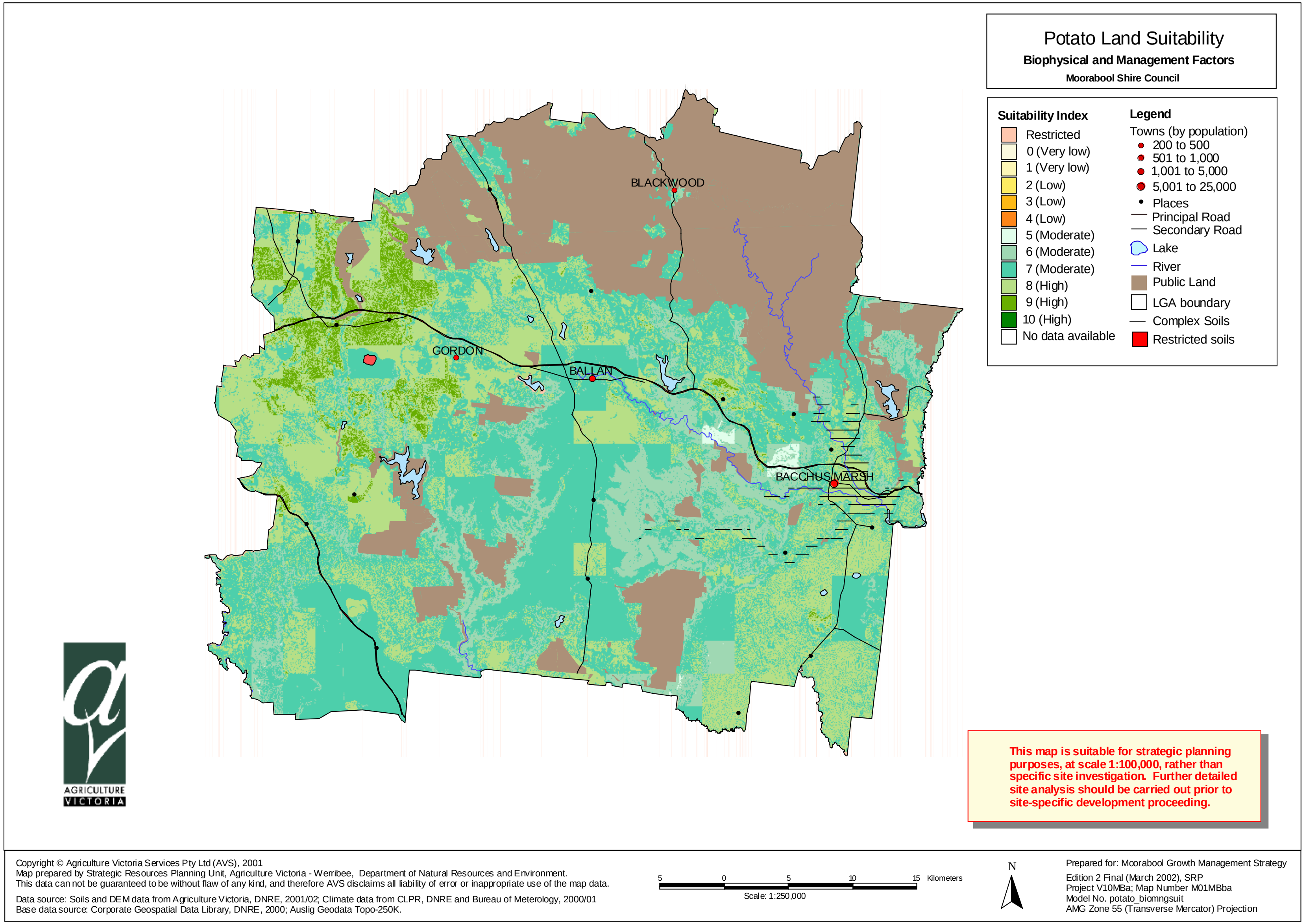
**Note:** The suitability area calculations have been approximated to the nearest ten hectares. Public land, totally more than 57,510 hectares, is excluded from the calculations. The total private land area mapped is estimated at over 150,690 hectares in the Moorabool Shire.

Significant areas of land highly suitable for potato production have been identified across the Shire, in particular areas to the west of Gordon, to the south of Ballan and in the area surrounding Bacchus Marsh (**Map 4.3**). The area in the middle of the Shire has predominantly been mapped as being of moderate suitability due to low rainfall recorded during the planting season (October to February) and tuber initiation period (November to December and February to March). Water deficiencies in the root zone at these times reduce the health and vigour of the tuber resulting in decreased yield and quality.

Soil units such as swamps and depressions have been identified as restricted for production as these soil units have one or more characteristics, such as very poor drainage, that make them unsuitable.

The horizontal striped pattern on the map represents a complex soil unit that was identified on the alluvial plains around Bacchus Marsh. Considerable variance within this unit means that its suitability will also be highly variable.

# Map 4.3 Land Suitability for Potato Production





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Project V10MBa; Map Number M01MBba
Model No. potato_biomngsuit
AMG Zone 55 (Transverse Mercator) Projection

## 4.4 Lavender

Lavender is a Mediterranean herb belonging to the Lamiacae (*Labiatae*) family which includes mint (*Mentha*) and sage (*Salvia*). The three main species of lavender grown worldwide are English Lavender (*Lavendula angustifolia*), Lavandin (*Lavandin intermedia*) and Spike Lavender (*Lavendula latifolia*). With a warm, dry climate lavender grows more readily across Australia than in many other countries, including its native habitat in the elevated regions of France. As lavender production in Australia only started in the 1980s, the market is still relatively small with most lavender produced for the fresh and dried flower markets, oils and value added kitchen and skincare products.

### Lavender: Criteria for Growth

| | | | **Optimal** | **Least Desirable** |
|---|---|---|---|---|
| **Soil** | pH | Surface | 7 to 8 | 4.5 to 5.5 |
| | Sodicity | Surface | Non-sodic | Sodic |
| | Texture | Surface<br>Sub-surface | SL, FSL<br>SL,FSL,CL,SCL,LC | LC,S,LS<br>HC,MC |
| | Drainage | Surface<br>Sub-surface | Well drained<br>Well drained | Very poorly drained<br>Very poorly drained |
| **Climate** | Rainfall | Annual (mm)<br>During flowering season | 625-750 mm<br>>25 mm | <300 mm<br><10 mm |
| | Frost | Spring | No frost | >0 days frost |
| | Wind strength | (m/sec) | Low | High |
| **Landscape** | Slope | % | 2-5% | 16-20% |
| | Aspect | | NE | S,SW |

Soil: Lavender is a hardy herbaceous plant that can tolerate a wide range of soil conditions. Ideally, well drained soils with a north easterly aspect and a pH of 7 to 7.5 are optimal. Lime is often needed to raise the pH of the soil.

Climate: Lavender plants can withstand windy conditions, air circulating around them often producing the healthiest plants. Many species can generally withstand drought and frost, however there may be a need to drip feed or irrigate young plants during dry conditions.

Landscape: Lavender will grow on slopes and since they are Mediterranean plants, optimal growth will occur if they are on a north-easterly aspect to obtain maximum sunshine.

### Lavender Suitability for Moorabool Shire

| **Suitability** | **Hectares within the Shire** |
|---|---|
| Low | 0 |
| Moderate | 91,980 |
| High | 61,570 |

**Note:** The suitability area calculations have been approximated to the nearest ten hectares. Public land, totally more than 57,510 hectares, is excluded from the calculations. The total private land area mapped is estimated at over 150,690 hectares in the Moorabool Shire.

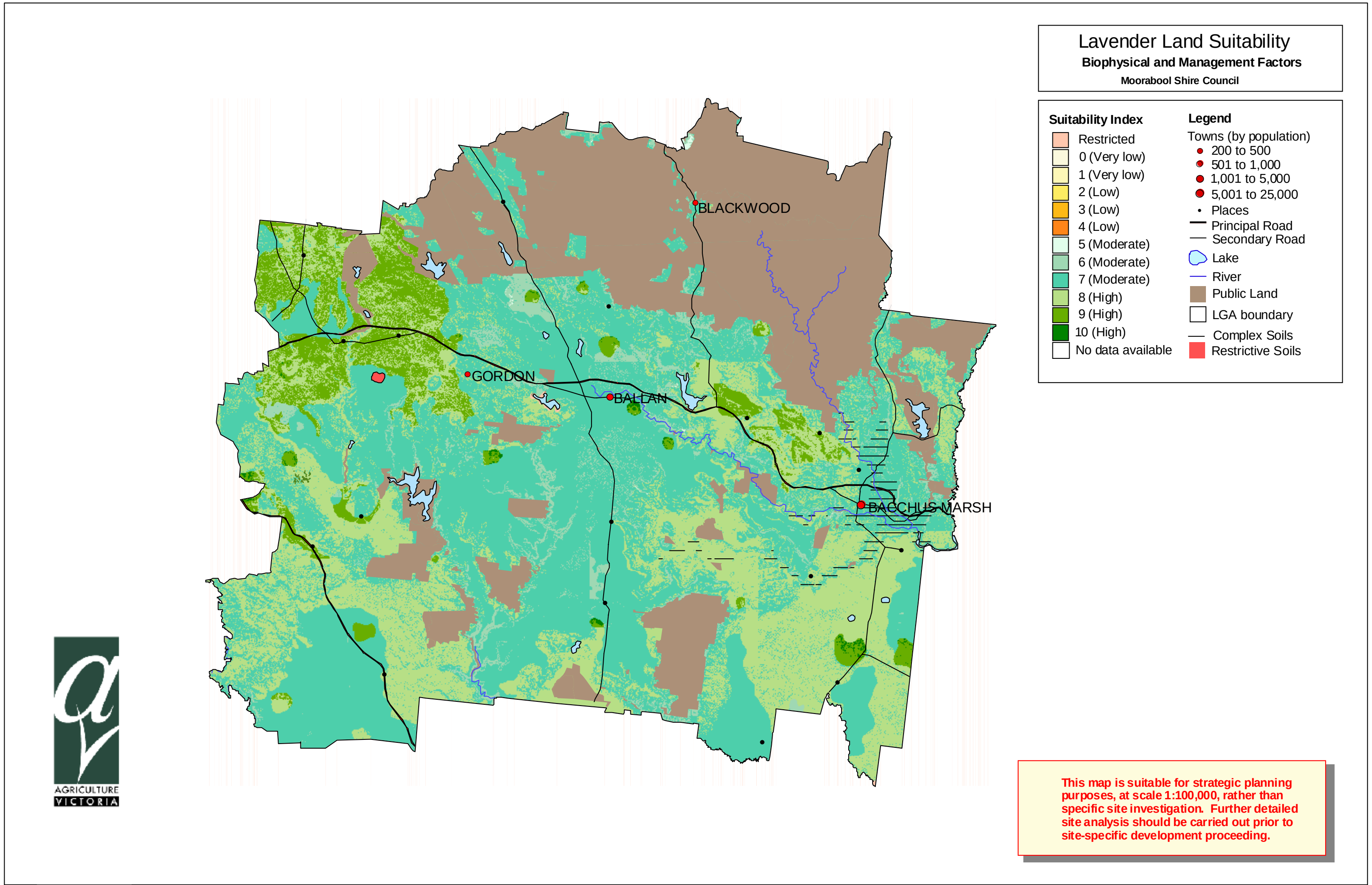
**Map 4.4** represents the land suitability analysis for the production of lavender in the Moorabool Shire. Lavender is a hardy plant that will grow in many varied conditions.

Significant areas of high suitability have been identified within the Shire. The area to the west of Gordon has predominantly been classified as being of high suitability. The rating of this area is influenced by the occurrence of relatively high rainfall during the periods when lavenders are flowering and undergoing significant growth.

The suitability analysis also reveals areas of the Shire that have been classified as moderately suitable for the production of lavender. The extensive areas of moderate suitability (index value of 7) in the centre of the Shire are associated with soils exhibiting poor drainage. The moderate suitability of the area to the south of Gordon has been influenced by steep terrain. These areas are less suitable for lavender production due to the increased costs and risks associated with operating in steep terrain.

Some soil units within the Shire have been identified as restrictive, and shown in red. These soil units include swamps and depressions. These soil units have one or more characteristics, such as very poor drainage, that make them unsuitable for the production of many crops and commodities. A complex soil unit has been identified on the alluvial plains around Bacchus Marsh, which is represented on the maps by a horizontal striped pattern. There is considerable variance within this unit and its suitability for agriculture will vary depending on the soil types and their inherent physical properties.

# Map 4.4 Lavender Land Suitability





Map prepared by Strategic Resources Planning Unit, Agriculture Victoria - Werribee, Department of Natural Resources and Environment.


Data source: Soils and DEM data from Agriculture Victoria, DNRE, 2001/02; Climate data from CLPR, DNRE and Bureau of Meterology, 2000/01
Base data source: Corporate Geospatial Data Library, DNRE, 2000; Auslig Geodata Topo-250K.

Prepared for: Moorabool Growth Management Strategy

Edition 2 Final (February 2002), SRP
Project V10MBa; Map Number M03MBb
Model No. Lavender
AMG Zone 55 (Transverse Mercator) Projection

## 4.5 Olives

Successful promotion of the health benefits of olive oil and the diversification of Australian cuisine has driven an increase in the demand for olive products in recent years. In recent years, it was estimated that Australia 95% of olive products were imported, including 16,000 tonnes of olive oil per year and 7,000 tonnes of olive fruit (Sweeny, 1999). The mild winters and pleasant summers experienced in south eastern Australia are similar to the Mediterranean climate and are seen as ideal for olive production as it allows for fruit production throughout the year.

### Olives: Criteria for Growth

| | | | Optimum | Least Desirable |
|---|---|---|---|---|
| **Soil** | pH | Surface<br>Sub-surface | 6 to 7.5<br>5.5 to 6 | >8.5, <4.5 |
| | Sodicity | Surface | non-sodic | >8.5, <4.5 |
| | Texture | Surface<br>Sub-surface | cl,zcl,sl<br>cl,zcl,sl | mc, hc<br>mc, hc |
| | Useable Depth | | >50cm | <15cm |
| | Drainage | Surface<br>Sub-surface | well drained<br>well drained | poorly drained, very poorly drained<br>poorly drained, very poorly drained |
| **Climate** | Temperature | Maximum during growing season | >18ºC | <15ºC |
| | Rainfall | Average monthly during growing season | 40 to 60 mm | <15 mm, 15 to 30 mm, >100 mm |
| | Frost | No. days a month | 0 | >20 |
| **Landscape** | Slope | 0 to 2 degrees | | >15º |

Soil: For optimum growth, olives require well drained soils with a pH of 6-7.5. Nitrogen is required in large quantities and phosphorous, potassium and magnesium are also important for plant growth. Unless the soil in which olives are planted is extremely rich, fertiliser will be required. Olives do not require deep soil for growth since they posses a shallow root system, but do require moist soils throughout the year.

Climate: Olives require average monthly rainfalls between 30mm to 100mm, with optimum growth reached at between 40mm to 60mm. Although they can survive a small amount of frost, they grow best in the total absence of frost. Temperatures above 18°C are suitable for growth whilst anything below 10°C is considered restrictive to growth.

### Olives Suitability for Moorabool Shire

| Suitability | Hectares within the Shire |
|---|---|
| Low | 0 |
| Moderate | 11,750 |
| high | 141,810 |

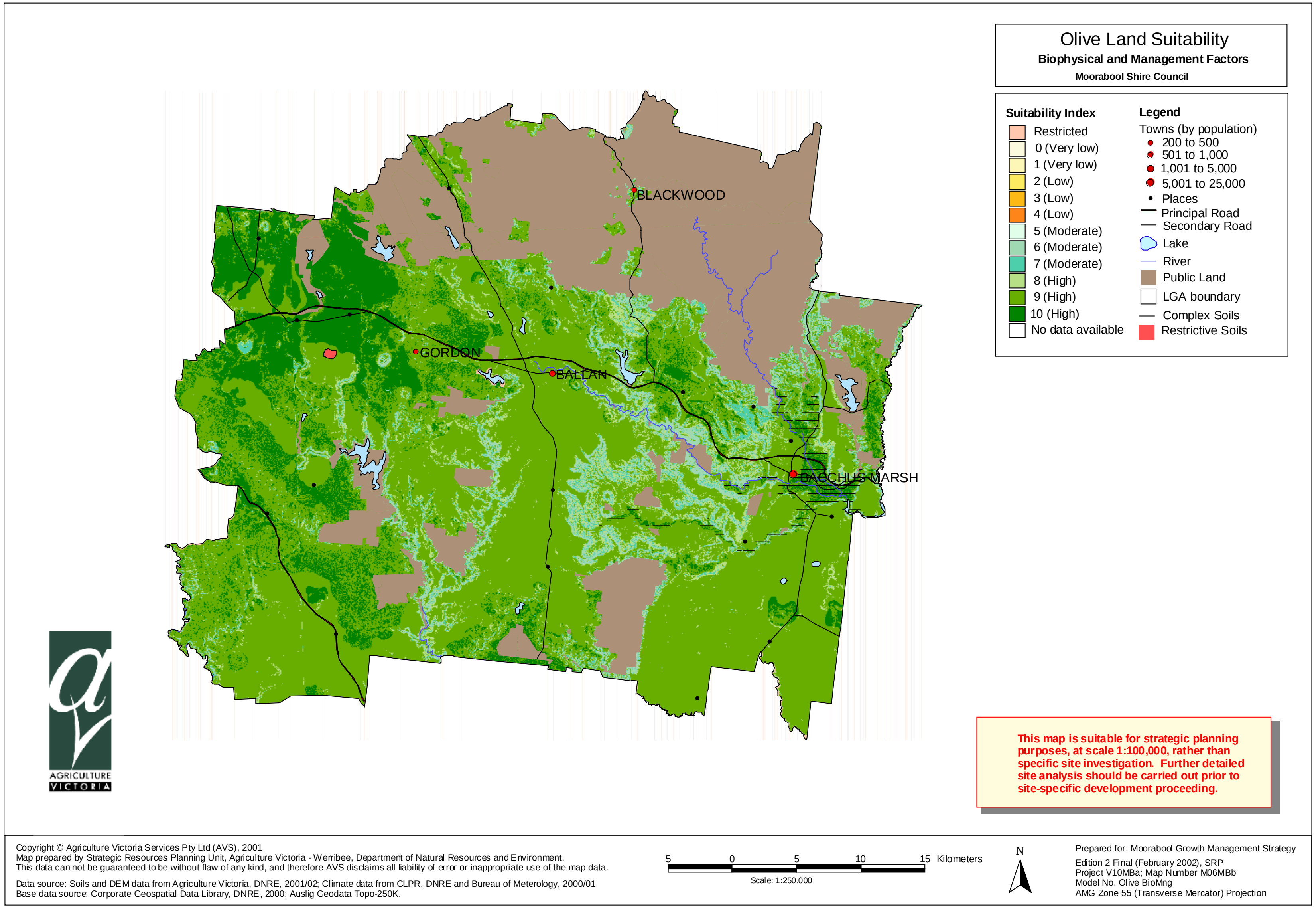
**Note:** The suitability area calculations have been approximated to the nearest ten hectares. Public land, totally more than 57,510 hectares, is excluded from the calculations. The total private land area mapped is estimated at over 150,690 hectares in the Moorabool Shire.

The majority of the Shire has been mapped as highly suitable (index value 8 to 10) for olive production (**Map 4.5**). Areas of highest suitability were identified in the north-west of the Shire around the townships of Gordon and Wallace. The relatively temperate climate and gentle terrain influence the Shire's overall suitability for olive production.

Areas that have been identified as moderately suitable for the production of olives are associated with steep terrain, in excess of 8 degrees, and soils that exhibit poor drainage.

Some areas have been classified as restricted. These include swamps and depressions which have one or more characteristics, such as very poor drainage, making them unsuitable for the production of many crops and commodities. A complex soil unit has been identified on the alluvial plains around Bacchus Marsh, which is represented on the maps by a horizontal striped pattern. There is considerable variance within this unit and, therefore, its suitability will vary depending on the localised soil type and their inherent physical properties.

# Map 4.5 Olive Land Suitability





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Data source: Soils and DEM data from Agriculture Victoria, DNRE, 2001/02; Climate data from CLPR, DNRE and Bureau of Meterology, 2000/01
Base data source: Corporate Geospatial Data Library, DNRE, 2000; Auslig Geodata Topo-250K.

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Project V10MBa; Map Number M06MBb
Model No. Olive BioMng
AMG Zone 55 (Transverse Mercator) Projection

## 4.6 Buckwheat

Buckwheat, *Fagopyrum esculentum* M., belongs to the family Polygonacae. It is a broad leaf, summer growing crop with dark hulled triangular, starch filled seeds. Buckwheat is gluten free and of high nutritional value, containing rutin, high levels of amino acids, high dietary fibre and excellent levels of vitamins and minerals. It is ground into flour to make breads and noodles or used whole in soups or other dishes.

Australian production of buckwheat is in its infancy. Currently production is small but is expected to expand. Japan provides a potential export market for Australian buckwheat. Currently, Japan imports buckwheat as whole grain and mills it into flour for making soba noodles and breads, and into whole or kibbled kernels for soups and other dishes. Buckwheat can be grown organically, requiring little chemical input. It is also an excellent rotational crop.

