FUTURE LANDSCAPES

BACKGROUND REPORT

Ballarat Biodiversity Action Plan 2016

REGIONAL AGRICULTURAL AND BIODIVERSITY CLIMATE ADAPTATION AND OPPORTUNITIES PLAN

CITY OF BALLARAT

WITH FUNDING FROM:
State Government Victoria Department of Environment, Land, Water & Planning
cultivate agribusiness
CERRF CENTRE FOR REGIONAL AND RURAL FUTURES
DEAKIN UNIVERSITY

City of Ballarat

Biodiversity Action Plan

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This Plan was developed as part of Stage 1: Background research, climate scenario modelling and adaptation planning of the Future Landscapes Project, which was collaborative project with Hepburn Shire, Golden Plains Shire, Pyrenees Shire, Moorabool Shire, City of Ballarat and Cultivate Agribusiness Central Highlands Inc.

Executive Summary

The *Ballarat Biodiversity Action Plan 2016* aims to strengthen the capacity of the people of Ballarat to protect, enhance and restore biodiversity across the City, under the significant threats of land use change and climate change. The Strategy was developed based on local environmental context, evaluation of biodiversity assets, climate-change modelling for key ecosystems, focal areas for conservation of key ecosystems, known threats to biodiversity, community and stakeholder engagement and alignment with existing biodiversity strategies.

Ballarat City contains approx. 35,440 ha of native vegetation, which covers 17.7% of the region, and there are at least 489 native plant species and 217 native animal species. Strategic areas for biodiversity conservation included the extensive areas of Dry Forest to the east of Ballarat, the wetlands of Lake Burrumbeet, Lake Learmonth and Lake Wendouree, and the Hills Herb-rich Woodlands around Mount Bolton. The community recognised Canadian Forest, Mount Clear and Yarrowee River as some of the significant areas for biodiversity conservation in the City.

Climate modelling predicted that future climates will be a) adverse for Dry Forests but to a lesser extent in the eastern ranges, b) moderate for Riparian Forests but they are likely to be affected by changes to stream flow and ground water, and c) moderate to favourable for Plains Grassy Woodlands. Accounting for climate change, potential focal areas for future biodiversity conservation include the Dry Forests to the east of Ballarat.

Important threats that need to be managed to improve the chances of maintaining biodiversity under climate change include habitat fragmentation, land-use change, pest plants and animals, altered fire regimes and changed hydrology. Community and stakeholder engagement provided valuable insight into the threats to biodiversity, their concerns about biodiversity, information needs of the community, current biodiversity activities and potential actions to improve biodiversity in the City.

The Biodiversity Strategy for Ballarat City has seven key components:

1. Protect native ecosystems from clearance across the City.
2. Increase the understanding of biodiversity values and threats amongst the community.
3. Create ‘Environmental Zones’ around strategic areas where threats to biodiversity are managed and revegetation is used to buffer, extend and link existing remnant vegetation.
4. Within Focal Areas (strategic and favourable future climate), restore historical ecosystems and plant historical dominant species.
5. Within Strategic Areas (strategic but adverse future climate), recreate the ecosystem structure with resistant local species.
6. Within Favourable Areas (favourable future climate but low strategic value), restore historical ecosystems and plant historically-dominant species.
7. Within Marginal Areas (low strategic value and adverse future climate), recreate the ecosystem structure with ‘climate ready’ species.

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1. Introduction

Biodiversity is integral to our lives today and for future generations. Like plants and animals, we are fundamentally reliant on the resources that native ecosystems provide and regulate – water, food, energy and shelter. To increase production of food and fibre, humans have converted extensive areas of native ecosystems to production systems. Today native ecosystems exist as highly-fragmented remnants in varying states of degradation. In this depleted and degraded state, native ecosystems will face the substantial additional challenge of a rapidly changing climate.