### Buckwheat: Criteria for Growth

| | | | **Optimal** | **Least Desirable** |
|---|---|---|---|---|
| **Soil** | Drainage | Surface | Well drained | Very poorly drained |
| | Texture | Surface | SL,FSL | HC,VFSCL,ZCL |
| | Useable depth | | >300 mm | <150 mm |
| | Electrical Conductivity (EC) | Surface | Very low | High |
| **Climate** | Temperature | Daily Extreme (>28°C)<br>Monthly Maximum<br>Monthly Minimum | <3 days<br>18 to 25<br>9 to 12 | >7 days<br>>28<br>13-20 |
| | Rainfall | During flowering season (Dec-March) | 50-100 mm | 0-25 mm |
| | Daily Extreme temperature during ripening | >28°C | <3 days | >7 days |
| | Frost | December-March | 0 days | >=2 days |
| | Wind Direction | | S,SE,SW | N,NW |
| | Wind Speed | | Low | High |
| **Landscape** | Slope | | 0-6º | >15º |
| | Aspect | | NE,E | W,N,NW |

Soils: Buckwheat will grow in a wide variety of soils as long as they are well drained.

Climate: Buckwheat is a high rainfall, cool climate crop. It favours conditions commonly found at altitude or close to the coast, where there are reliable summer rainfall combined with cool daytime temperatures (Bluett, 2001). The flowers will not seed at temperatures much over 27ºC, therefore a large number of hot days during flowering will reduce yield. Seedlings can survive mild spring frosts but frost in early autumn before ripe grains are formed can severely affect yields.

Landscape: Certain landform features can restrict the production of buckwheat. These include floodplains subject to flooding or waterlogging, and steep hills that prohibit access.

## Buckwheat Suitability for Moorabool Shire

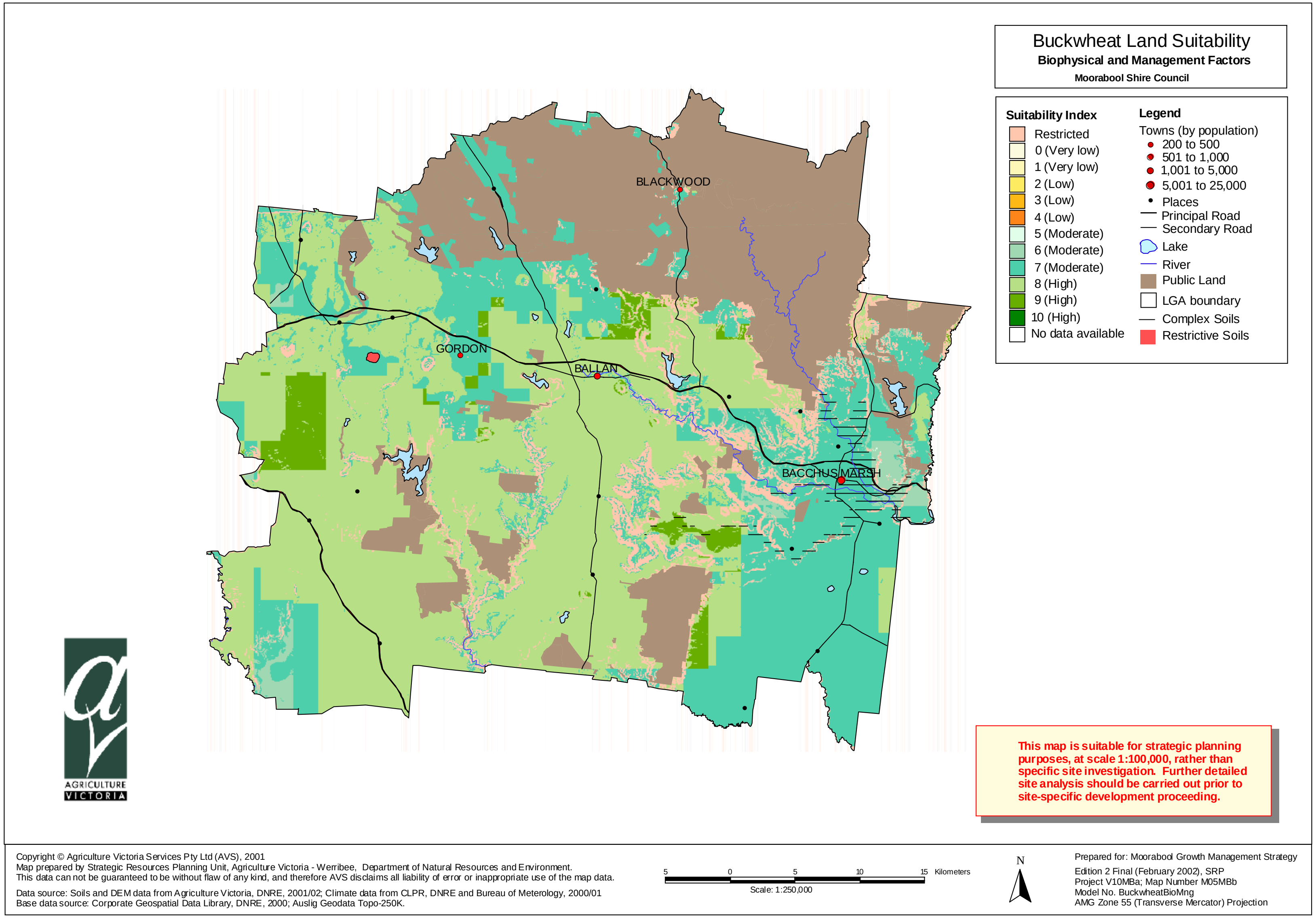
| Suitability | Hectares within the Shire |
|---|---|
| Low | 0 |
| Moderate | 53,370 |
| High | 88,290 |

**Note:** The suitability area calculations have been approximated to the nearest ten hectares. Public land, totally more than 57,510 hectares, is excluded from the calculations. The total private land area mapped is estimated at over 150,690 hectares in the Moorabool Shire.

Areas within the Shire that have the highest suitability for the production of buckwheat (index of 10) are located in the west between the townships of Wallace and Elaine (**Map 4.6**). Steep terrain, such as the area to the south of Ballan and Gordon, has been classified as restricted as it inhibits the access of the heavy farm machinery used to plant and harvest the crop. The working of high angle slopes also increases the risk of soil erosion during periods of heavy precipitation.

The area surrounding Bacchus Marsh has been classified as being of moderate suitability due to the relatively low rainfall in this part of the Shire. The suitability of this area is also impacted by the greater incidence of extreme heat days (>30ºC) during summer.

# Map 4.6 Buckwheat Land Suitability



## 4.7 Winter Wheat

Winter wheats are a "long season" variety of wheat, which are sown around the time of the autumn break, remain vegetative throughout the winter and flower around mid-November (DNRE, 1997). Red Winter wheats are very suitable for high quality feed, as they are less susceptible to sprouting in the ear than White Winter wheats. Winter wheats are purpose grown for markets in Australia, New Zealand and Asia seeking high quality, high energy feed wheats.

Winter wheat has a very high yield potential in the high rainfall districts of South Eastern Australia (DNRE, 1997). However, successful crop production and marketing requires skill and management, and considerable effort. Successful management of the crop involves an annual cycle of carefully timed activities that require a high level of attention.

### Winter Wheat: Criteria for Growth

| | | | **Optimal** | **Least Desirable** |
|---|---|---|---|---|
| **Soil** | pH | Surface | 6-6.5 | <4.5 |
| | | Sub-surface | 6-6.5 | <4.5 |
| | Sodicity | Surface | Non-sodic | Sodic |
| | Texture | Surface | scl,cl,sl | hc,s |
| | Depth to B horizon | | >300 mm | <50 mm |
| | Drainage | | Well drained | Very poorly drained |
| | Coarse Fragments | % | <5% | >50% |
| | Electrical Conductivity (EC) | Surface | very low <0.15 dS/m | High >0.55 dS/m |
| | | Subsurface | very low <0.15 dS/m | High >0.55 dS/m |
| **Climate** | Temperature | Max monthly Temp Apr-May | 18-20ºC | >30ºC, <15ºC |
| | | Max monthly Temp Oct-Dec | 18-20ºC | >30ºC, <15ºC |
| | Rainfall | Annual | 700-1000 mm | <250 mm |
| | Frost (2ºC) | November Late Frost | 0 days | >4 days |
| | | April to May | 0 | 10-31 days |
| **Landscape** | Slope | | 0-6º | >20º |

Soils: Winter wheats can tolerate a wide variety of soil types, however good soil structure is essential and the crop will suffer under prolonged water logging. High acidity and/or soil element imbalance should be avoided. High yielding winter wheats have a high requirement for phosphorus and nitrogen.

Climate: Winter wheats are sometimes referred to as "long season wheats" (DNRE, 1997). They are well adapted to long season districts in the high rainfall zone, and have reasonable prospects with good autumn rains in early April and reliable spring rains through to November. Areas where spring rainfall ceases before September or October are not suitable for the production of winter wheats, but very high summer rainfalls can be catalysts to disease and waterlogging.

The date of the last frost in spring is critical to the condition of Winter wheat. However, comprehensive data on this factor is not available throughout Victoria and, therefore, was not included in the land suitability modelling. Dates before 15th October are the most preferable and it is recommended that the date of the last frost be investigated for individual sites. Moving the sowing date to early autumn can overcome the effect of late frosts. Winter wheats are best suited to inland areas at a distance of at least 2-3km from the coast, as they will not tolerate salt laden ocean winds.

Landscape: Certain landform features can restrict the development of Winter wheat. These include floodplains subject to flooding or waterlogging, and steep hills that prohibit access.

## Winter Wheat Suitability for Moorabool Shire

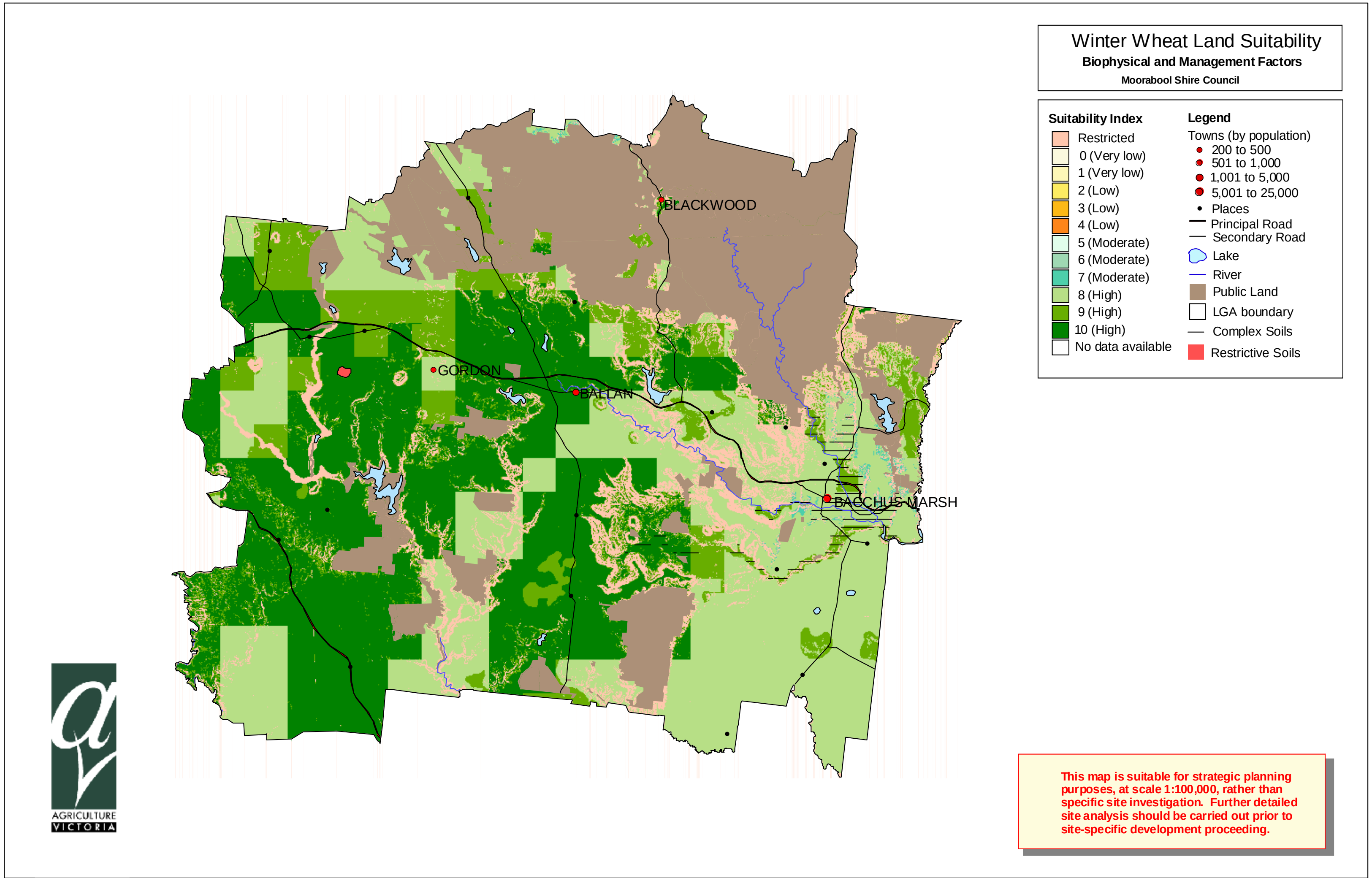
| Suitability | Hectares within the Shire |
|---|---|
| Low | 0 |
| Moderate | 510 |
| High | 136,170 |

**Note:** The suitability area calculations have been approximated to the nearest ten hectares. Public land, totally more than 57,510 hectares, is excluded from the calculations. The total private land area mapped is estimated at over 150,690 hectares in the Moorabool Shire.

Large areas of private land have been identified as highly suitable (index value 8 to 10), with the areas of highest suitability located in the western half of the Shire between the townships of Gordon and Wallace, and further to the south around Elaine (**Map 4.7**). These areas are characterised by relatively high rainfall and highly suitable soils. Variations in soil suitability have primarily been influenced by drainage.

Restricted areas that have been mapped throughout the Shire, such as the area to the south of Ballan, are associated with steep slopes. Steep slopes impact on the suitability of an area for winter wheat production due to the difficulties associated with accessing and operating machinery in this terrain.

Map 4.7 Winter Wheat Land Suitability





Map prepared by Strategic Resources Planning Unit, Agriculture Victoria - Werribee, Department of Natural Resources and Environment.
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Data source: Soils and DEM data from Agriculture Victoria, DNRE, 2001/02; Climate data from CLPR, DNRE and Bureau of Meterology, 2000/01
Base data source: Corporate Geospatial Data Library, DNRE, 2000; Auslig Geodata Topo-250K.

5 0 5 10 15 Kilometers
Scale: 1:250,000

N

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Project V10MBa; Map Number M07MBb
Model No. WinterwheatBioMng
AMG Zone 55 (Transverse Mercator) Projection

## 4.8 Pasture: Perennial Ryegrass/White Clover

**Perennial Ryegrass, White Clover**

Perennial ryegrass is a long lived, tufted, densely tillered perennial native to European countries with a temperate climate. It is the most widely sown and economically important pasture grown in improved pastures in southern and irrigated areas of Victoria. It is the preferred perennial pasture grass for most dairy areas because of its high yield of quality feed, ease of establishment and management, persistence and grazing tolerance, and competitive nature with other sown and volunteer species.

Establishment of perennial ryegrass-white clover pasture is relatively easy. However, specific soil, climate and landscape conditions are required in order to obtain high levels of productivity. Experts who participated in the Land Suitability Analysis identified the criteria necessary for growth for production of 10 tonnes per hectare of perennial ryegrass - white clover pasture. Mixtures of perennial ryegrass and white clover yield less than heavily fertilised monocultures of perennial ryegrass.

### Perennial Ryegrass-White Clover: Criteria for Growth

| | | | **Optimal** | **Least Desirable** |
|---|---|---|---|---|
| **Soil** | Water holding capacity | | 20-30,40-45% | 5-10% |
| | Drainage | | Well drained, moderately well, and rapidly drained | Very poorly drained |
| | Electrical Conductivity (EC) | Surface | very low <0.15 dS/m, and low 0.15-0.3 dS/m | High >0.55 dS/m |
| | PH | | 5.5-6.5 | <5.0 |
| **Climate** | Temperature | Average Monthly Temperature (May – September) | 18-25ºC | <10ºC |
| | Rainfall | Average Monthly Temperature (Nov–March) | 150-200mm | <75, >200mm |
| **Landscape** | Slope | (degrees) | <30º | >45º |
| | Altitude | (m above sea level) | <379m | >379m |
| | Aspect | | N, NW, NE | S,SW,SE |

Soils: The experts agreed that soils are the most important criteria for the production of perennial ryegrass pastures. The soil attributes identified where: drainage, salinity and moisture holding capacity. Perennial Ryegrass is suited to medium to heavy textured soils with good fertility. Moisture holding capacity takes into account soil surface texture and drainage, with clay loams and silty clay loams being the most preferable. Perennial ryegrass can tolerate a wide range of drainage conditions, but is not tolerant of high salinity.

Climate: Perennial ryegrass is most suited to areas with an annual rainfall of at least 550mm and a growing season of at least 7 months. It is most productive in autumn and spring when the growing conditions are most favourable. Lower temperatures between mid May to the end of September will limit plant growth.

Perennial ryegrass is susceptible to rusts and viruses. Crown rust may develop on plants during warm and humid weather, particularly in the autumn and late spring and stem rust can occur in late spring and summer. A condition called ryegrass staggers can occur in livestock grazing perennial ryegrass in late summer and early autumn. This is caused by toxins that are concentrated in the crown of the plant and produced by an endophyte (fungus living inside the plant).

Landscape: Aspect, slope and altitude are important factors for growth. Higher altitudes can limit growth due to low temperatures, while north facing pastures will be more productive due to the greater amounts of sunlight received throughout the day.

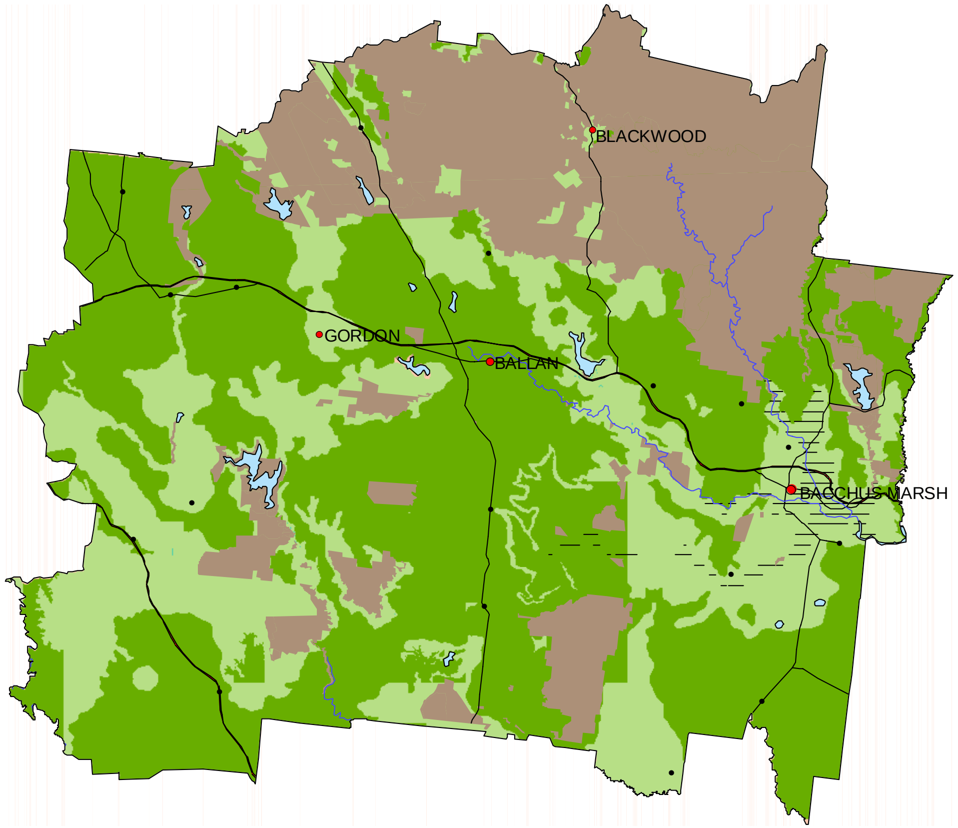
## Perennial Ryegrass Suitability for Moorabool Shire

| Suitability | Hectares within the Shire |
|---|---|
| Low | 0 |
| Moderate | 20 |
| High | 153,540 |

**Note:** The suitability area calculations have been approximated to the nearest ten hectares. Public land, totally more than 57,510 hectares, is excluded from the calculations. The total private land area mapped is estimated at over 150,690 hectares in the Moorabool Shire.

The Moorabool Shire has predominantly been classified as highly suitable (index value 8 to 9) for the production of perennial ryegrass/white clover pasture due to the generally suitable climatic conditions across the Shire and the tolerance of perennial ryegrass to a range of soil conditions (**Map 4.8**). Areas of highest suitability lie to the west of Gordon, in the centre of the Shire near Ballan and to the southeast around Balliang East.

# Map 4.8 Perennial Ryegrass/White Clover Pasture Land Suitability (high yield 10 – 14 t/ha/yr)




**Pasture Land Suitability**
**Ryegrass/White Clover**
**Moorabool Shire Council**

**Suitability Index**
- Restricted
- 0 (Very low)
- 1 (Very low)
- 2 (Low)
- 3 (Low)
- 4 (Low)
- 5 (Moderate)
- 6 (Moderate)
- 7 (Moderate)
- 8 (High)
- 9 (High)
- 10 (High)
- No data available

**Legend**
Towns (by population)
- 200 to 500
- 501 to 1,000
- 1,001 to 5,000
- 5,001 to 25,000
- Places
- Principal Road
- Secondary Road
- Lake
- River
- Public Land
- LGA boundary
- Complex soils

**This map is suitable for strategic planning purposes, at scale 1:100,000, rather than specific site investigation. Further detailed site analysis should be carried out prior to site-specific development proceeding.**

AGRICULTURE VICTORIA



Data source: Soils and DEM data from Agriculture Victoria, DNRE, 2001/02; Climate data from CLPR, DNRE and Bureau of Meterology, 2000/01
Base data source: Corporate Geospatial Data Library, DNRE, 2000; Auslig Geodata Topo-250K.

5 0 5 10 15 Kilometers
Scale: 1:250,000

N

Prepared for: Moorabool Growth Management Strategy
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Project V10MBa; Map Number M11MBb
Model No. PstrBioMng1
AMG Zone 55 (Transverse Mercator) Projection

## 4.9 Pasture: Phalaris

**Phalaris**

Phalaris is a winter growing perennial grass that is native to the Mediterranean Region and well suited as a pasture species for Victorian conditions (Reed, 1999). The establishment of phalaris plays an important role in the management of salinity and soil erosion. Phalaris holds a competitive advantage in drought affected areas, as it is tolerant to water stress and is able to persist in areas that are too hot for perennial ryegrass (Reed, 1999). Therefore phalaris is best suited to areas of relatively low rainfall, where competition with higher yielding species, such as perennial ryegrass, is limited. Furthermore, to maximise production in high value areas pasture species such as perennial ryegrass should be established in preference to phalaris pasture, due to the higher yields obtained from perennial ryegrass.

The establishment of phalaris is not limited by drainage characteristics of the soil, as the species can tolerate waterlogged soil. Phalaris is also tolerant of moderately saline soils and establishes best on heavy textured soils (Reed, 1999). Aluminium toxicity can impact on root development. If acidity is limited to the topsoil then the application of lime can improve suitability. However, subsoil acidity (high aluminium) is not easily corrected by liming and may render the site unsuitable.

Establishment of phalaris can be difficult due to slow seedling growth and intolerance of phalaris to competition from more vigorous sown or weed species (Reed, 1999). These difficulties can be overcome through managing the sowing time and grazing regime. Experts who participated in the Land Suitability Analysis identified the criteria necessary for production of 8 tonnes per hectare of phalaris/sub clover pasture.

### Phalaris: Criteria for Growth

| | | | Optimal | Least Desirable |
|---|---|---|---|---|
| **Soil** | Useable Depth | | > 5 cm | < 5 cm |
| | pH | | >5.8 pH | <5.8 pH |
| | Electrical Conductivity (EC) | Surface | very low <0.15 dS/m, and low 0.15-0.3 dS/m | High >0.55 dS/m |
| **Climate** | Rainfall | Average Monthly Temperature (Nov–March) | 150-200mm | <75, >200mm |
| **Landscape** | Aspect | | E, S, W | N, NW, NE |

Soils: The experts agreed that soil characteristics were important criteria for the production of phalaris pastures. The most important soil attributes identified were; salinity and useable depth[7]. Phalaris is suited to medium to heavy textured soils with good fertility. Phalaris can tolerate a wide range of drainage conditions, but is not tolerant of high salinity.

Other issues that may need to be considered are low pH and associated high aluminium. The characteristics of the major soil type in Moorabool (brown sodosol: alkaline profile with increasing clay content) are favourable for phalaris, provided topsoil pH is raised by liming and fertility is increased with applications of phosphorus.

---

[7] The experts who contributed to the generation of the model considered that pH was a relatively minor factor

Climate: The experts agreed that annual rainfall was the most important factor for the successful establishment of phalaris pastures. The optimal range defined was 500mm to 800mm a year. In higher rainfall areas, phalaris may be out-competed by perennial ryegrass.

Landscape: Aspect was the only landscape factor considered by the experts to impact on the suitability. North facing slopes were considered a limitation to growth due to the increased evaporation rates in these areas resulting in water stress.

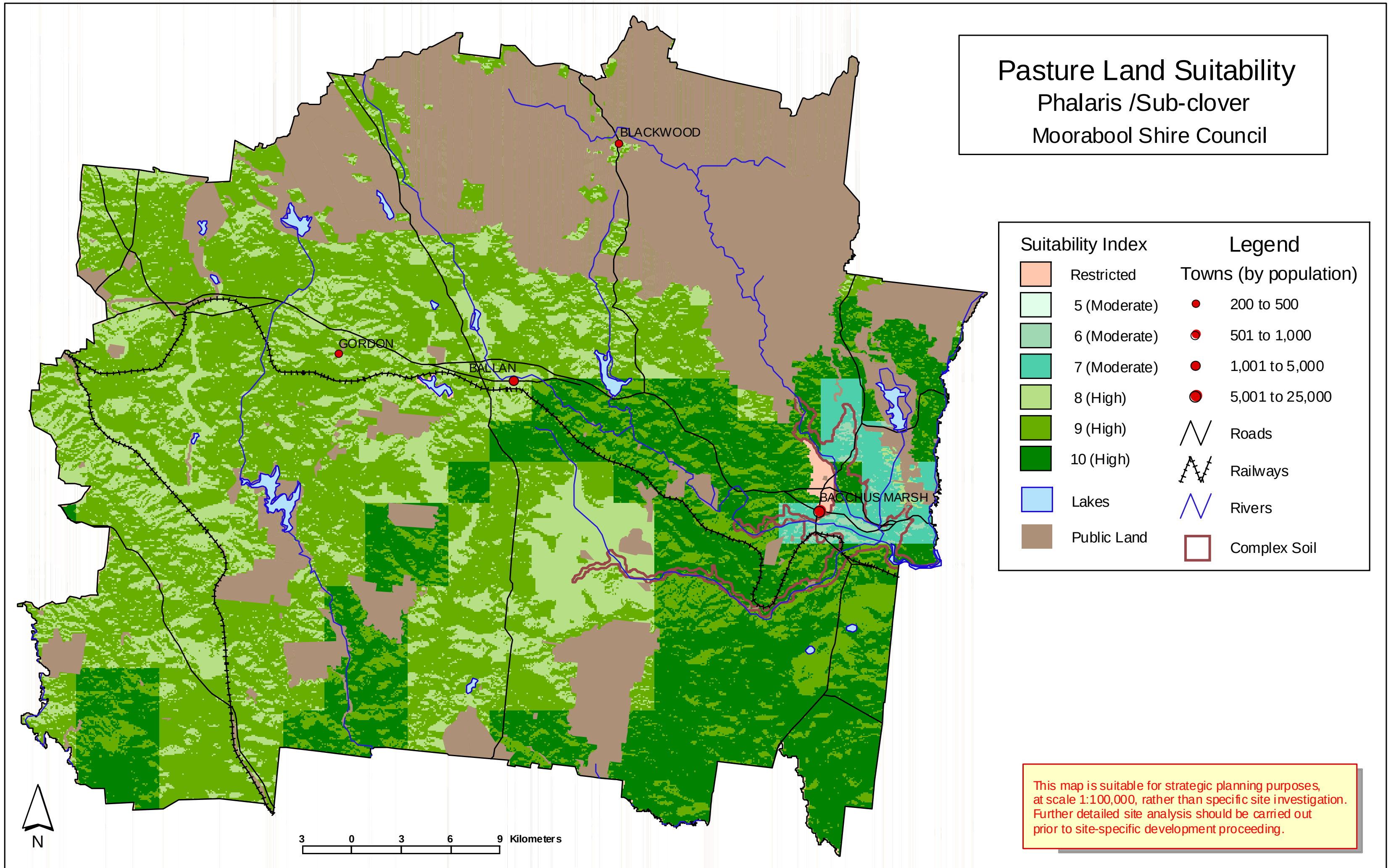
## Phalaris Suitability for Moorabool Shire

| Suitability | Hectares within the Shire |
|---|---|
| Low | 0 |
| Moderate | 2,310 |
| High | 151,250 |

**Note:** The suitability area calculations have been approximated to the nearest ten hectares. Public land, totally more than 57,510 hectares, is excluded from the calculations. The total private land area mapped is estimated at over 150,690 hectares in the Moorabool Shire.

The Moorabool Shire has predominantly been classified as highly suitable (index value 9 to 10) for the production of phalaris pasture reflecting the ability of phalaris to tolerate a wide range of soil, climate and landscape conditions (**Map 4.9**). Higher rainfall areas in the North West of the Shire are not as suitable as the high productivity of these areas reduces the competitiveness of phalaris against other sown and weed species. A complex soil unit has been identified on the alluvial plains around Bacchus Marsh, which is represented on the maps by a horizontal striped pattern. There is considerable variance within this unit and its suitability will vary depending on the localised soil type and their inherent physical properties.

## Map 4.9 Phalaris/Sub-clover Pasture Land Suitability (low yield < 8 t/ha/yr)





Map prepared by Spatial Science Section, Landscape Platform - Werribee, Department of Primary Industries.
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Data source: Soils and DEM data from Agriculture Victoria, DNRE 2001/02; Climate data from CLPR, DNRE and Bureau of Meterology, 2000/01
Base data source: Corporate Geospatial Data Library, DNRE, 2000

Prepared for: Moorabool Growth Management Strategy

Edition 1 (August, 2006)
Model No. Pasture (Phalaris/Sub-clover)
AMG Zone 55 (Transverse Mercator) Projection

## 4.10 Plantations: Radiata Pine

**Radiata pine**

Radiata pine *(Pinus radiata)* is a native of North America which was introduced into Australia in the 1850s as an ornamental tree. It was soon recognised as a suitable species for plantations due to its quick growth rate, ability to thrive in a number of different soil and climatic conditions and low market risk. Over 1 million hectares of radiata pine have been planted in Australia.

Radiata pine has a number of uses including light construction, furniture, internal flooring, mouldings, joinery, veneers and pulpwood. If treated, it is suitable for outdoor use. Small quantities can be used for sheep and cattle fodder.

Land suitability for radiata pine was modelled assuming optimal productivity of 15t/ha/yr. A management hierarchy was not constructed for radiata pine for two reasons: the large scale of plantations and a lack of quantitative data. Given the broad scale of plantations it is difficult to determine management criteria in a manner similar to that for horticultural crops. Experts felt there was insufficient quantitative information to assign ratings in the decision tree.

### Radiata pine: Criteria for Growth

| | | | **Optimal** | **Least Desirable** |
|---|---|---|---|---|
| **Soil** | pH | Surface | 4.5 to 8.5 | <4.5, >8.5 |
| | Drainage | Surface | Well, moderately and rapidly drained | Very poorly drained |
| | Impedance of B horizon | | Low | High |
| | Texture | Surface<br>Sub-surface | CL<br>CL | HC<br>HC |
| | Depth to bedrock | | > 3 m | <0.5 m |
| | Electrical Conductivity (EC) | Surface | Very low to moderate <0.15 – 0.55 dS/m | >0.55 dS/m |
| **Climate** | Temperature | Monthly °C | -10º to 50º | <-10º, >50º |
| | Rainfall | Annual | >1000 mm | <550 mm |
| **Landscape** | Slope | | 0-8% | >30% |
| | Altitude | | <900 m | >900 m |

Soil: Radiata pine can grow on a wide variety of soil conditions but grows best in well drained, loamy soils, while impermeable, poorly drained clays restrict root growth. Best development is on soils at least 1m deep. Hard pans close to the surface render the tree prone to drought damage, or to wind damage during wet weather. Although depth to the B horizon is an important factor, high impedance which prevents root penetration slows growth after several years and may affect the quantity of yields. Radiata pine is not salt tolerant with yields being affected at 0.15-0.55dS/m.

Climate: Radiata pine develops best on sites with an annual rainfall between 750mm and 1000mm and grows well in warm and temperate climates. Radiata pine will tolerate between 5 to 50 frosts per year and will tolerate light snowfalls, but is not suitable for areas of heavy snow. A mean temperature range of 25-27ºC in summer and 2-5ºC in winter is ideal for growth.

Landscape: Radiata pine has a low tolerance to poor drainage, therefore growing better on slopes rather than poorly drained flat areas. Trees may be blown over by strong winds on exposed or very wet sites. Erosion gullies restrict the growth of radiata pine. Productive yields are not obtained where trees are planted over 900m altitude. Access roads are also a requirement.

Radiata pine Suitability for Moorabool Shire

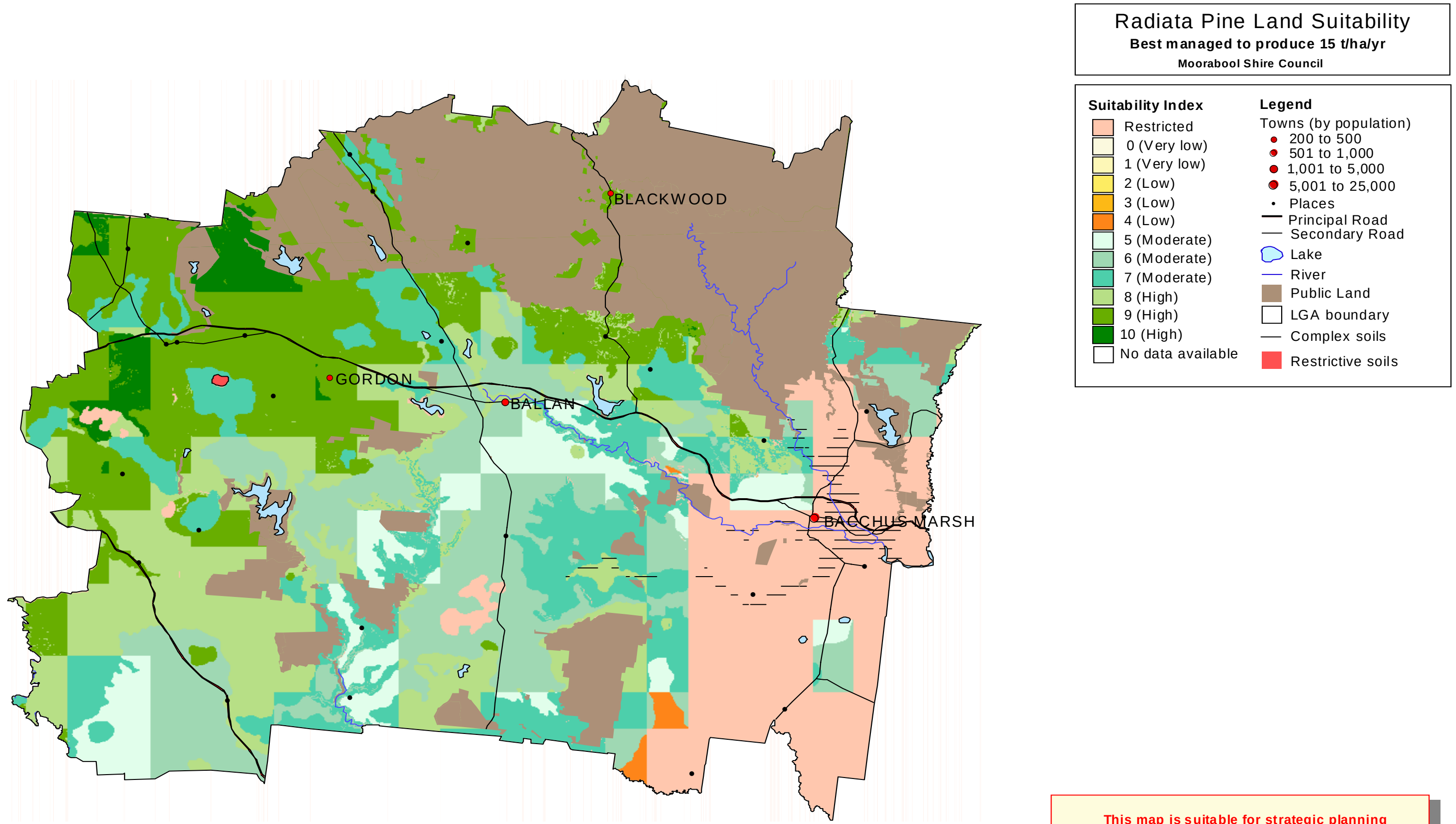
| Suitability | Hectares within the Shire |
|---|---|
| Low | 730 |
| Moderate | 64,900 |
| High | 60,530 |

**Note:** The suitability area calculations have been approximated to the nearest ten hectares. Public land, totally more than 57,510 hectares, is excluded from the calculations. The total private land area mapped is estimated at over 150,690 hectares in the Moorabool Shire.

Areas of high suitability (index value 8 to 10) are located in the west of the Shire around the townships of Gordon and Bungaree (**Map 4.10**). The southern and central parts of the Shire have predominantly been mapped as being moderately suitable (index value 5 to 7) due to soils being poorly drained and having high impedance at the B-horizon.

A large area of land around Bacchus Marsh has been mapped as restricted for the production of radiata pine because annual rainfall in this region is less than 550mm a year. Some soil units within the Shire have also been identified as restricted, and shown in red. These soil units include swamps and depressions.

## Map 4.10 Radiata Pine Land Suitability




AGRICULTURE VICTORIA

**This map is suitable for strategic planning purposes, at scale 1:100,000, rather than specific site investigation. Further detailed site analysis should be carried out prior to site-specific development proceeding.**



Data source: Soils and DEM data from Agriculture Victoria, DNRE, 2001/02; Climate data from CLPR, DNRE and Bureau of Meterology, 2000/01
Base data source: Corporate Geospatial Data Library, DNRE, 2000; Auslig Geodata Topo-250K.

5 0 5 10 15 Kilometers
Scale: 1:250,000

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Project V10MBa; Map Number M10MBa
Model No. RadiataPineBioMng1
AMG Zone 55 (Transverse Mercator) Projection

## 4.11 Protea

**Proteas**

Proteas are members of the Proteaceae family native to South Africa. Common proteas include the genera *protea*, *leucadendron* and *leucospermum*. *Leucadendrons* are grown for foliage and fruiting heads and proteas and *leucospermums* are grown for their flowers. Proteaceous species are generally grown in the open as field crops, with only windbreaks for protection. The main growing centres for the Proteaceae species are Western Australia and Victoria. Due to their exotic appearance they have established a niche within a much larger market based on traditional cut flowers.

### Inherent Criteria for Growth

| | | | Optimal | Least Desirable |
|---|---|---|---|---|
| **Soil** | pH | Surface | 5.5 – 6.0 | < 4.5 |
| | | Sub-surface | 5.5 – 6.0 | < 4.5 |
| | Drainage | | Well drained | Very poorly drained |
| | EC | Surface | Low, very low | High |
| | Useable Depth | | > 60cm | < 15cm |
| | Texture | Surface | SL, FSL, SCL | MC, HC |
| | | Sub-surface | SL, FSL, SCL | HC |
| **Landscape** | Slope | | 5 –10 degrees | > 15 degrees |
| | Aspect | | N, NE | SW, S |
| **Climate** | Wind | | Low & infrequent | High & strong |
| | Monthly average rainfall | | 75 – 100mm | < 30mm |
| | Monthly average temperature | | | |
| | Oct – Nov | | 20 – 25º | < 10º |
| | Late spring frost | | | |
| | Oct – Nov | | 0 days | < 10 days |
| | Extreme heat days | | | |
| | Nov – Feb | | 0 days | > 10 days |

Soil**:** One of the most important influences on growth for proteas is the soil type. The soil characteristics for optimal growth and production of proteas include deep (>600mm), well drained, slightly acidic soils, with low phosphorous levels (Department of Agriculture, 1996). All commercial varieties of Proteaceae prefer acidic rather than alkaline soils, ideally with a pH of 5.0 – 6.0. The capacity of the proteaceous species to scavenge minute amounts of phosphorous from nutrient deficient soil makes them vulnerable to toxicity when the phosphorous content of fertilisers is high.

Climate**:** Proteas are most suited to a mild climate with low humidity. *Protea* and *leucadendron* are adapted to winter rainfall and prefer a monthly average rainfall of 75-100mm. Protea can tolerate slight frosts but are more vulnerable than *leucadendron,* particularly in the late spring months of October and November. Consistent high temperatures can damage flowering protea crops (Department of Agriculture, 1996).

Landscape**:** The optimal landscape conditions for protea plantations are areas with a north or north-easterly aspect and a mild slope (5 to 10 degrees) to allow safe tractor access.