The *Future Landscapes Project* was initiated to provide Councils of the Western Central Highlands - Ballarat City, Hepburn, Moorabool, Pyrenees and Golden Plains Councils - with the capacity to adapt their planning and decision making given climate change predictions for the region. The project aimed to develop a strategic approach to management of land use (both native and production systems) under future climates across the region and within the separate jurisdictions. The *City of Ballarat Biodiversity Action Plan 2016* (presented here) was developed as part of the project. The intended outcome of this process is a coordinated and cost-effective approach to biodiversity planning, management and restoration across the region.

VISION

The vision for biodiversity in the City of Ballarat is:

1. To improve the biodiversity values of Ballarat City for future generations.
2. To support a well-informed community to actively protect biodiversity within Ballarat City.

AIM

The aim of the Ballarat Biodiversity Action Plan 2016 is to:

strengthen the capacity of the people of Ballarat to protect, enhance and restore biodiversity across the City, under the significant threats of land use change and climate change.

SCOPE

The strategy is designed to improve biodiversity values across Ballarat and, therefore, predominantly considers land not managed by the Council. It recognises the limit of the Council's operation, management and planning responsibilities. Consequently, there is an emphasis on the Council working with other government organisations and community groups to achieve biodiversity outcomes. However, the Council has an important role in educating the community about the

importance of biodiversity and providing information on how individuals can protect and improve biodiversity on their land.

2. Approach used to determine the strategy

To develop a strategy to *protect, enhance and restore biodiversity across the City, under the significant threats of land use change and climate change* we used the following sources of information.

1. Local environmental context.
2. Evaluation of biodiversity assets.
3. Climate-change modelling for key ecosystems.
4. Classification of the City into focal areas for conservation of key ecosystems.
5. Known threats to biodiversity.
6. Community and Stakeholder engagement.
7. Existing biodiversity strategies.

Local context for biodiversity involved compiling an overview of biodiversity in the City, the current status of different biota and our understanding of the needs of this biota. This information was drawn from published literature and reports, and databases.

Biodiversity assets (i.e. significant areas for biodiversity conservation) were evaluated both quantitatively using the DELWP product *NaturePrint* and qualitatively based on engagement with the community. *NaturePrint v2.0* provides an assessment of the strategic value or contribution of patches of native vegetation to the protection of the range of plants and animals found in Victoria (DSE, 2013). It combines modelling of species distributions and habitats, the condition of these habitats, pathways for connectivity across landscapes, potential for restoration, and threats to species persistence. As this strategy is for the people of Ballarat, it was important to engage with the community to understand which areas people valued and where there was active conservation.

Climate modelling is fundamental to any strategy for future conservation of biodiversity. Specifically, we needed to understand the likely impacts of climate change on the viability of native ecosystems in the City. Understanding the response of the full range of plants and animals is not possible with our current limited knowledge of the biology of most species. We used the pragmatic approach of predicting the responses of key ecosystems, with the assumption that the species dependent on these ecosystems would respond in a similar way. The project group decided to focus on the four

dominant ecosystems across the project region, of which three are found in Ballarat – Dry Forests, Riparian Forests and Plains Grassy Woodlands (Table 1). The responses of these three ecosystems were used as case studies to illustrate the effects of climate change on different types of native ecosystems and, therefore, inform strategies to buffer all native ecosystems against the changing climate.

Predicting the response of the key ecosystems to climate change involved three stages. First, models were built that could predict the current probability of occurrence of an ecosystem across the region based on twelve climatic and soils variables (Table 2). Second, the future probability of occurrence was predicted by inputting climate variables from projected climate scenarios to the models while keeping the soil variables constant. The current predictions for climate in Australia under the high emissions scenarios for 2030, 2050 and 2070 (Bi et al., 2013) were used in separate modelling runs. The high emission scenarios were chosen as Australia is unfortunately tracking the climate changes of this scenario. Last, as there was reasonable variation in probabilities of occurrence for ecosystems spatially and temporally, the 'median suitability' of future climate for an ecosystem was calculated from the median probability over the four periods (current, 2030, 2050 and 2070) to summarise how suitable the future climate will be for an ecosystem.