## Protea Suitability for Moorabool Shire

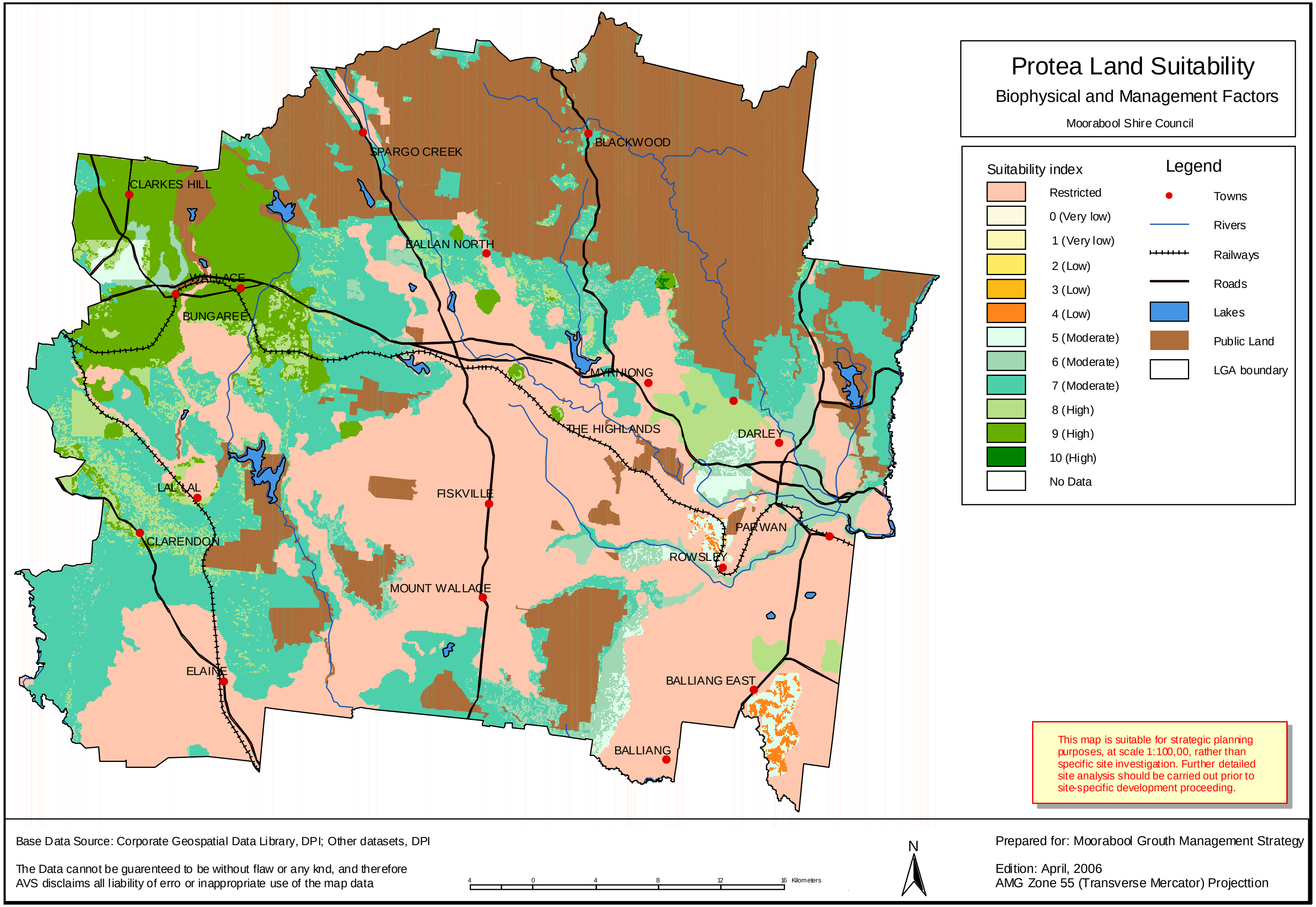
| Suitability | No. Hectares within the Shire |
|---|---|
| Low | 699 |
| Moderate | 54,689 |
| High | 24,300 |

**Note:** The suitability area calculations have been approximated to the nearest ten hectares. Public land, totally more than 57,510 hectares, is excluded from the calculations. The total private land area mapped is estimated at over 150,690 hectares in the Moorabool Shire.

The suitability of Moorabool for protea production varies significantly across the Shire, with the majority of this variation explained by changes in soil suitability (**Map 4.11**). The highest suitability for production is found in the north east largely due to optimal pH value, deep and well drained soils in the area. There are several small areas with a slightly lower suitability to the west, as a result of lower soil suitability, and to the east due to moderate climate suitability. Around 40% of the remaining area was identified as being moderately suitable for protea production largely due to lower soil suitability.

Shallow and poorly drained soils to the south of Balliang East were ranked as having low suitability for protea production. Approximately half of the study area has been identified as restricted and therefore unsuitable for protea production due to the soil texture.

# Map 4.11 Protea Land Suitability



## 4.12 Horses

Any assessment of the suitability of land for carrying horses needs to consider both landscape and management factors. The landscape factors assess the natural resource requirements for keeping horses (soil structure, tree cover, access to water courses, slope and paddock shape), while the management factors assess issues relating to horse health, pasture quality, stocking rate and infrastructure.

An initial analysis based on solely landscape factors highlighted the limitation of only considering biophysical conditions, showing little differentiation in suitability for horses across the Shire. As a result, the relative carrying capacity, as a function of rainfall was calculated (in dry sheep equivalents) and used, along with pasture growth (see section 4.8 and 4.9), to weight the output of the original landscape suitability model. The final map produced (**Map 4.13**) represents the suitability of land for horses based on a "maximum grazing" management system in which most, if not all, of feed requirements are sourced from pasture. This map should be used in conjunction with **Map 4.12** (recommended stocking rates for horses) to assess land suitability for carrying horses.

It is important to note that when the full feed potential is not reached, because of low rainfall or because good grazing management procedures have not been followed, the carrying capacity of the land would be reduced. More detail regarding the modelling of landscape selection characteristics and stocking rates is provided below.

### Landscape Selection Characteristics for Horses

The experts identified six main landscape characteristics as important in assessing land suitability for horses: slope, fence length versus paddock area, soil (sand content), tree cover and access to natural water courses. These characteristics are explained below and the relative ratings (optimum and least desirable) for each component of the characteristics is shown in model criteria section following.

| | | **Optimal** | **Least desirable** |
|---|---|---|---|
| Soil | Sand Content | Textures without a large proportion of sand | Sand, Loamy sand, Sandy loam, fine sand and coarse sand |
| | Tree Cover | Low to moderate density | High density |
| Landscape | Water Courses | >20m from water course | <20m from water course |
| | Slope | 0-10º | >25º |
| | Ratio Paddock Area to Fence Length | >1 kilometre fence per hectare | <1 kilometre fence per hectare |

**Slope:** Slope was considered an important characteristic as steep slopes inhibit access by vehicles (tractors) and are likely to be more prone to erosion. The combined effect of difficulty in trafficking the slope and pugging can cause erosion of the soil surface, reducing the capacity to maintain an adequate grass cover throughout the whole year.

**Fence length versus paddock area:** This aspect was identified as important due to the behavioural characteristics of horses to pace along fence lines and create bare patches. For a paddock of a given area, a long narrow shape will therefore be more advantageous than a square shape. Excessive pacing by horses, resulting in additional pasture damage, may occur where horses are located in several small paddocks adjacent to one another.

**Sand Content:** Very high sand content is not suitable to maintain good pasture cover. Pasture persistence is difficult to manage as the plants can be easily pulled from the ground when being grazed by the horse. Horses can also ingest sand if kept in bare paddocks, which can induce sand colic.

**Tree Cover:** The density of the tree cover directly influences pasture growth, therefore areas of highly dense tree cover are not suitable for horses as adequate pasture will not grow. The absence of any trees does not restrict the land for horses, however some shelter from wind and sun should be provided.

**Water Courses:** It is important to restrict horse access to water courses running through a paddock to maintain water quality and minimise environmental and pasture degradation as well as limit infections of hooves and legs from lengthy contact with mud. Banks of water courses are also often steep and horses may injure themselves.

### Management Regimes

An important aspect of horse ownership is management of horse health, pasture, stocking rates and the infrastructure. Given the lack of spatially distributed data on management regimes most of these aspects could not be adequately modelled. **Table 4.2** summarises the ideal horse management regime. Stocking rate, however, was in fact incorporated into the model using an equation developed by French (1987). See below for more detail.

Table 4.1 Horse Management Issues and Management Aims

| MANAGEMENT ISSUES | IDEAL MANAGEMENT REGIME |
|---|---|
| Stocking Rate (Spelling 500kg horse with avg requirement of 64MJ/d/head) | To maintain a minimum ground cover of 1000-1200 kg/DM/ha (~2.5cm of growth). Maintain condition above condition score 2. Provide 64 MJ/d/head – supplementary feed if necessary. |
| Worming | 6-8 weeks (worming), check teeth once year, vaccinations once year at maintenance, trim feet 6-8 weeks. |
| Manure | Frequent management essential. Harrowing in summer after rain event. Fresh pickup best. Otherwise strategic harrowing. |
| Fertilising | Soil test for P, K, S and pH to maintain 15 mg/kg Olsen P, 200 mg/kg Skene K, 12 mg/kg CPC S and pH (H20) above 5.5 |
| Rotation (Electric temporary fencing) | Spelling of pasture required as 2 weeks on and 4 weeks off. Triggered by 2200 – 1200kg/DM/ha. |
| Weed Control | Removal of all weeds (Minimised if previous practices followed) |
| Supplementary feed | As required to maintain condition score above 2. Be aware of feed quality and supplier. Check cost of energy and feed. |
| Pasture Growth Control | Slash during very high growth and at the end of summer to remove rank grasses. |
| Pasture repair | Bare areas should be repaired and or set aside as high traffic areas (feed pads, crushed rock/sand). |
| Shelter | Provide shelter from sun and wind. |
| Pasture composition | >= 70% perennial ryegrass and 10% clovers, the rest likely to be annual grasses. |
| Stud Design | As per "Hoofprints, A manual for horse property management" by Jacquie Foyel. |
| Holding Infrastructure (stabling/yarding) | As above, needed to hold overweight horses. |
| Grazing behaviour | Property manager to account for grazing behaviour. |
| Mixed/Cross grazing | Watch stocking rate and supplementary feeding requirement. |

### Stocking Rate

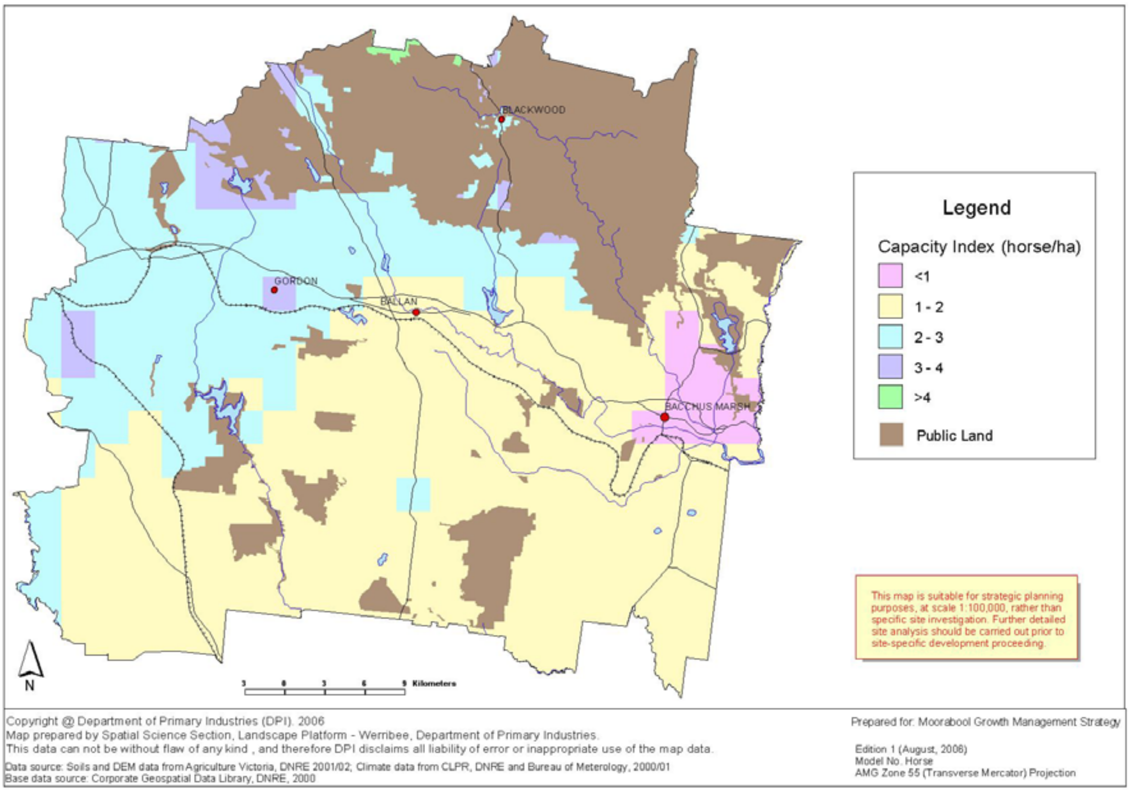
The appropriate stocking rate for a property is difficult to estimate as it is highly dependant on the type of grazing management system used, how much pasture the land can produce and the size and activity of the horse(s). The model estimated the Dry Sheep Equivalent (DSE) across the Shire based on the equation developed by French (1987) which predicts that 1.3 DSE/ha could be carried for each 25mm of rainfall over 250mm (**Map 4.12**). For modelling purposes it was assumed that the horse concerned was a light work horse (**Table 4.1**).

Table 4.2 DSE Rating for Various Classes of Horse

| Class of Horse | DSE rating |
|---|---|
| Light Horse | 10.0 |
| Draught Horse | 14.0 |
| Pony | 6.0 |
| Horse – light work | 13.5 |
| Horse – heavy work | 18.7 |

**Source:** Avery, 1996, p131

Map 4.12 Recommended stocking rates for horses per hectare based on rainfall



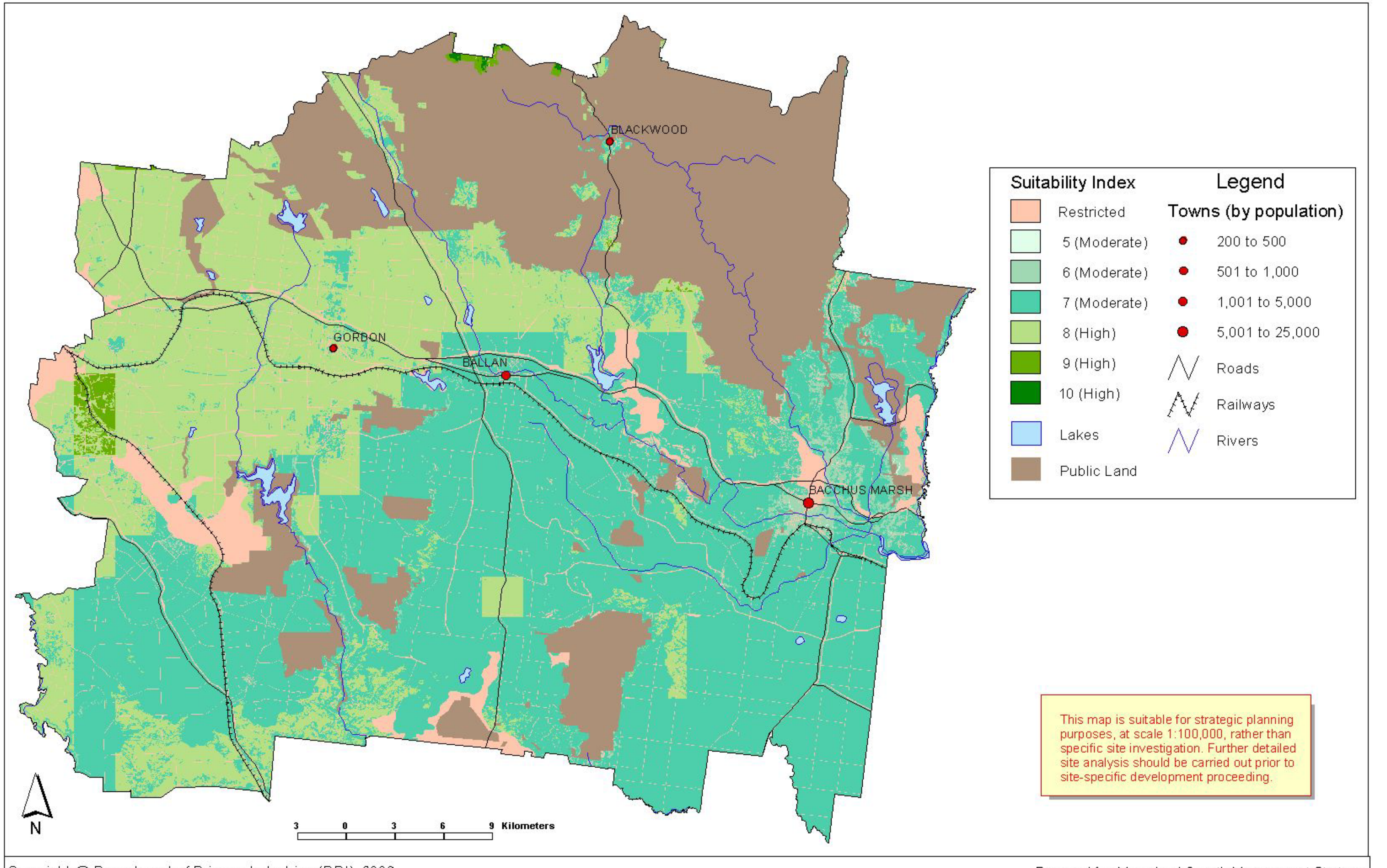

### Land Suitability for Horses Across Moorabool Shire

| Suitability | Hectares within the Shire |
|---|---|
| Low | 0 |
| Moderate | 75517 |
| High | 72027 |

**Note:** The suitability area calculations have been approximated to the nearest ten hectares. Public land, totalling more than 57,510 hectares, is excluded from the calculations. The total private land area mapped is estimated at over 150,690 hectares in the Moorabool Shire.

**Map 4.13** shows the result of the Landscape Selection model in Moorabool Shire. Areas of moderate suitability are located in the south and east parts of Moorabool, while areas of higher suitability are located in the north and west parts. The result of this is highly consistent with the land carrying capacity based on rainfall, as shown in **Map 4.12**. Restricted areas are scattered throughout the Shire because they are either with sandy surface or too close to the water body.

Map 4.13 Horse Suitability as a function of landscape suitability, suitability for pasture and carrying capacity (based on rainfall)





Map prepared by Spatial Science Section, Landscape Platform - Werribee, Department of Primary Industries.
This data can not be without flaw of any kind , and therefore DPI disclaims all liability of error or inappropriate use of the map data.
Data source: Soils and DEM data from Agriculture Victoria, DNRE 2001/02; Climate data from CLPR, DNRE and Bureau of Meterology, 2000/01
Base data source: Corporate Geospatial Data Library, DNRE, 2000

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Edition 1 (August, 2006)
Model No. Horse
AMG Zone 55 (Transverse Mercator) Projection

## 4.13 Composite Maps: Multiple Agricultural Uses

### Trends in Agriculture

The study of the Moorabool Shire aims to provide information that will enable the preservation of 'high value' agricultural land. The judgement of 'high value', however, is a dynamic concept which requires a detailed understanding of the context in which decisions will be made. The agricultural sector and associated supply systems are currently undergoing, and will continue to go through, major structural changes. These changes are driven by globalisation; changes in consumer needs and attitudes; new technological advances; increasing environmental awareness and governmental regulation. A number of these trends are discussed in more detail below because it is predicted that they will have profound implications for the future of the agricultural sector in Australia (Barry, 1995; Boehkje, 1995; Tweeten, 1997).

*Globalisation*: A new, global economy has emerged where products have access to more free and open markets. As a consequence of globalisation, agricultural and agribusiness firms in Australia have both increased competition in their traditional domestic market and found additional opportunities in other countries. It will be essential to be able to compete in the global market, even for those firms focusing in Victoria, because the competition will be global in nature.

*Increasing Environmental Awareness*: The agricultural sector is increasingly vulnerable to, and impacted by, the heightened interest of society in environmental problems and reducing environmental degradation. There will be enormous pressure for the adoption of environmentally friendly (or at least benign) production practices by agriculturalists.

*Changes in Consumer Needs*: Much of agriculture is changing from a commodity industry to one with differentiated products. Consumers are more demanding; they expect quality control and products with specific characteristics to be available when desired. Examples include; white corn, waxy maize, high oil content soybeans, high protein wheat, extensive varieties of wines, free-range chicken and antibiotic/chemical-free beef. Segmented or niche markets for some food and industrial-use products can appear and disappear rapidly.

*Niche Markets:* Although the tendency is towards larger firms, smaller firms will continue to play an important role when they serve niche and specialty markets. Small, specialised markets such as specialty crops, special types of livestock, special use crops (e.g. for specific industrial uses), and ethnic foods are all candidates for successful niche marketing. Agricultural and agribusiness firms will need to respond quickly to changes in the economic climate and consumer demands. They must maintain flexibility to respond more quickly than their competitors, thus retaining the capacity to serve niche markets.

If the concept of "high value" agricultural land is associated with the capacity to sustain multiple agricultural uses, it could be argued that Moorabool Shire will have a greater ability to position itself in the *new world* economy. Moreover, land which has been identified as biophysically suitable will have the added benefit of requiring fewer of those inputs that are perceived by society as potentially damaging to the environment or are a food safety risk (see Point 2, above).

## Combined Land Suitability for Vegetables

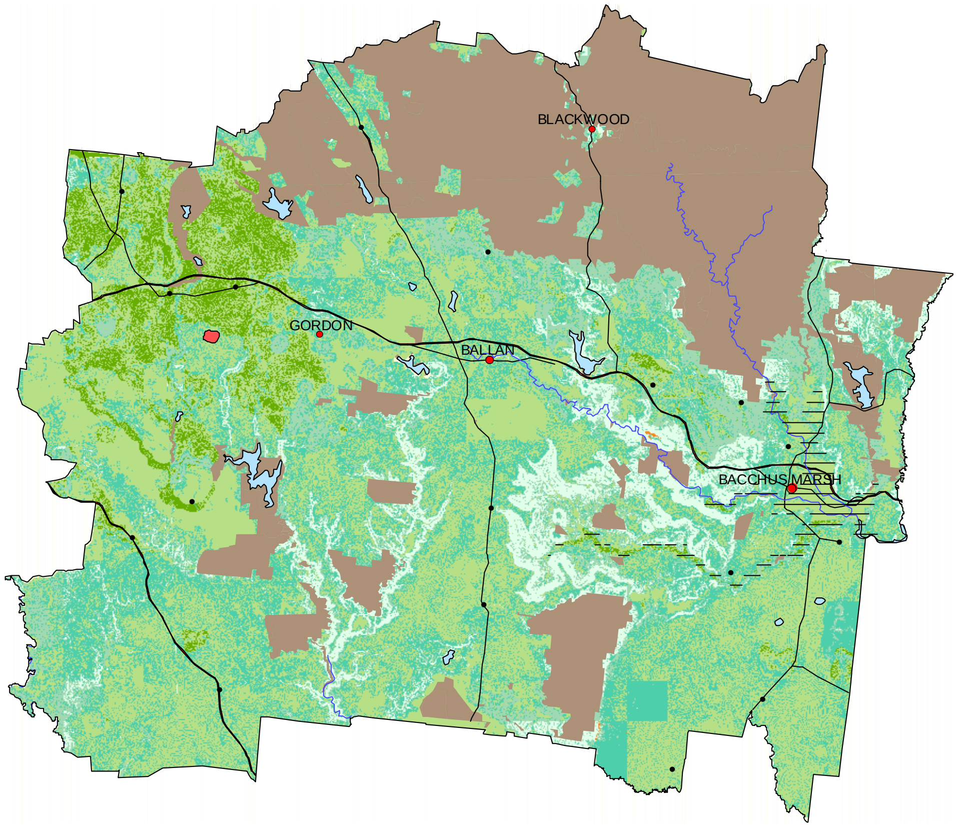
**Map 4.14**, combines the land suitability analysis for Brassica, Artichoke and Potatoes to produce a map of land suitability for 'vegetables' across Moorabool Shire. Interpretation of the map reveals that the majority of Moorabool has been classified as moderately to highly suitable for the production of vegetables. The highest suitability areas occur in the north west of the Shire, near the townships of Gordon and Bungaree.

# Map 4.14 Combined Land Suitability for Vegetables

## Vegetable Suitability

**Brassica, Artichoke and Potato**

**Moorabool Shire Council**




**Suitability Index**

- Restricted
- 0 (Very low)
- 1 (Very low)
- 2 (Low)
- 3 (Low)
- 4 (Low)
- 5 (Moderate)
- 6 (Moderate)
- 7 (Moderate)
- 8 (High)
- 9 (High)
- 10 (High)
- No data available

**Legend**

Towns (by population)
- 200 to 500
- 501 to 1,000
- 1,001 to 5,000
- 5,001 to 25,000
- Places
- Principal Road
- Secondary Road
- Lake
- River
- Public Land
- LGA boundary
- Complex Soils
- Restricted soils

**This map is suitable for strategic planning purposes, at scale 1:100,000, rather than specific site investigation. Further detailed site analysis should be carried out prior to site-specific development proceeding.**


Map prepared by Strategic Resources Planning Unit, Agriculture Victoria - Werribee, Department of Natural Resources and Environment.


Data source: Soils and DEM data from Agriculture Victoria, DNRE, 2001/02; Climate data from CLPR, DNRE and Bureau of Meterology, 2000/01
Base data source: Corporate Geospatial Data Library, DNRE, 2000; Auslig Geodata Topo-250K.

5 0 5 10 15 Kilometers
Scale: 1:250,000

N

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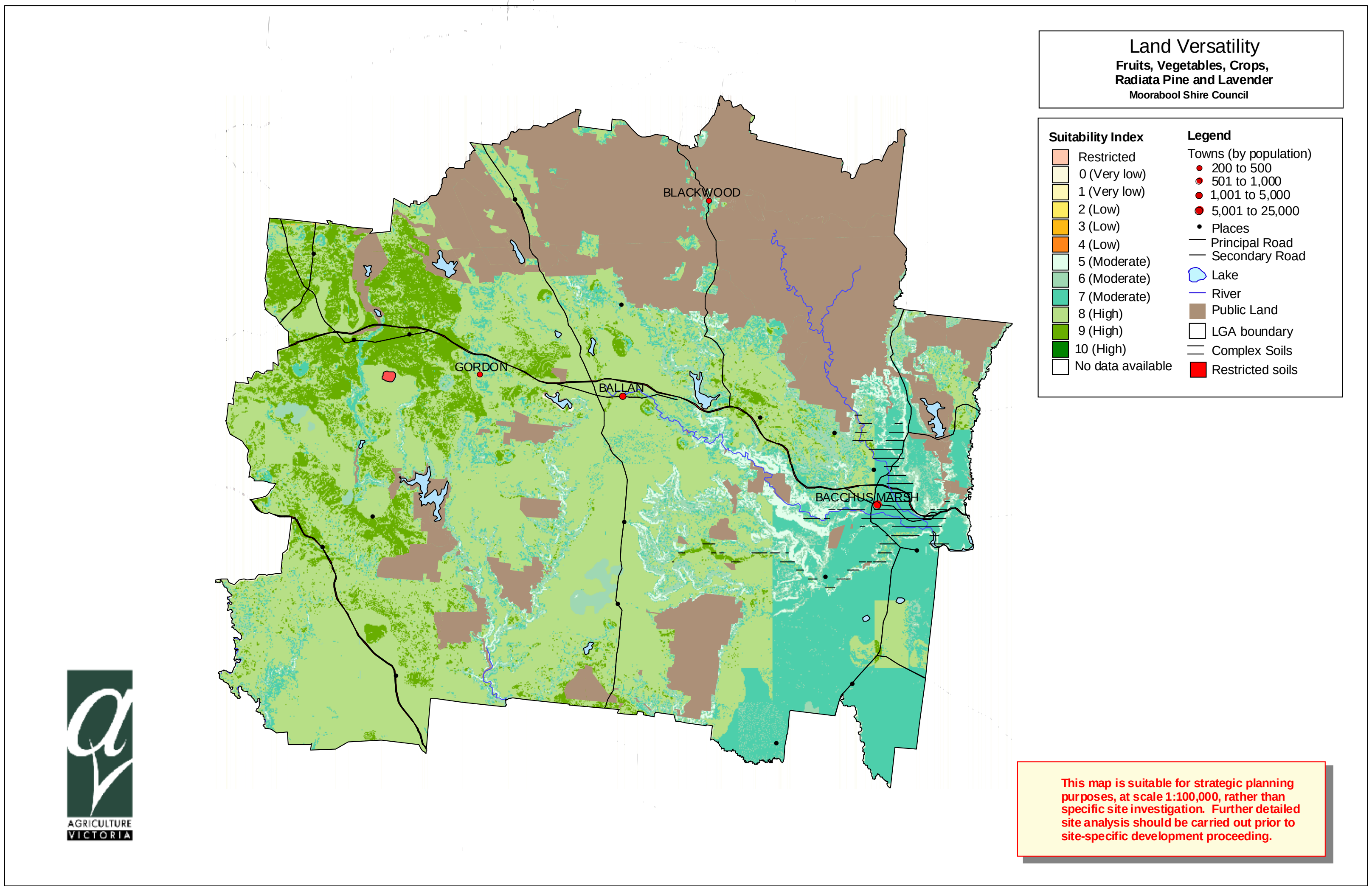
Project V10MBa; Map Number M12MBbb
Model No. ag_suit
AMG Zone 55 (Transverse Mercator) Projection

## Combined Land Suitability for Agriculture: 'Land Versatility'

**Map 4.15**, combines the map of 'agricultural suitability' with the protea, lavender and radiata pine suitability maps, to produce a composite map of 'Land Versatility' which highlights areas which are suitable for a wide variety of commodities. Areas mapped as moderately suitable (index value of 5) are strongly associated with steep slopes. The difficulties and dangers associated with operating on these slopes impact on the suitability of these areas. The area south of Bacchus Marsh has been mapped as being of moderate suitability (index value of 6), largely due to the lower rainfalls received in this part of the Shire.

Areas of highest versatility are found in the north west of the Shire, around the townships of Bungaree and Gordon. These areas have a high annual rainfall and are characterised by soils that are deep, and moderately to well drained.

# Map 4.15 Land Versatility





Map prepared by Strategic Resources Planning Unit, Agriculture Victoria - Werribee, Department of Natural Resources and Environment.


Data source: Soils and DEM data from Agriculture Victoria, DNRE, 2001/02; Climate data from CLPR, DNRE and Bureau of Meterology, 2000/01
Base data source: Corporate Geospatial Data Library, DNRE, 2000; Auslig Geodata Topo-250K.

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Project V10MBa; Map Number M15MBbb
Model No. land_versatility
AMG Zone 55 (Transverse Mercator) Projection

# 5. PHYSICAL AND ENVIRONMENTAL ANALYSIS

Managing the condition of environmental resources has important implications for economic growth, social quality of life, and the sustainability of a regions' resource base. This chapter presents a strategic environmental analysis of the natural resources of Moorabool Shire, with a specific focus on water, vegetation, biodiversity, salinity, erosion, and flooding.

## 5.1 Water Quality and Availability

Water quality and availability is a topical issue in Australia, with demands for water for irrigation increasing and many new developments proposed. Interest in water quality and availability in Australia can be grouped into four main areas:

(i) Surface water availability, allocation, use and efficiency of use.
(ii) Sustainability of surface water use including environmental flows.
(iii) Groundwater availability– demand, allocation and efficiency of use.
(iv) Infrastructure and investment.

### Water Quality

Many Australian inland rivers and streams are subject to discharge and pollution from urban, agricultural, mining and industrial activities. Rising water tables resulting from clearing vegetation and affects of irrigation, have increased salinity levels within streams and large areas of land. Erosion, physical barriers, de-snagging, channel modifications and inappropriate regulations have also contributed to degraded water and river habitat quality. Within Victoria, water quality monitoring programs are run by three organisations: the Department of Sustainability and Environment (DSE), the Environment Protection Authority (EPA) and Melbourne Water (MW). Data collected by these organisations is coordinated and stored by the Victorian Water Quality Monitoring Network (VWQMN).

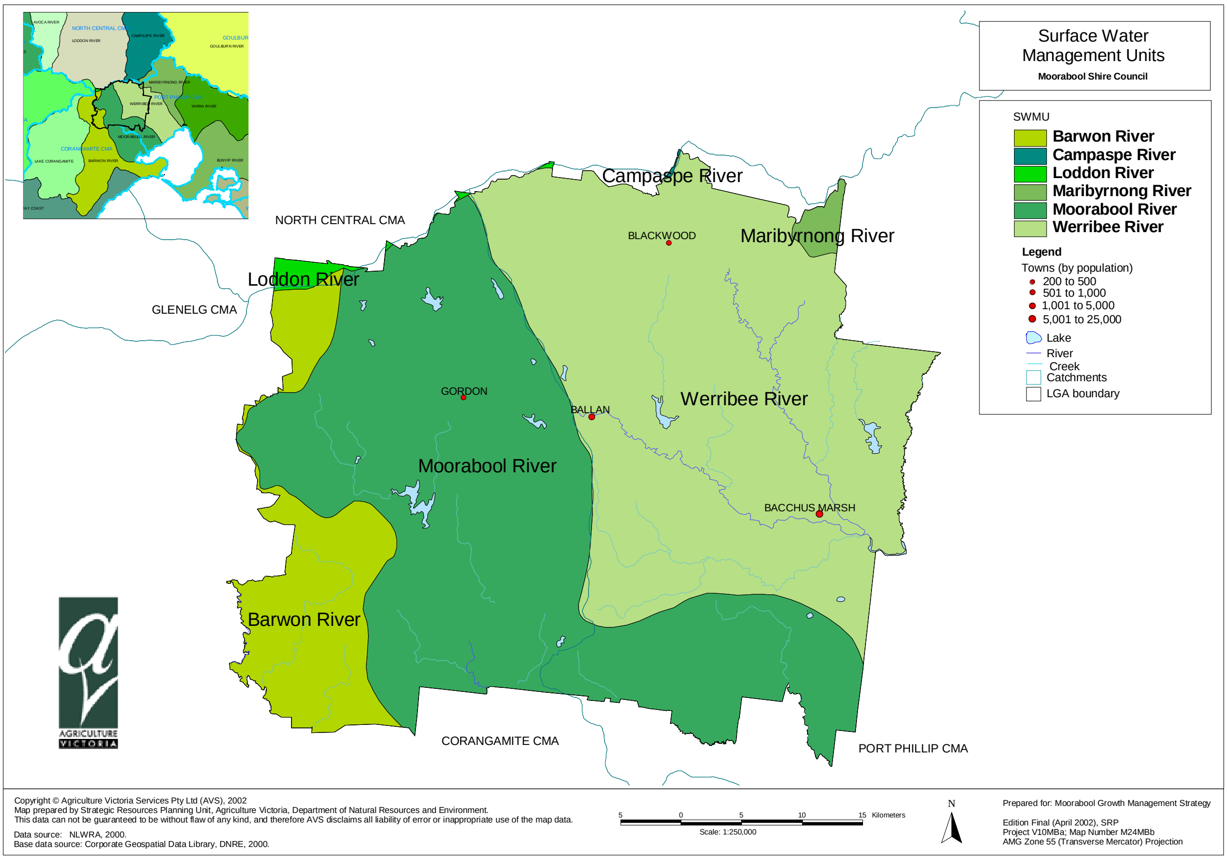
The VWQMN is responsible for 180 monitoring sites across regional Victoria, covering 27 of the 30 basins within the State. Of the remaining three basins, two are sampled by the Murray-Darling Basin Commission only, and the other (Millicent Coast) has no significant rivers or streams within Victoria (NLWRA, 2001c). The VWQMN has been measuring water quality indicators for up to 25 years at approximately monthly intervals. Incorporation of the EPA's monitoring sites into this network has increased the number of sites in the disturbed middle and lower river reaches, in Victoria's main rivers. MW carries out monitoring of 50 sites on urban streams in the Yarra, Dandenong, Maribyrnong and Werribee catchments (NLWRA, 2001c). The measurements used for assessing water quality generally relate to: total phosphorus, total nitrogen, turbidity, electrical conductivity, and pH of the water. Poor water quality can result in algal blooms, high salinity, increased sediment loads in streams and acidification of water as well as having significant impacts upon the supply of water for consumption and irrigation.

Water quality within the Moorabool Shire is influenced by various agricultural and urban land uses within the region. The general trend is for water quality to be high in the upper reaches of the river basins deteriorating as the water moves into the lower reaches. This trend reflects the pattern of land use, as the upper reaches are relatively undisturbed while the lower reaches are impacted by more intensive land uses, such as agriculture and urban development (Walker & Reuter, 1996).

Moorabool Shire is covered by five surface water management areas (SWMAs) or river basins. The majority of the Shire is covered by the Moorabool, Werribee, and Barwon

River Basins, each of which is described in more detail below. Smaller sections of the Maribyrnong and London River Basins also extend into the Shire (**Map 5.1**). The River basins are named after their major river, and are defined as catchment areas that drain to the sea (NLWRA, 2001c).

Map 5.1 Surface Water Management Areas




## *Werribee River Basin*

The Werribee River Basin covers an area of 197,300 hectares and extends from the Great Dividing Range to Port Phillip Bay. The rivers' major tributaries include the Lerderderg River and the Goodman, Parwan, Arnold, Toolern and Pyrites Creeks. The Basin has three major water storages; the Pykes Creek and Melton Reservoirs are primarily used for agricultural irrigation while the Merrimu Reservoir is used for both agriculture and urban supplies.

In the Werribee River Basin all water quality parameters except for pH were found to be poor, with a slight downward trend for pH and total nitrogen. The poor quality probably reflects degradation from urban uses (NLWRA, 2001c).Water quality outside the monitoring sites is considered to be good due to the undisturbed nature of the area.

## *Moorabool River Basin*

The Moorabool River Basin extends 70 km from the Great Dividing Range near Ballarat to Port Phillip Bay. The Basin covers an area of 217,042 hectares, with the mean annual flow of 115,000 ML representing 0.5% of the State's total discharge.

Water quality is monitored at 4 sites at which five water quality attributes are recorded for trend analyses. Water quality within the Moorabool River Basin is considered to be good in the upper reaches of the basin and poor in the lower reaches, a reflection of the more intensive agricultural land use in this region (NLWRA, 2001c).

### *Barwon River Basin*

The Barwon River Basin is located in the west of the Shire, extending from its headwaters in the Otway and Brisbane Ranges to the Bellarine Peninsula. The total area of the basin is 388,077 hectares or 1.8% of the State (DNRE, 2002). The water quality measured in the basin was good for pH but had poor nutrient levels and turbidity (NLWRA, 2001c).

## Water Availability

Water availability refers to the ability of a catchment to supply water for both human needs and environmental flows. Current average annual water use in Victoria is around 5,788 GL/a (NLWRA, 2001c) with surface water meeting 89% (5,166 GL/a) of the requirement and the remaining 622 GL/a coming from groundwater. 814 GL of surface water is used to meet commitments on the Murray System in New South Wales, which brings the total of diverted surface water to 5 980 GL/a.

The current level of usage represents around 87% of the estimated sustainable yield for surface water and 25% of the total groundwater sustainable yield for Victoria. By the year 2050 it is expected that the use of surface water will have risen by 7% while groundwater use is expected to rise by 29%. This level of use (at 2050) represents around 94% of the sustainable yield for surface water. Despite the overall sustainability of water use being below 100%, surface water and groundwater use in some of the river basins and aquifers in Victoria is unsustainable with current use and allocation exceeding the sustainable yield.

The relative volumes of water use for the different use types are expected to alter over the next 50 years. Use of surface water is currently dominated by Victoria's large irrigation industry which represents 78% of all surface water consumed in Victoria. In comparison, urban domestic consumers account for 17% and the industrial/commercial sector accounts for only 5%. Forecast estimates of use for 2050 suggest that the industrial/commercial sector will increase to 11%, at the expense of irrigators which will decline to a 73% share. The proportion of water consumed by the urban domestic sector is likely to remain relatively constant at about 17%. This shift in water use from irrigation to the industrial/commercial sector results from the assumption in the forecasts that the industrial/commercial sector is given priority supply over irrigators which, in turn, reflects the greater willingness of the industrial/commercial sector to pay a higher price for water.

### Surface Water Resources

Sinclair Knight Merz (SKM) undertook an analysis of water resource availability and use within Victoria. The potential for future development of SWMAs (**Map 5.1**) was based on the National Land and Water Resources Audit (NLWRA) analysis, which developed category ratings to define the status of water resource use (NLWRA, 2001c).

Within the Moorabool Shire, the Werribee River SWMA has been categorised as highly developed with respect to diversion and fully developed with respect to allocation (NLWRA, 2001c). The fully developed categorisation suggests that water allocation is at 100% of the sustainable yield, and that further water resources cannot be allocated without impinging upon environmental values and environmental water provisions. The Moorabool River SWMA has been categorised as being moderately developed with respect to diversion and fully developed with respect to allocation

(NLWRA, 2001c). Finally, the Barwon River Basin was categorised as being moderately developed for both diversion and allocation (**Table 5.1**).

Table 5.1 Surface Water Management Areas (SWMA) Development Categories

| SWMA | Diversion | | Allocation | | Comment |
|---|---|---|---|---|---|
| | **Category** | **Volume (ML)** | **Category** | **Volume (ML)** | - |
| Werribee | 3 | 32 250 | 3* | 33 000 | - |
| Moorabool | 2 | 16 270 | 3* | 45 270 | Categorisation pending outcome of streamflow management plan. |
| Barwon | 2 | 40 060 | 2 | 45 700 | - |

When the development potential for the river basins is considered it is clear that there are very few opportunities within Moorabool Shire for further increases in water use (**Table 5.1**). For SWMAs considered to be 'fully developed', further development can only take place if water rights are acquired via water trading or through increases in efficiency.

There is an important distinction to be made, however, between volumetric development potential (i.e. the potential for further increases in water use) and economic development potential (i.e. potential for increase in water based economic activity). Assessment of the economic development potential is important from the point of view of potential regional development. A comparison of volumetric and economic development potential is shown in **Table 5.2**, using economic development ratings based on an assessment of the ability to acquire water by trade and the likelihood of achieving water savings by efficiency gains. The volumetric development potential was defined as follows:

High: 100 000ML available for further use.
Medium: 35 000-100 000 ML available for further use.
Low: <35 000 ML available for further use.
None: No water available for further use.

Table 5.2 Development Potential for Surface Water Management Areas

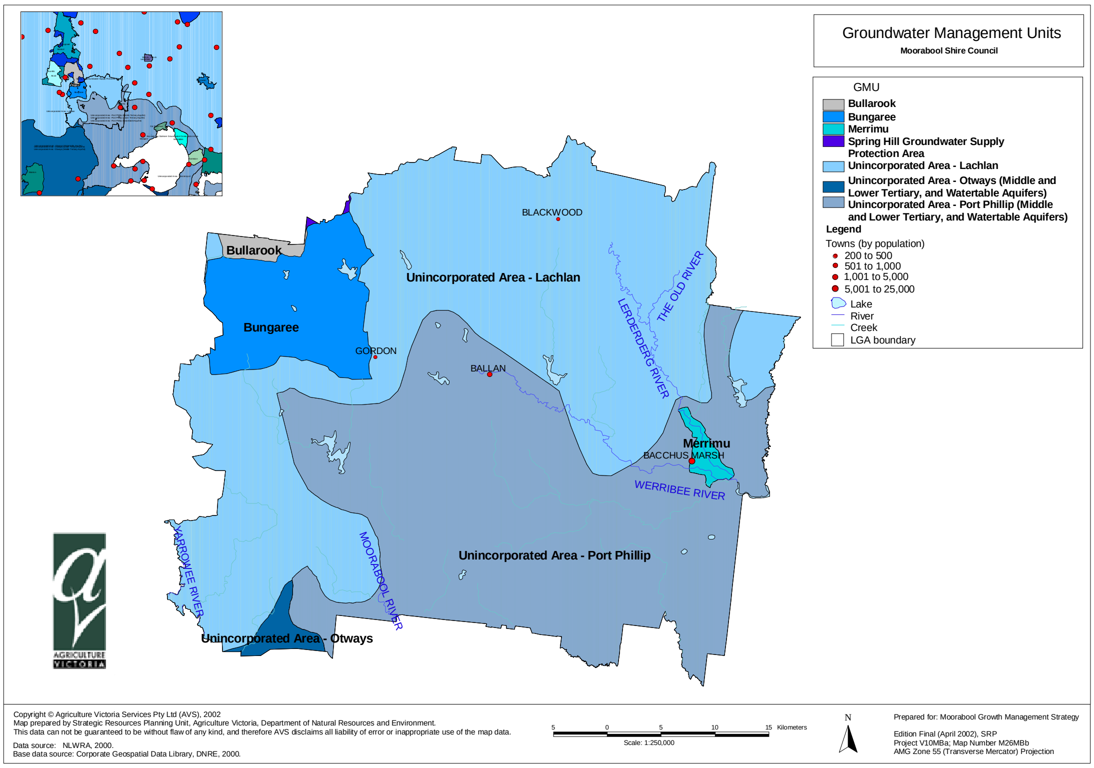
| SWMA | Development Potential (Volumetric) | Potential for Trade | Potential For Water Saving | Overall Development Potential (Economic) |
|---|---|---|---|---|
| Moorabool | Low | Low | Low | Low |
| Barwon | Low | Low | Medium | Low |
| Werribee | Low | Medium | Medium | Medium |

The Moorabool and Barwon SWMA both have a low development potential with respect to volumetric and economic development. The Werribee SWMA has a moderate economic development potential through efficiency savings and water trading.