Focal conservation areas for the key ecosystems were classified by considering the strategic value for biodiversity conservation and the predicted impact of climate change for an area. The strategic value of native vegetation was quantified using the *NaturePrint v2.0* layer. The predicted impact of climate change was estimated from the median suitability value. Values from these two layers were range standardised (0-1) and then each layer was classified into low (0-0.5) and high (0.51-1.00). Using the strategic values and median sutiability, land across the City was classified in 'Focal Areas' (high strategic value, favourable climate), 'Strategic Areas' (high strategic value, adverse climate), 'Favourable Areas' (favourable climate, low strategic value) and 'Marginal Areas' (low strategic value, adverse climate).

Known threats to biodiversity besides climate change needed to be considered to ensure the success of the strategy. The future viability of native ecosystems will increase with each threat that is reduced. The Strategy was informed by current understanding of the approaches to minimise the impact of important threats.

Community engagement was crucial to designing a strategy that meets the biodiversity needs for the Council and the people of Ballarat. It was essential to understanding the City-specific aspirations, threats and conservation activities for biodiversity in the area. A community workshop was held at the Ballarat Town Hall where members of the public, community groups and government organisations were invited to voice their views on biodiversity in the City. Attendees were subsequently updated on the project's progress and were asked to encourage others to communicate their views to the project team. The understanding obtained from these exchanges helped guide us towards a strategy that reflected the community's needs for biodiversity conservation.

Existing biodiversity strategies developed for the region by government organisations or community groups (e.g. Landcare) were reviewed to aid alignment between this and other plans, and to learn from previous efforts and thinking. The intention was to facilitate collaboration among natural resource managers and increase the success of regional conversation of biodiversity.

Table 1 Ecological vegetation classes (EVCs) that define the Ecosystems used in the climate modelling for Ballarat City.

Ecosystem	Component EVCs
Dry Forest	20 Heathy Dry Forest
	21 Shrubby Dry Forest
	22 Grassy Dry Forest
Riparian Forest	18 Riparian Forest
	56 Floodplain Riparian Woodland
	68 Creekline Grassy Woodland
	83 Swampy Riparian Woodland
	164 Creekline Herb-rich Woodland
	198 Riparian Woodland
	641 Riparian Woodland
Plains Grassy Woodlands	55 Plains Grassy Woodland
Plains Grasslands	132 Plains Grassland

Table 2 Environmental variables used in the current and future ecosystem distribution models.

Environmental variable	Description
Climate (mean value 1961-1990)	
Mean annual rainfall	
Hot season rainfall	Total rainfall between December and March
Maximum temperature of warmest month	Maximum temperature in February
Minimum temperature of warmest month	Minimum temperature in February
Minimum temperature of coldest month	Minimum temperature in July
Soils	
Subsoil clay	Clay content of 10-30 cm soil layer
Regolith depth	Depth to bedrock
Total N in topsoil	N concentration in 0-10 cm soil layer
Total C in topsoil	C concentration in 0-10 cm soil layer
CEC in topsoil	Cation exchange capacity in 0-10 soil layer
Electrical conductivity in topsoil	Estimate of soil salinity in 0-10 cm soil layer
Available water content in topsoil	Water content in 0-10 con soil layer

3. Findings

3.1 Local environmental context

Ballarat City contains approx. 35,440 ha of native vegetation, which covers 17.7% of the region (Fig. 1). Like many agricultural areas around regional centres in Victoria, there has been substantial historical clearance of vegetation as the town expanded. Native vegetation has been replaced predominantly by mixed farming and grazing, with several areas of forestry.

The native vegetation of the City supports a rich biodiversity. There is an estimated total of 489 native plant species and 217 native animal species (Viridans, 2016), with many more likely to be found with an extensive survey. Of these species, 14 plant and 39 animal species are rare or threatened. There are at least 24 eucalypts, 22 acacias, 61 orchids, 61 peas, 88 Asteraceae, 121 grasses, 23 mammals, 191 birds, 12 reptiles and 9 amphibians. Significant species include Yarra gum (*Eucalyptus yarraensis*), brush-tailed phascogale (*Phascogale tapoatafa*), powerful owl (*Ninox*

(Rhabdoglaux) strenua) and growling grass frog (*Litoria raniformis*). Unfortunately, the native species compete with around 309 weeds and 18 introduced animals.

Historically (1961-1990), mean annual maximum temperature across the area ranged from 16.6 ^{o}C to 18.6 ^{o}C. The mean annual rainfall ranged from 630 to 865 mm yr^{-1}, with higher rainfall around Mount Bolton and Chapel Flat. Soils are predominantly loams with large areas of clay loams and some areas with sandy loams. The area includes the headwaters of Burrumbeet Creek and Yarrowee River, which flows south, and the headwaters of Creswick Creek, which flows north.

3.2 Evaluation of Biodiversity Assets

The *NaturePrint* map developed by DELWP identifies large areas of native vegetation that are strategic to biodiversity conservation in the City (Fig. 2). Strategic areas have relatively high species diversity, good condition habitat, high connectivity with other vegetation, a high probability of being retained and a lower risk of degradation by weeds. To the east of Ballarat the extensive areas of Dry Forest are strategic for biodiversity conservation. Other strategic areas include the wetlands of Lake Burrumbeet, Lake Learmonth and Lake Wendouree, and the Hills Herb-rich Woodlands around Mount Bolton. So far, engagement with the community has recognised Canadian Forest, Mount Clear and Yarrowee River as some of the significant areas for biodiversity conservation in the City.

3.3 Climate-change modelling

The current distribution of the four target ecosystems was successfully predicted from climate and soils variables. Dry Forests were found in areas with a lower clay content, shallower soils and lower minimum temperatures in winter. Plains Grassy Woodlands were found in areas that had low summer rainfall and higher clay content.

Riparian Forests are found from the mountains to the plains, covering the full range of climatic conditions in the region. Consequently, Riparian Forests were modelled separately as low elevation (< 300 m) and high elevation (> 300 m) forests, and the results combined to provide more realistic predictions across the region than were achieved with a single model. The distribution of Riparian Forests was strongly predicted at high elevations by lower clay content, higher mean annual rainfall and lower minimum temperature in summer at high elevation while at low elevations it was

predicted by higher minimum temperatures in summer, moderate soil carbon concentrations and higher minimum temperatures in winter.

Dry Forests were predicted to be affected by climate change over the coming decades (Fig. 3). Climatic conditions were predicted to remain equally favourable for Dry Forests between now and 2030. Then in 2050, a dramatic decrease in the extent of favourable climates is predicted, with areas of moderate climate north of Invermay and west of Mount Clear. By 2070, climates are predicted to be adverse to Dry Forests throughout the City.

Predictions for Plains Grassy Woodlands were variable across the City and among the decades (Fig. 5). Few areas were predicted to have adverse future climates. Overall, these predictions suggest that climates are likely to remain moderate to favourable for Plains Grassy Woodland across the City.

The impact of climate change was predicted to be slower for Riparian Forests (Fig. 4). Climatic conditions for Riparian Forests were predicted to remain equally favourable in 2030 as they are now. In 2050 and 2070, conditions are predicted to become more adverse for Riparian Forests across the east of the City, which includes the Yarrowee River and the headwaters of the Creswick Creek. However, these predictions for Riparian Forests are optimistic, as they did not include the potential impact of decreased stream flows from reduced rainfall and increased extraction of surface and groundwater across the region.

3.4 Focal areas for conservation of key ecosystems.

By combining the strategic value of native vegetation patches and the predicted responses to climate change (Figs. 2-5), we produced a map of focal areas for conservation (Fig. 6). This showed focal areas for biodiversity conservation in the forests of the east of the City. These forests include areas of Creswick Regional Park, Nerrina Historic Reserve and State Forest to the east Durham Lead.

3.5 Threats to biodiversity

Biodiversity has been decreasing over the decades across the City due to the several interacting threats. Climate change is yet another threat that our native plants and animals must cope with. To have the best chance of maintaining biodiversity under climate change, we must reduce the

pressures from other significant threats. The main threats to biodiversity across the City are discussed below with potential strategies for mitigating their impact.