### Groundwater Resources

The principle groundwater resources in Victoria fall south of the Great Dividing Range and are contained in tertiary or younger unconsolidated sediments (**Map 5.2**). A similar analysis of development potential was undertaken for Groundwater Management Units (GMUs), Unincorporated Areas (UAs) and Provinces in Moorabool Shire (**Table 5.3**). GMUs are defined as hydraulically connected groundwater systems at a scale appropriate for management (NLWRA, 2001c). Groundwater Provinces are based on a combination of the principal hydrogeological basins and geological zones within Victoria. The UAs comprise the areas between the GMUs and the Province boundaries.

Map 5.2 Ground Management Units, Moorabool




The resource development was categorised as follows:

*Category 1*: Low level resource development
Developed Use between 0% and 30% of Sustainable Yield (SY)

*Category 2*: Minimum level resource development
Developed Use between 31% and 70% of SY

*Category 3*: High level resource development
Developed Use between 71% and 100% of SY

*Category 4:* Over developed resource
Developed Use greater than 100% SY.

Table 5.3 Groundwater Management Units (GMUs) Development Categories

| **GMU** | **Groundwater Use** | | **Groundwater Allocation** | |
|---|---|---|---|---|
| | **Development Category** | **Total Abstraction (ml)** | **Development Category** | **Total Allocation (ml)** |
| Bungaree | 4 | 4 337 | 4 | 5 870 |
| Unincorporated Area – Lachlan | 1 | 22 780 | 1 | 23 140 |
| Unincorporated Area – Port Phillip (middle tertiary aquifer) | 1 | 650 | 1 | 650 |
| Unincorporated Area – Port Phillip (watertable) | 1 | 7 570 | 1 | 7 570 |
| Merrimu | 3 | 356 | 3 | 362 |
| Ballarook | 1 | n/a | 1 | n/a |

Groundwater is used very little within the Moorabool Shire with the exception of Bungaree and Merrimu GMUs. The Lachlan and Port Phillip GMU's which comprise most of the Moorabool Shire area, have been categorised as having low level resource development with respect to both use and allocation. In contrast, Bungaree is considered to be over developed and the Merrimu GMU, although significantly smaller, is considered highly developed. Most of this extraction from Merrimu may relate to the coal mining and mineral sands industries. When resource commitments in a GMU reach 70% of the estimated sustainable yield, as in the case of Bungaree and Merrimu, the area is declared a Groundwater Supply Protection Area (GSPA), and groundwater community management groups are established.

Assessment for the potential for groundwater development involves consideration of the current development status, aquifer salinity, aquifer depth and aquifer yields. The potential for further increases in groundwater use is available in central Moorabool. There is also scope for economic development based on savings achieved through increases in efficiency of use and potentially water trading.

## 5.2 Vegetation and Biodiversity

Biodiversity refers to the variety of life forms, including plants, animals and micro-organisms, their genetic make-up and the ecosystems of which they form a part (State of the Environment Advisory Council (State of the Environment Advisory Council, 1996, p4-4). A unique assemblage of organisms and ecosystems have resulted from the historical isolation of the Australian landmass. Many species are endemic to this continent, raising the preservation of Australia's biodiversity to a matter of global heritage.

### Bioregions

Victoria is composed of a number of bioregions, which are defined as the biogeographical areas, which capture patterns of ecological characteristics in the landscape or seascape, providing a natural framework for recognising and responding to biodiversity values (Platt and Lowe, 2002). As bioregions reflect underlying environmental features, it is believed that they can also be related to patterns land use. Within the Moorabool Shire, two bioregions have been identified; the Central Victorian Uplands and the Victorian Volcanic Plain.

#### The Central Victorian Uplands Bioregion

The Central Victorian Uplands Bioregion covers 5.9% of Victoria. The majority of the Shire falls within the Central Victorian Uplands Bioregion, which stretches from Beaufort in the west through Ballarat, Seymour and Alexandra, to Beechworth in the east. The majority of the bioregion consists of private land with only 2% covered by reserves (2,070ha).

#### The Victorian Volcanic Plain Bioregion

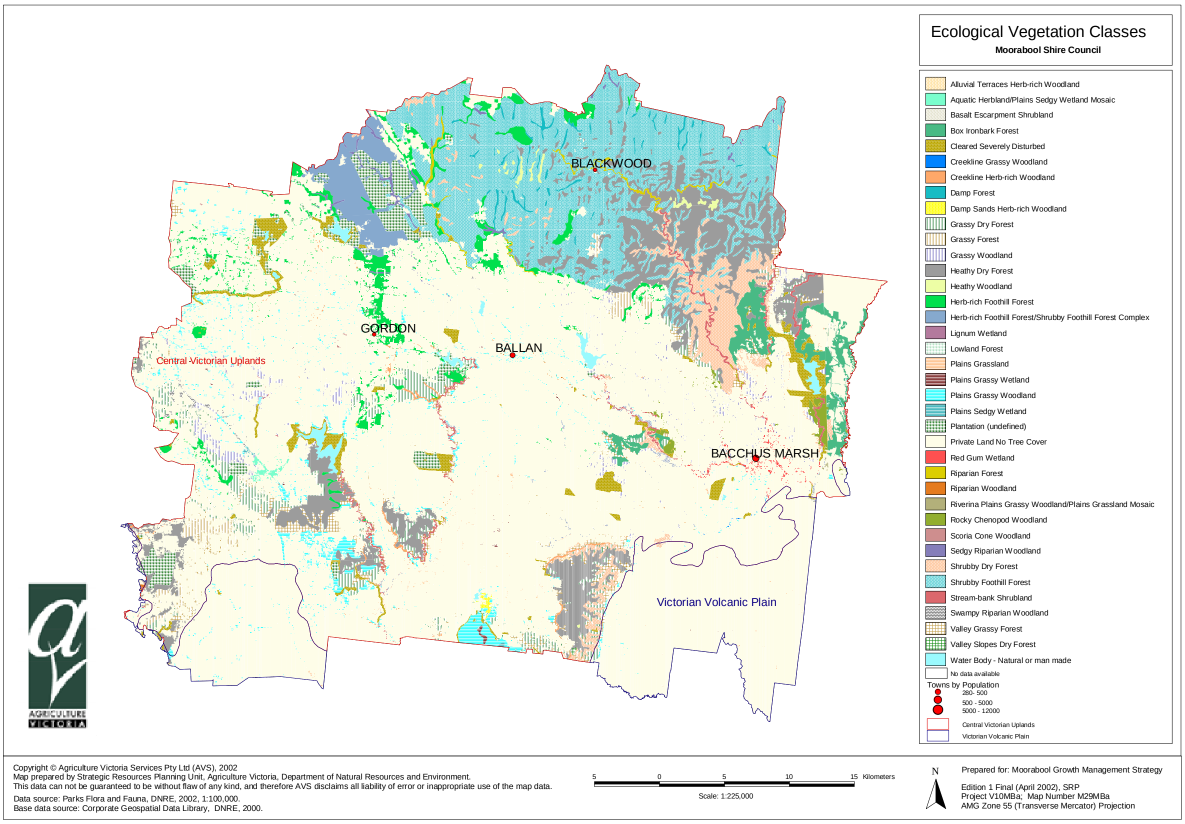
The Victorian Volcanic Plain Bioregion covers 9.1% of Victoria but only takes in the South West and South East corners of Moorabool, extending west from Melbourne to Portland, south to Colac and north to Beaufort. Once again the majority of the bioregion is made up of private land with only 2% of the region (37,320 ha) protected within parks and reserves.

## Ecological Vegetation Classes (EVCs)

Ecological Vegetation Classes (EVCs) are a classification system for native vegetation that identifies floristic communities that exist under a common regime of ecological processes (Crown - State of Victoria, 1997a, b and c).  Such a description allows a link to be made between vegetation patterns and broad landscape features such as coasts, lakes, plains, dissected terrain, plateaus and mountains and their respective climates.

Thirty-eight EVCs have been mapped within Moorabool Shire (**Map 5.3).**  As the majority of the Shire has been cleared, primarily for agricultural purposes, the remaining native vegetation is generally patchy with two-thirds of this area located on public land.  The dominant EVC's include the Shrubby Foothill forest in the north, Heathy Dry Forest and Herb-rich Foothill Forest, Grasslands, and Box Ironbark Forests in the east.

Map 5.3 Ecological Vegetation Classes (EVC)

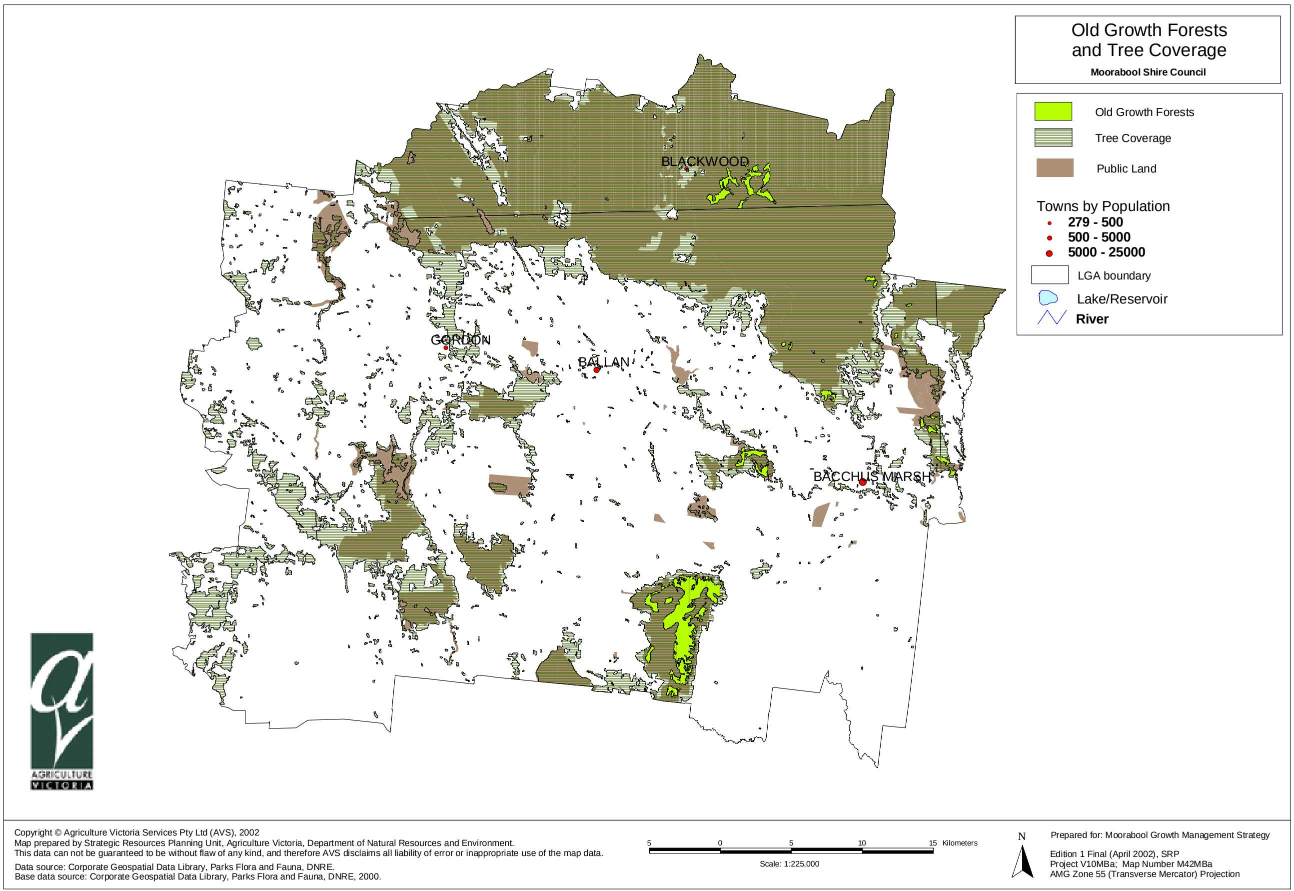



Grassy Forest, Grassy Woodlands, and Grassy Dry Forest EVCs occur as longitudinal pockets within the centre and west of the Shire.  This is situated on Freehold and State Forest.  Plains Grassy Woodland EVC occurs in the south of the Shire on Reserve land.  Long Forest is a small reserve in the southeast of the Shire that contains isolated remnants of mallee vegetation which is now some of the only naturally occurring mallee south of the Great Dividing Range.

## Tree Cover

Native tree coverage in Moorabool Shire is relatively poor as much of the land has been cleared for agriculture (**Map 5.4**).  Tree cover includes all woody vegetation greater than two metres in height and with a crown cover (foliar density) greater than 10 percent.  This definition provides for the identification of small patches of remnant tree cover which provide corridors and habitat for native fauna.

Map 5.4 Tree Cover and Old Growth Forests




## Environmental Significance

The natural environment within Victoria has been significantly disturbed since European settlement, due to practices such as extensive land clearing for agriculture, urbanisation, and the introduction of exotic species. This disturbance has resulted in the degradation of important ecosystems, habitat fragmentation, a decrease in biodiversity and the invasion of pest species.

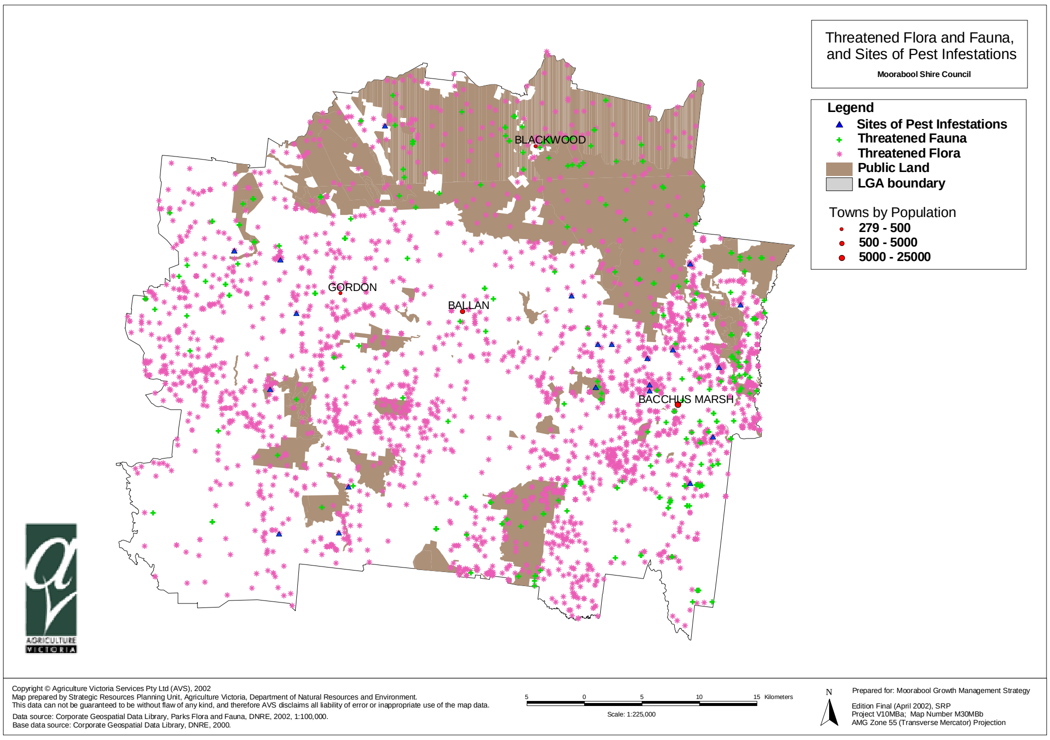
### Pest Infestation

The invasion of pest species is widespread throughout the Shire. **Map 5.5** shows a representation of sites where pest infestation have been reported. Pest species impact both on the environmental values and the productivity of a region. Pest species compete with native species for a share of nutrients, resulting in changes in the structure of an ecosystem. The environmental health of an area can also be impacted through a reduction in soil stability, decrease in biodiversity, reduction in water quality and a change in the vegetation structure. The infestation of agricultural areas with pest species results in decreased yields and land degradation.

### Threatened Flora and Fauna

The importance of protecting threatened fauna and flora has been recognised through a number of both State and Federal policies. These include the Flora and Fauna Guarantee Act (1988), Commonwealth Endangered Species Protection Act (1992), National Strategy for the Conservation of Australia's Biodiversity (1992) and the Planning and Environment Act (1987). These documents provide a policy framework for the conservation of biodiversity within Victoria. Sites containing threatened flora and fauna have been mapped across the Shire (**Map 5.5**).

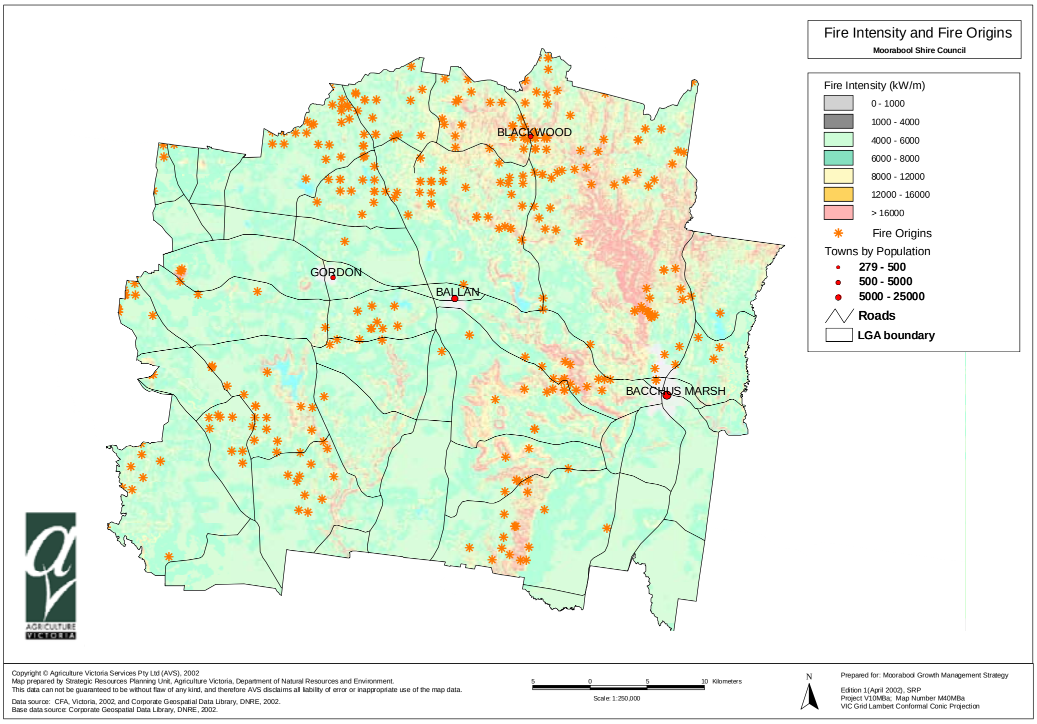
Map 5.5 Threatened Flora & Fauna, Pest Infestations, and Wetlands




## Fire Hazard

The potential for bushfires is a hazard that needs to be identified and managed. **Map 5.6** depicts fire origins of all fires recorded by the Department since July, 1972 and fire intensity based on vegetation, contours, water features, built up areas, and roads. Fire intensity is a measure of the destructive capabilities of fire and is calculated in terms of kilo watts of energy per metre of fire front. The Upper Werribee catchment, surrounding Bacchus Marsh, has the most severe intensity rating, extending NNW to Blackwood and SSW of Balliang.

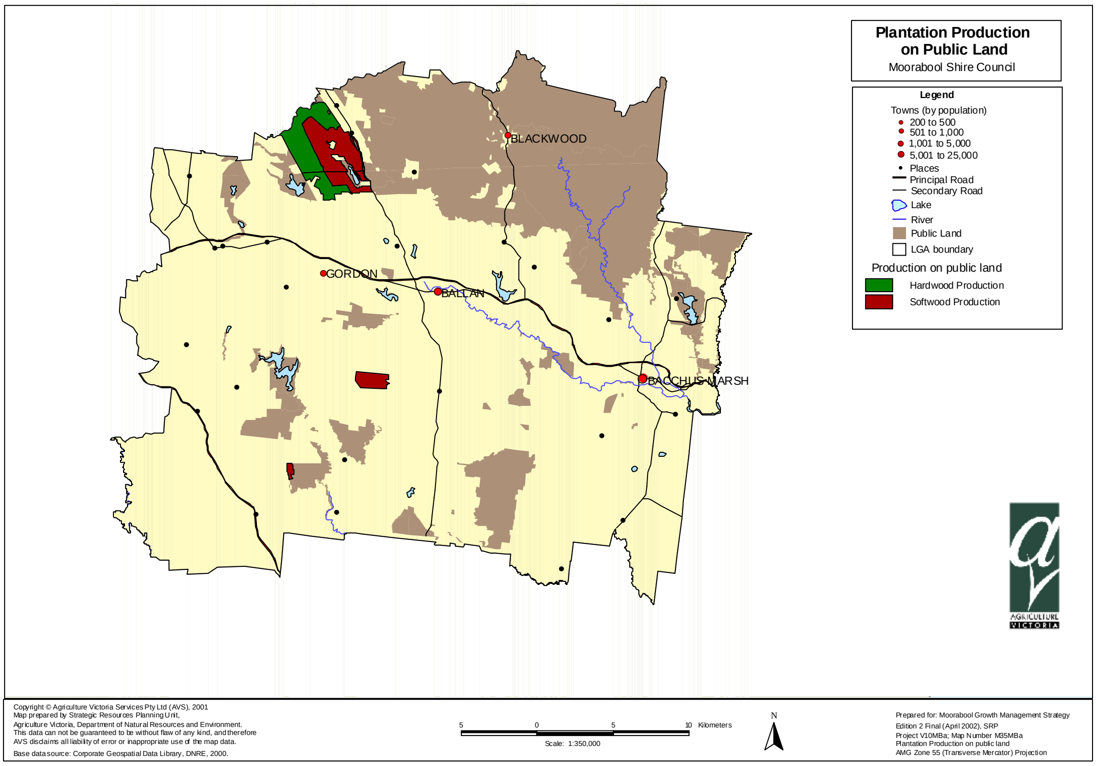
Map 5.6 Fire Intensity and Fire Origins



## 5.3 Forestry

Forestry production within the Moorabool Shire is based on a number of privately owned plantations and State forests (**Map 5.9**). Publicly owned native forests within Moorabool Shire are principally found in the Brisbane Ranges National Park, and the Lerderderg and Werribee Gorge State Parks. Isolated small areas of native forests also occur on freehold land. **Map 5.9** shows the distribution of hardwood (green) and softwood (red) plantations on public land in the Moorabool Shire. The native forestry resources in this area are part of the West Victoria Regional Forestry Agreement signed in March 2000, which aims to ensure sustainable management of native forestry resources.

Map 5.7 Hardwood and Softwood Plantation Production on Public Land



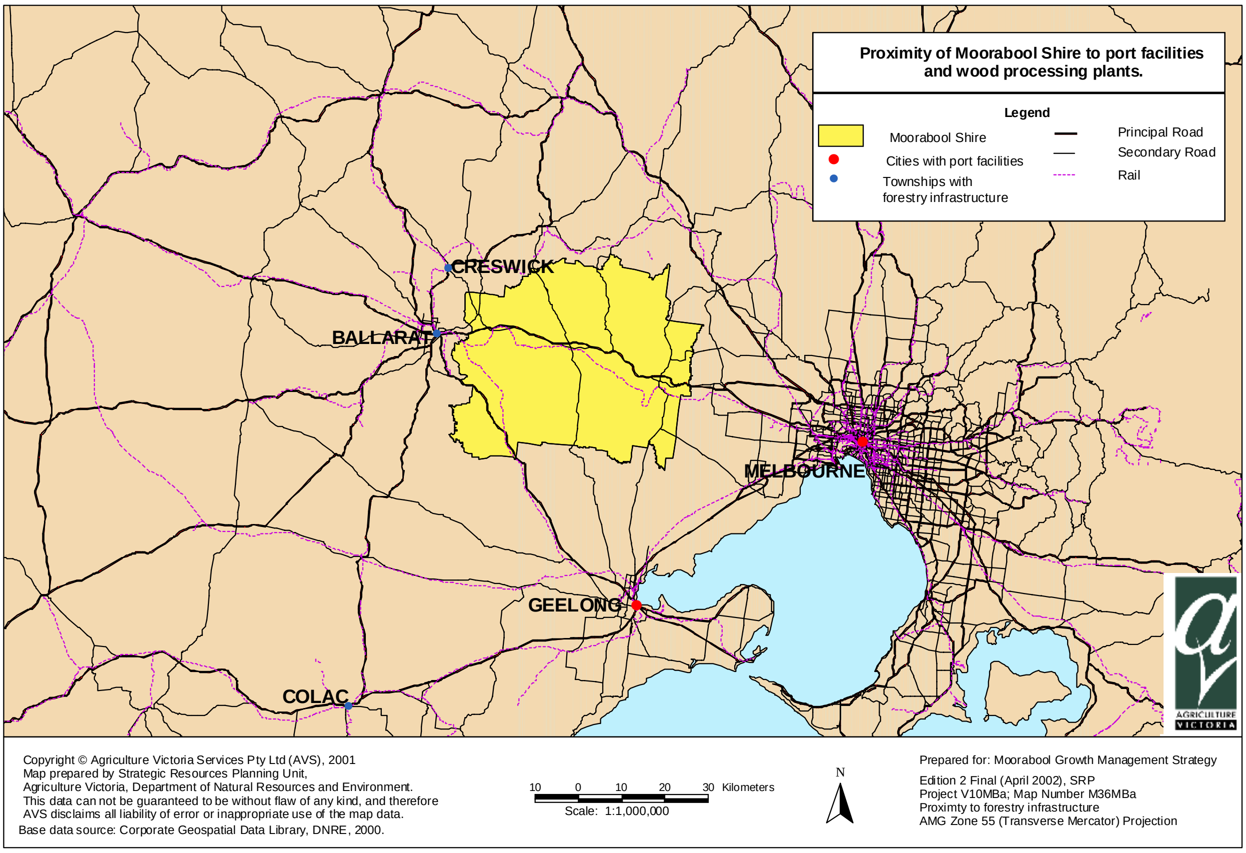

### Transport and Infrastructure Factors

Transport costs are a critical factor in determining the economic viability of a plantation, with an increase in haulage distance resulting in a decrease in profitability. Therefore the proximity of existing infrastructure, such as roads, port facilities and wood processing facilities is important in determining the potential for the development of commercial forestry. The forest industry is well serviced by infrastructure within the region (**Map 5.10**). Ports capable of handling timber and timber derived products are located at Melbourne and Geelong. Geelong is designed as a bulk handling facility for products such as logs, woodchips and sawn timber, while Melbourne Port can handle these products in addition to dealing with high value containerised products, such as paper, pulp and newsprint. The Moorabool Shire has a well-developed existing road and rail networks that are capable of meeting the requirements of the forest industry.

The wood processing industry is well established in the area, with major sawmills in the region located at Colac, Ballarat and Geelong. Processing facilities are also located within close proximity to the Shire, with a chipboard manufacturing plant in

Ballarat that utilises pulp, and pine woodchip export facilities that have recently been developed in Geelong.

Map 5.8 Proximity to Ports and Wood Processing Facilities




## Biophysical Suitability

The climate of the Moorabool Shire is broadly suited to the establishment of plantations (Chapter 4, **Map 4.9**). It should be noted, however, that this analysis was specifically for radiata pine and the suitability of an area will vary depending upon the species that are intended for the area. Species such as Blackwood and Tasmanian Blue Gum, for example, are sensitive to drought and therefore are only suited to the northern part of the Shire, which experiences relatively high rainfall. While the area around Bacchus Marsh which experiences low rainfall may only be suitable for the establishment of drought tolerant species, such as Sugar Gum (*Eucalyptus cladocalyx*).

Historically plantations in this region have been dominated by the softwood species Radiata Pine (*Pinus radiata*), in 1994 this accounted for 99% of the plantations. Over recent years there has been a shift to the production of hardwood species with 33% of the plantation area now made up of hardwood species. Tasmanian Blue Gum (*Eucalyptus globulus*) is the dominant hardwood species grown in the region. In the year 2000 there was a dramatic growth in the establishment of Tasmanian Blue Gums with an increase of 54 per cent from the previous five year period. The evidence of this change can be seen throughout the Moorabool Shire, with the establishment of extensive Tasmanian Blue Gum plantations in many areas. The demand for plantation hardwood is predicted to grow as the harvesting of hardwoods from native forests is reduced to sustainable levels. Plantation hardwood may provide a more reliable source of timber, as yields from native forests are subject to considerable political and environmental pressures.

Establishment of farm forestry has the potential to provide many direct benefits to existing agriculture in the Moorabool Shire. The economic benefits include an alternative income source to support existing agriculture, secondary benefits such as increased productivity of crops and pastures, and improved animal health can result from strategically placed planting that provide shelter effects. There are also a number of environmental benefits associated with the establishment of forestry on agricultural land. These include the management of salinity through the lowering of the water table, improvement of water quality and soil stabilisation. The Central Victorian Farm Plantation has promoted farm forestry in the Moorabool Shire through the release of a strategic plan that establishes a target of 5.2 per cent of privately owned agricultural land to be planted within the region. Farm plantations make up 13 per cent of the total plantation resource for this region.

The Moorabool Shire is well positioned to take advantage of the economic, social and environmental benefits associated with the establishment of commercial plantations for a number of reasons. Firstly, the proximity of the Moorabool Shire to an existing transport network, port facilities and wood processing plants. Secondly, the overall suitability of the climate and landscape of the Moorabool Shire to the production of plantation species, such as Radiata Pine, Tasmanian Blue Gum and Sugar Gum. Lastly, the industry is already well established in the area, which means both the infrastructure and expertise required in establishing plantations are readily available.

## 5.4 Salinity Risk

Rising groundwater and salinisation of land and water is an increasing problem in many southern parts of Australia. An estimated 2.5 million hectares of land has been affected by saline groundwater discharge, and the area is predicted to increase at least fourfold over the next three to four years (NLWRA, 2001b).

In many parts of Australia, clearing of perennial native vegetation for agriculture, such as grazing and cropping, has reduced the water uptake by deep rooted vegetation, and caused increased rainfall to infiltrate the ground water system. This causes the water tables to rise, bringing saline groundwater closer to the surface, concentrating salts in the soil as the water evaporates, and mobilising near surface salts already in the soil. The movement of salt to the land surface with rising groundwater on non-irrigated areas, is known as dryland salinity. The warning signs of land affected by dryland salinity include sick or dying trees, declining vegetation, the appearance of salt tolerant volunteer species, bare salt patches and saline pools in creek beds. Any of these can affect crop productivity, the sustainability of agriculture and the quality of water in rivers and streams (NLWRA, 2001a). Other impacts include:

- Agriculture – loss of productivity and yield.
- Land – degradation from soil erosion.
- Water – rising water tables brings naturally occurring salts to surface, eutrophication of streams, salting of drinking water and wetlands.
- Vegetation and biodiversity- loss of riparian vegetation, damage to flora and fauna habitats.
- Infrastructure – corroding salt damage to roads, foundations, infrastructure, and buildings.

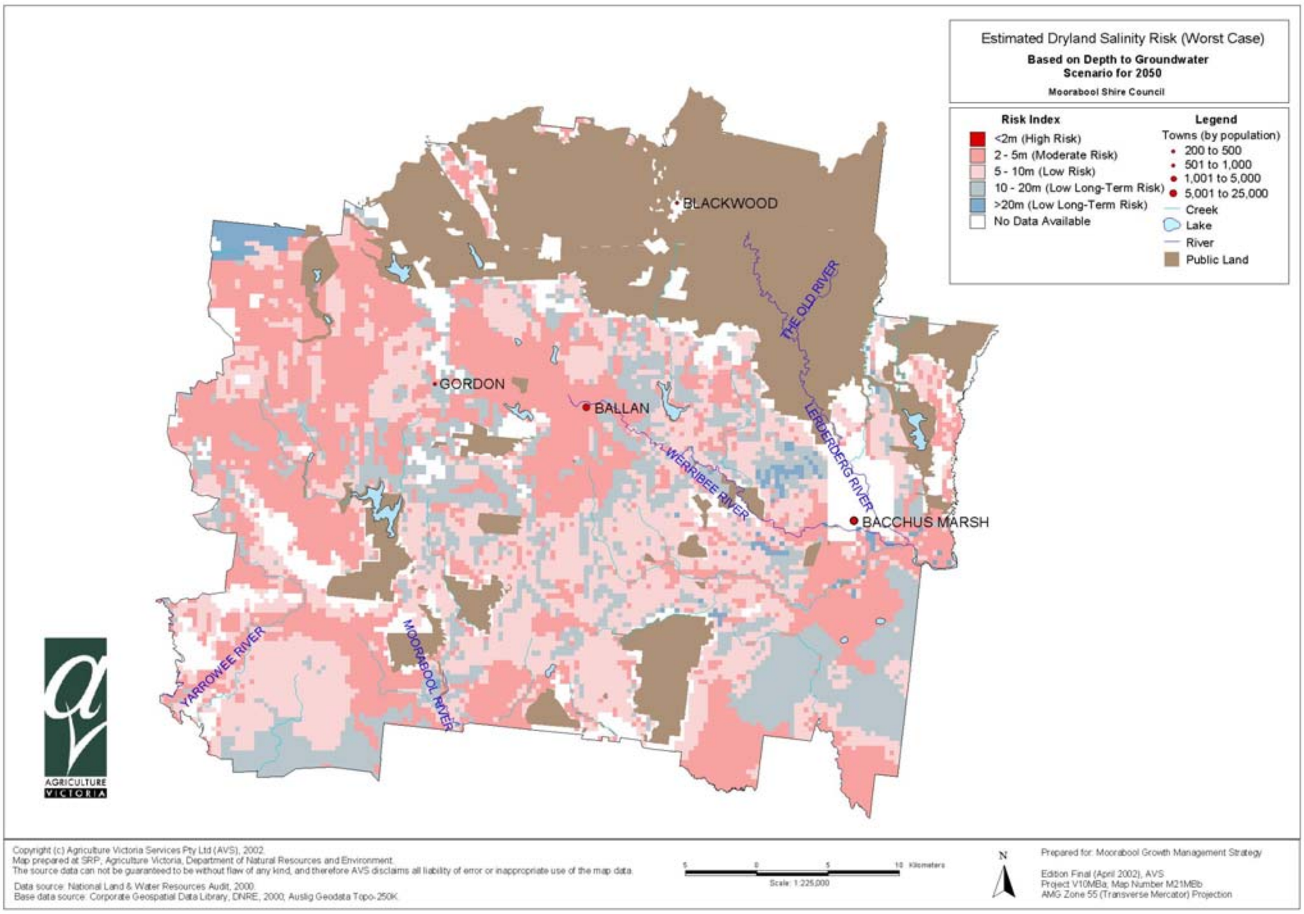
For appropriate management of dryland salinity, the extent of the groundwater flow systems contributing to dryland salinity and the processes that control groundwater recharge and discharge need to be understood. A number of key factors determine whether there is an excess of water in a catchment system and whether dryland salinity would occur, such as climate, land cover, salt stores, and hydrogeology.

## Dryland Salinity Risk

In Victoria the area predicted to be at risk from shallow saline watertables is approximately 670 000 ha. This could increase to over 3 million hectares within 50 years. Between 8% and 18% of the State's agricultural land is predicted to fall into the high salinity risk category, with up to a further 47% in the moderate risk category under the worst case scenario. High risk areas are concentrated in the Goulbourn-Broken and North Central regions in northern Victoria and the Glenelg – Hopkins and Corangamite regions of southern Victoria (NLWRA, 2001b).

**Map 5.11** shows the estimated potential dryland salinity risk in 2050 based on current watertable depths. Water table depths of less than 2 metres are considered to be of "high risk", as it approaches the root zone of most crops and pastures. The information is based on a 5-year historical trend analysis of bore levels in the state. Due to the higher than average rainfall in years 1989 – 1993, this information is regarded as the *worst case scenario*.

Map 5.9 Salinity Risk Scenario for 2050 (worst case scenario)




The Corangamite CMA Region is predicted to have 51 200 ha of land with shallow water tables in 1998. The worst case prediction for 2020 is 213 300 ha and by 2050 worst case scenario of 499 100 ha. Impacts on grazing land are greatest in the Glenelg Hopkins, Goulbourn Broken and Corangamite regions of the State. Potential impacts of shallow watertables and dryland salinity on physical infrastructure, particularly roads and rail, are predicted to more than double by 2050. These changes, particularly for the road network, would be expected to greatly increase the maintenance costs incurred by State and local government.

Wetlands in the Goulbourn-Broken and Corangamite regions are expected to be most affected, with over 40% of wetlands in each region predicted (in the worst case scenario) to be in landscapes with shallow watertables by 2050. The number of rare or threatened plant and animal species whose habitat is located in shallow watertable areas is expected to increase substantially: plant species from 122 to between 196 and 346 and animal species from 269 to between 317 and 485.

A two to three fold increase in the length of stream or perimeter of reservoir, lake or wetland located in areas of shallow watertable is predicted over the coming 50 years. Much of the increase is predicted for the Goulbourn and North Central regions, and under the worst case trend scenario, for the Glenelg and Corangamite regions. If realised, this change would result in increased groundwater discharge to streams and increased stream salinity.

### Irrigation Salinity

Excessive irrigation and poor drainage cause waterlogging and local salinity problems. *Victoria's Salinity Management Framework – Restoring Our Catchments* (DNRE, 2000) provides an outline of Victoria's progress in the management of salinity since 1988 (year of publication of the previous strategy) and establishes directions and targets to guide action in the future. Recent groundwater and catchment modelling and research indicates that many grazing and cropping systems recharge greater amounts to watertables compared to native vegetation. These findings highlight the need for substantial land use change.

### Contribution of Groundwater Flow Systems

A catchment's hydrogeological characteristics determine its capacity to accommodate and transmit infiltrating water. When the transmissivity of the aquifer is such that the increased volume of recharge cannot flow through the aquifer, new flow directions will result, with a corresponding change in the pattern of discharge. Land or stream salinity will occur where the discharged groundwater is saline.

Dryland salinity in eastern Australia is most common within the fractured Paleozoic rocks of the Dividing ranges along the eastern and south-eastern seaboards. The Paleozoic rock consists of blocks of three fundamentally different types - metamorphosed sedimentary sequences of sandstone, siltstone, and shale. The fractured sedimentary rock aquifers comprise the most common and significant groundwater systems causing dryland salinity in the Paleozoic rocks in the uplands of South Eastern Australia in both NSW and Victoria.

**Map 5.12** shows the distribution of the groundwater flow systems that contribute to dryland salinity, mapped nationally by the NLWRA. Within the Moorabool Shire, dryland salinity is associated with the Palaeozoic rocks, and the Cainozoic and Mesozoic sediments and volcanics. The groundwater flow systems include the intermediate, local and regional flow systems. The dominant hydrogeological province is a local flow system in Paleozoic rocks and Mesozoic volcanics. The Paleozoic rocks have a high salt storage, and are heavily fractured and deeply weathered as a result of compression and age. The weathered terrain and abrupt changes in slope cause the discharge of saline aquifers at the breaks in slope into the lower landscapes.

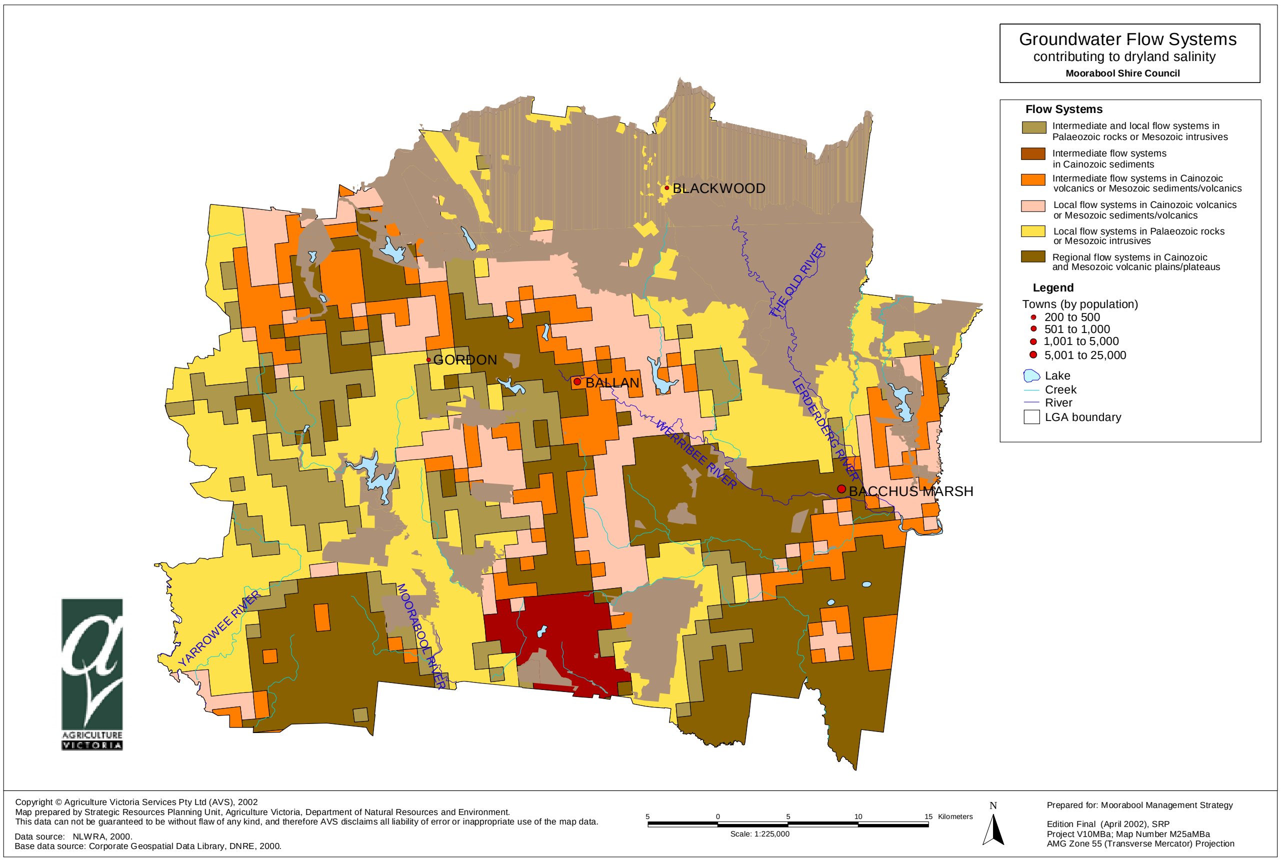
Regional flow systems are aquifers greater than 50 kilometres in distance and over 300 metres in thickness, and occur in the Cainozoic and Mesozoic volcanics (See **Map**

**5.12**). The volcanics make up the basalt plains of western Victoria and form the plains, plateaus and scoria cones in the Moorabool Shire. Extensive fractures in the volcanic rock were caused from rapid cooling of the basalt lava. These form networks of fractures that connect to act as a conduit transmitting groundwater flows catchment wide.

Intermediate flows occur within catchments and are in the Cainozoic sediments in the central south of the Shire. These are comprised of extensive non-marine silts, sands, gravels and some minor marine limestone and clays. The extent of dryland salinity and regional discharge in the Cainozoic sediments is controlled by the rock type and its characteristics, and the structure or topography of the plains. Sand and gravel enhance the movement of groundwater and transmit fluids as a thick interconnected aquifer.

Local flow systems may cause discharge and recharge within a few kilometres, and tend to occur within subcatchments and at the foothills of ranges (NLWRA, 2001b and c). A local flow system occurs in the Cainozoic volcanics and Mesozoic sediments/volcanics. The Mesozoic sediments are fine grained and of a low permeability, thus the aquifer establishes a local flow system. Most of the salinity that occurs is associated with the marine clays (NLWRA, 2001b). Coarse grained colluvium deposited around the granitic intrusions act as an aquifer and usually cause recharge on the mid to lower slope.

Map 5.10 Groundwater Flow Systems




## Management Dryland Salinity

Appropriate management of dryland salinity requires knowledge about the extent of the groundwater flow systems contributing to dryland salinity and the processes that control groundwater discharge. Groundwater flow systems that contribute to salinity can vary from local systems of less than a few kilometres, which can be managed through the efforts of a small number of landholders, to vast regional systems of hundreds of kilometres which would require the co-ordinated efforts of many communities for amelioration.

The *Victoria's Salinity Management Framework – Restoring Our Catchments* (DNRE, 2000) provides an outline of Victoria's progress in the management of salinity since 1988 (year of publication of the previous strategy) and establishes directions and targets to guide action in the future. It is mentioned that recent groundwater and catchment modelling and research indicates that many agricultural production practices in grazing and cropping systems cannot reduce the amount of water leaking into the groundwater systems (leading in turn to salinisation) in comparison to native vegetation. These findings highlight the need for substantial land use change (DNRE, 2000).

The management options for dryland salinity are summarised in the table below according to the various groundwater flow systems seen in **Map 5.12**. The management strategies are derived from the NLWRA (2001c) report and Walker, Gilfedder & Williams (1999).

Table 5.4 Hydrogeological Provinces and Management

| Flow System | Hydrogeological Province | Management Strategy |
|---|---|---|
| Regional flow systems in Cainozoic and Mesozoic volcanic plains/plateaus | Regional discharge controlled by topography and structure | Large scale plantation forestry for the pulp wood industry;<br>Large-scale dryland salinity processes and implies inherent difficulties for effective farm based catchment management strategies aimed at dryland salinity mitigation. |
| Intermediate and local flow systems in Palaeozoic rocks or Mesozoic intrusives | Intermediate discharge form unweathered fractured rock aquifers at break of slope; and intermediate discharge in valley floors | Revegetation/reafforestation of upper catchment using perennial pastures, native pasture and native trees;<br>Groundwater pumping in agriculture and saline aquaculture;<br>Large scale dryland salinity processes and implies inherent difficulties for effective farm based catchment management strategies aimed at dryland salinity mitigation |
| Intermediate flow systems in Cainozoic volcanics or Mesozoic sediments/volcanics | Discharge controlled by structure and topography | Catchment management strategies due to large scale dryland salinity processes;<br>Large scale plantations for pulpwood industry;<br>Large scale dryland salinity processes require catchment wide management strategies |
| Intermediate flow systems in Cainozoic sediments | Discharge controlled by facies change | Saline agriculture;<br>Catchment wide management strategies aimed at salinity mitigation |
| Local flow systems in Cainozoic volcanics or Mesozoic sediments/volcanics | Local discharge over low(er) hydraulic conductivity structures; and local discharge controlled from stratigraphy | Large scale dryland salinity processes require catchment wide management strategies;<br>Groundwater pumping may control groundwater levels in areas where groundwater flow is tolerable of for irrigation;<br>Modification of catchment water balance using surface drainage, perennial pastures and native hardwood plantations |
| Local flow systems in | Local discharge over | Farm based catchment management |

| Flow System | Hydrogeological Province | Management Strategy |
|---|---|---|
| Palaeozoic rocks or Mesozoic intrusives | low(er) hydraulic conductivity structures; and local discharge from unweathered rock aquifers at break of slope | strategies; Revegetation/reafforestation of steeper hill slopes; Groundwater pumping where salinity is low; Modification using surface drainage, perennial pastures, and native hardwood plantations |

In agricultural areas where dryland salinity is considered a high risk, a number of land use options for managing salinity are available and Walker, Gilfedder, Williams (1999); they include:

- replacement of (annual) pastures with those based on perennial species such as lucerne and phalaris;
- revegetation and salt tolerant plantations in the most leaky parts of landscapes and in special locations in particular landscapes (e.g., at the break of slope in some areas of granitic geology);
- improved crop management to increase the efficiency of conversion of growing season rainfall into grain; and
- the use of perennial species in the ley pasture phase of crop rotation or native hardwood plantations.

The NLWRA recommends practices such as engineering works and revegetation to mitigate salinity, given that local flow systems tend to respond rapidly to management practices (NLWRA, 2001b). For the regional flow systems set out in **Map 5.12** however, farm based management strategies are not as effective and region wide catchment strategies are essential.

## 5.5 Flood Data and Planning

Within many parts of Victoria and the Moorabool Shire, natural processes of upstream erosion and downstream deposition of alluvial material have resulted in many waterways being perched above their floodplains. The cleared land use for agriculture is contributing to deterioration in the natural riverine, floodplain, and estuarine environments. A characteristic of such systems is a generally low river capacity, resulting in frequent overtopping of natural levee banks (SKM, 1999). In the past, many of these rivers have been subject to "river improvement" activities to improve their capacity to convey flood flows. Such activities include de-snagging, artificial levees, channel widening, and channel straightening. The effect of these activities has been to reduce flood attenuation and increase peak flows and in-stream erosion. These impacts must be balanced against the benefit to some landholders in flood mitigation and drainage improvements.

The main river systems within the Moorabool Shire are Werribee River; Lerderderg River; Moorabool River; Maribyrnong River (northern extent); Yurrong River (northern extent); and Old River.

### Floodways and 1% Annual Exceedance Probability Flood Extent

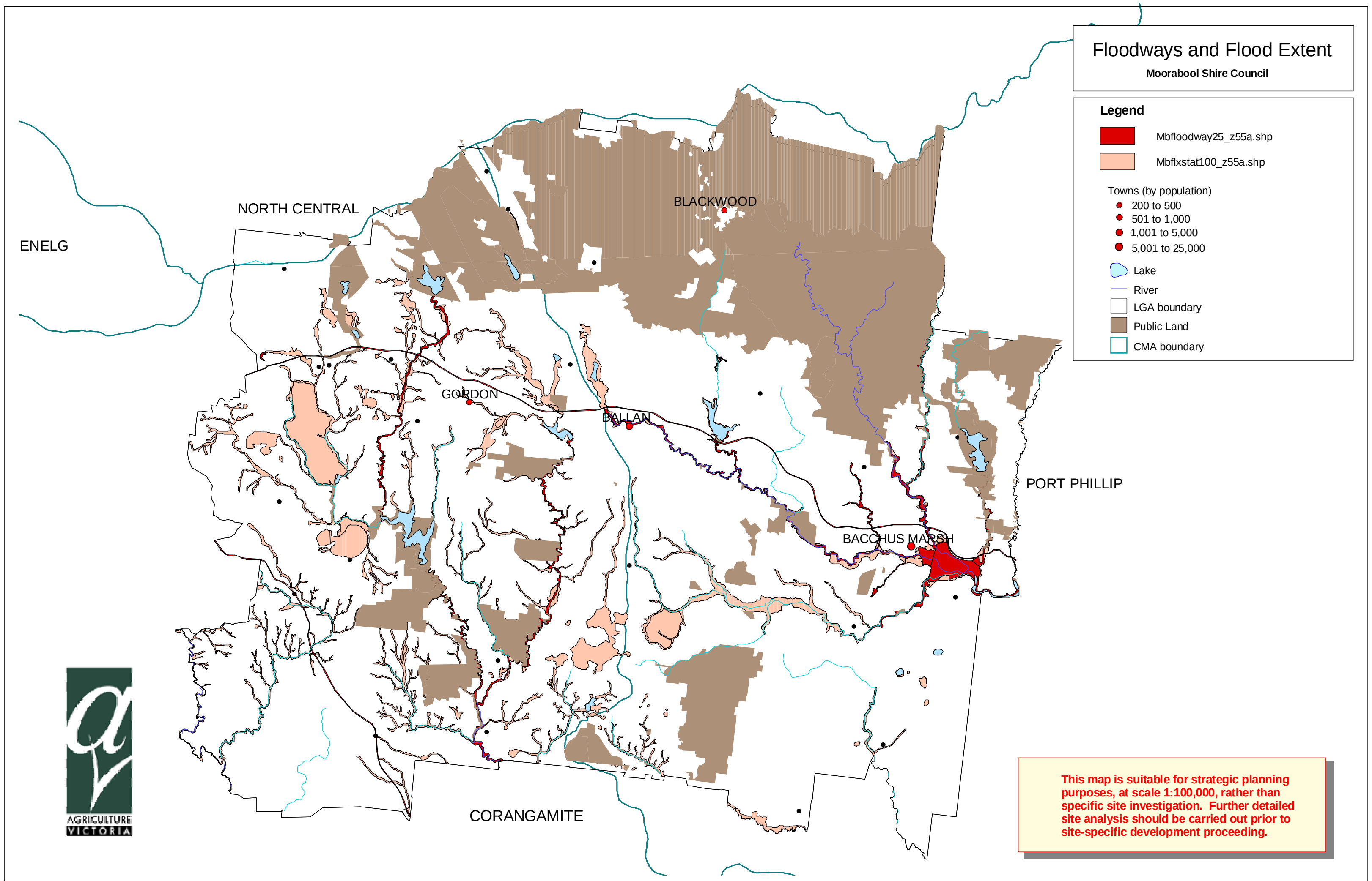
Floodways generally comprise the most hazardous parts of the floodplain and are often associated with fast flowing floodwater and/or areas of relatively deep flooding (SKM, 1999). The floodway data in **Map 5.13**, shown as a striped pattern, delineates interpreted floodways in Moorabool Shire.

The 1% Annual Exceedance Probability (AEP) represents the probability of a single flood event in one hundred years, and delineates the areas likely to be inundated through statistical modelling. The flood data maps provide a record of all past mapping and known problem areas and should only be used for identifying the location of past flood problem areas (EGIS, 2000). This data is based on hydrological modelling and mapping, and will be used in the revision and development of Shire Planning Scheme overlays. The flood extent data, shown in pink on **Map 5.13**, has similar extents to the floodways in Moorabool.

### Planning

The AEP Flood extent will be the basis for subsequent declaration of the Land Subject to Inundation Overlays (LSIO) and planning controls under the Victorian Planning Provision (VPP). LSIO identify flood prone land where the flood risk is not considered sufficient to denote a floodway or where there is insufficient information to define the floodway. Similarly, the floodway extents should be used for determining Urban Floodway Zones and Rural Floodway Overlays under the VPP. The criteria to delineate floodways and flood extents is in accordance with the Advisory Notes for Guidelines for Delineating Floodways (Edwards, 1998), which incorporated flooding characteristics, socioeconomic and environmental factors.

## Map 5.11 Floodways and 1% Annual Exceedance Probability





Map prepared by Strategic Resources Planning Unit, Agriculture Victoria, Department of Natural Resources and Environment.

Data source: DNRE, Floodplain Management Unit, 2002; data at scale 1:25,000.
Base data source: Corporate Geospatial Data Library, DNRE, 2000.

5 0 5 10 15 Kilometers
Scale: 1:225,000

N

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AMG Zone 55 (Transverse Mercator) Projection

## 5.6 Erosion Risk

Soil erosion is a natural geological process that occurs without human intervention. However, disturbance of the land through human activity may accelerate soil erosion, especially where these activities remove the vegetation cover from the soil (Cooke and Doornkamp, 1978). Native vegetation forms a protective layer for the soils. When this is removed, soils become exposed and are at risk to water and wind erosion. The aim of this investigation is to determine the risk of the soils to erode as a result of water and wind movement. Types of accelerated soil erosion that may occur across the Shire include; sheet, rill, tunnel, gully, stream bank, and landslips.

Loss of soil due to erosion can have significant on site and off site effects. On site effects include the loss of the topsoil; the soil layer that contains nutrients vital to plant growth. This loss of topsoil reduces rooting depth and reduces water infiltration of the soils; which may then make soils more prone to erosion. Off site effects may include damage to fences; restriction of farm traffic; clogging of irrigation systems, waterways and reservoirs by eroded materials; damage to aquatic systems by silt build up; and excess of nutrients in water bodies.

It is important to note that erosion risk not erosion hazard is being assessed. Erosion hazard is a measure of soil loss (expressed in tonnes/hectare/year) and considers not only soil factors but also land use and land management practices, which are not used in assessing inherent soil erosion risk. As illustrated in Maschmedt (2000) a steep well grassed hill slope has a high erosion risk due to its slope, however has a low erosion hazard due to good management practices maintaining a protective vegetation cover.

### Water Erosion Risk

The inherent risk of soils eroding as a result of water movement has been determined by the topographical and soil characteristics that influence the soils ability to resist detachment and accept rain water. Factors that were considered in assessing inherent water erosion risk are in **Table 5.4**.

The other significant area for soil erosion to occur is along active watercourses. All watercourses within the Shire are prone to stream bank erosion if their banks do not have adequate vegetation cover. **Map 5.14** shows that the highest risk areas occur between the towns of Bacchus Marsh, Fiskville and Rowsley, and along sections of the Werribee and Lerderderg Rivers.

Tunnel erosion is caused by stormwater runoff moving through underground channels resulting in the removal of subsurface soils (Boucher, 1990). Gullies are formed when these tunnels further erode and ultimately break through to the surface. Boucher notes that the management of tunnel erosion is complex due to locating the source of the tunnel erosion, mechanics, and soil characteristics. **Map 5.14** shows the greatest risk of tunnel erosion occur on steep, cleared, sodic duplex soils, with an annual rainfall of >500 mm (Boucher, 1990).

Table 5.5 Topographical and Soil Factors Used to Assess Water Erosion Risk

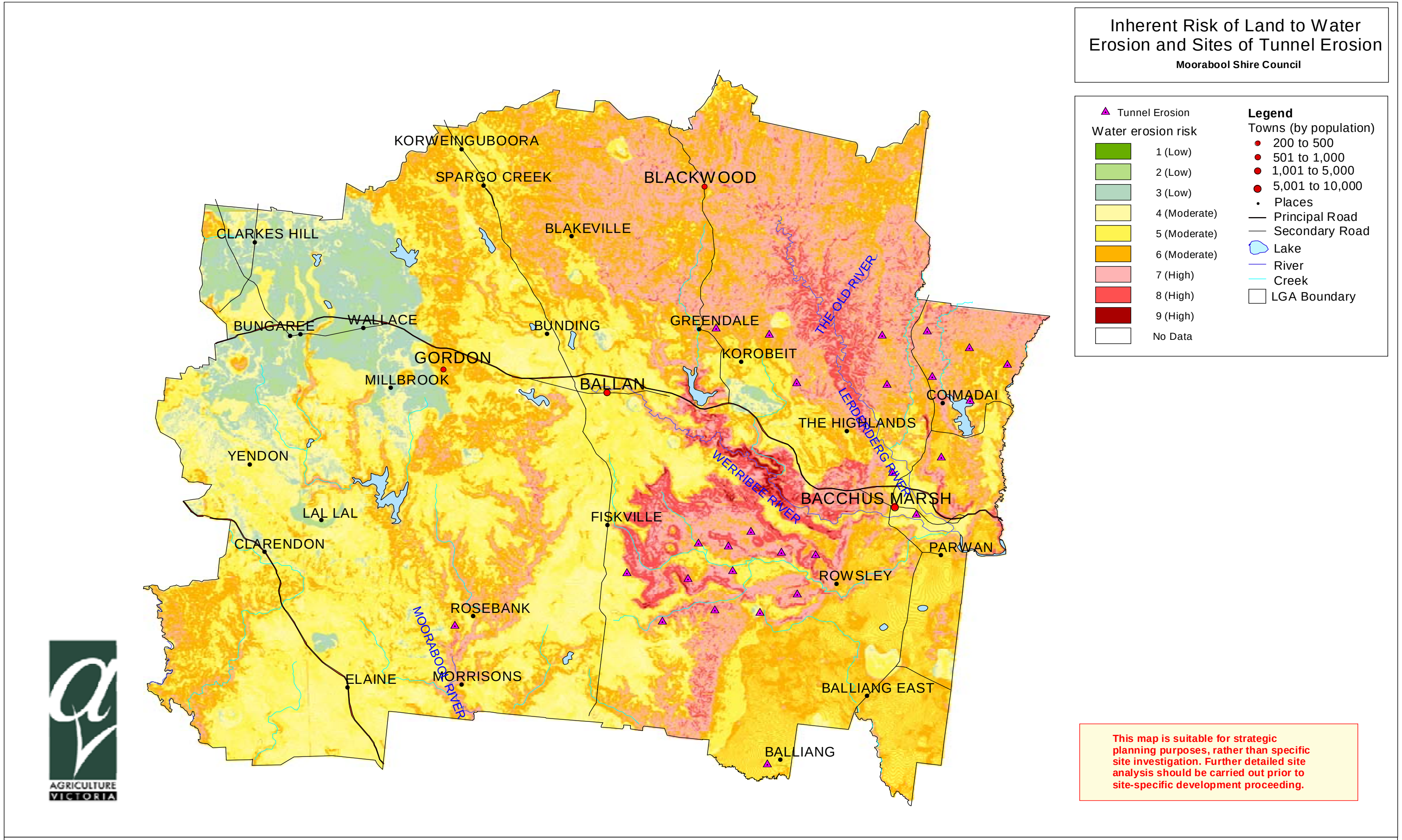
| | |
|---|---|
| Slope | Influences water run off velocity, sediment transport and potential for land slips to occur, the greater the slope the higher erosion risk. |
| Permeability | Measure of the soil's ability to transmit water and influences the capacity for the soil to absorb rainwater. Less permeable soils have higher erosion risk as occurrence of surface run off can increase. |
| Drainage | Estimate of local soil wetness condition, and affects the capacity for the soil to absorb water. Imperfectly and poorly drained soils increase erosion risk due to the potential for increased surface run off. |
| Depth to impeding layer | Depth of soil above a layer that may impede or restrict water movement. This layer is usually the clay subsoil but can also include hard pans, rock etc. Soil erosion risk increases where soils above this layer are shallow (<25 cm), as potential for surface run off increases. |
| Surface texture | Texture of the soil influences the capacity of the surface soil to resist detachment due to raindrop impact. Sands and silts generally detach more easily than loams and clays due to their low coherence. |
| Sub soil texture | The texture of the subsoil is important when considering tunnel and gully erosion. Clayey subsoils, particularly if unstable can disperse and therefore soil erosion risk increases. |
| Subsoil sodicity | Sodicity causes clay particles in the soil to disperse when they come in contact with water. Sodic soils have little strength when wet and are prone to gully and tunnel erosion. |
| Depth to B horizon | Depth of soil above potentially dispersive subsoils. The greater the soil depth above the B horizon reduces the risk for the B horizon to be exposed to raindrop impact. |

**Source:** MacDonald *et. al.*, 1990; Maschmedt, 2000; Wells, 1998.

## Management of soils at risk to erosion

To reduce the risk for soils to erode management practices that focus on maintaining a protective vegetation cover for the soil should be implemented. Maintaining vegetation cover may require fencing off areas at risk to erosion and reducing the impact of stock and vehicular traffic in these areas. Other management options include contour banking, strip cropping, minimum tillage, wind breaks, correct orientation of crop rows or beds, rapid reforestation after plantation harvesting, and planting vegetation in the riparian zone of major watercourses and along coastal dunes.

# Map 5.12 Inherent Risk of Land to Water Erosion






Data source: Soils and DEM data from Agriculture Victoria, DNRE, 2001. Boucher (1990) Commission for Environment (1992).
Base data source: Corporate Geospatial Data Library, DNRE, 2001; Auslig Geodata Topo-250K.

5 0 5 10 15 Kilometers
Scale: 1:225,000

N

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Model No. SoilErosionRisk
AMG Zone 55 (Transverse Mercator) Projection

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