Habitat fragmentation is the breaking up of once continuous native ecosystems into small and often isolated patches following land-use change. The impact of fragmentation is that habitat patches no longer provide enough habitat or suitable environmental conditions to support viable populations of many species. Mobile species (e.g. birds) that move among habitat patches may be able to supplement their needs but this depends on the extent, quality and isolation of habitat patches in the area. Revegetation that increases the size of individual patches and improves connectivity among patches is the primary method for mitigating the effects of habitat fragmentation.

Land-use change from native ecosystems to production systems (i.e. forestry, grazing and cropping) and then increasingly both to urban developments is associated with increasing clearance, disturbance and degradation of native ecosystems. Restoring large areas to native ecosystems is the ultimate solution to biodiversity decline. The demands of an ever increasing human population mean we have a limited capacity to reduce the extent of production systems. However, we can protect significant areas for biodiversity by regulating the expansion of towns (e.g. green belts and no clear zones), protecting and enhancing biodiversity on public and private land, reducing the intensity of surrounding agriculture (e.g. fertilizers, pesticides and stocking rates) and reducing the intensity of disturbance within native ecosystems (e.g. logging, firewood collection and fuel reduction burning).

Pest plants and animals compete directly with native species for resources. Pests are responsible for substantial losses in the biodiversity across the City. We cannot expect to eliminate pest species from the City but we can manage their numbers and, therefore, their impact on native species. There are many programs to manage pest species and these should continue and be expanded for particularly aggressive species.

Altered fire regimes can substantially change the structure and composition of native ecosystems. Native species have developed strategies to cope with the historical fire regime of their ecosystem. The climate is predicted to become hotter and drier across the region, so it is likely that the frequency of fire will increase in most ecosystems. Fuel reduction burning to reduce the risk of fire to humans, has increased the frequency of fire within native ecosystems. An increasing fire frequency will quickly alter the structure and composition of native vegetation, as many species

cannot fully recover before the next managed or natural fire. In addition, repeated burning is likely to reduce the capacity of native species to tolerate and recover from drought and other disturbances. Given the negative impacts of an increased fire frequency, significant areas for biodiversity should not be subjected to fuel reduction burning. Instead, ecological burning regimes should be developed for native ecosystems that had historically high fire frequencies (e.g. grasslands).

Changed hydrology has substantial impacts on the water supply upon which native plant and animals rely. The quantity and quality of water in the landscape has been dramatically altered by regulation of waterways, unregulated diversion of drainage lines, extraction of ground water, increased deep drainage following clearance and chemical runoff. Native freshwater and floodplain species have adapted to particular flow regimes within and among years, and many trees rely on access to ground water to survive dry periods. The future is predicted to be drier across the region, so water availability will decrease. Consequently, we must be more efficient with our water use to ensure adequate water is available in the landscape for native plants and animals. The capture and extraction of water should be considered and regulated to meet the flow and water availability requirements of native plants and animals, particularly in significant areas for biodiversity. Water quality can be improved by regulating both rural and urban inputs to streams, and strategic revegetation of the landscape.

3.6 Community and stakeholder response

The community and stakeholders engagement workshop at the Ballarat Town Hall provided valuable insight into the threats to, concerns about and potential solutions for biodiversity conservation in the City. The main points raised at this workshop are summarised here.

Threats to biodiversity

- Population growth and associated urbanization.
- Land clearance. Offset system is not a solution. Specifically, old trees are being cleared from freeway corridor while Landcare plants seedlings.
- Fuel reduction burning is simplifying the structure and species composition of vegetation.
- ‘tidying up’ the landscape, including weed control is reducing the diversity of remnant vegetation.
- Regulation of creeks.

Concerns

- The strategy needs to be implemented and used to leverage funding for biodiversity conservation.
- Public interest in the environment is declining, so governments are reducing their investment.
- Conflict among the conservation and development priorities of different arms of government.
- Pollution from burning stubble.

Information needs of the community

- Audit of extent and condition of native ecosystems.
- Information on species to plant for future climate.

Some biodiversity conservation activities

- Council plants thousands of trees each year.
- Urban Forest Strategy.
- Ballarat Environment Network manages many reserves.
- Franklins Bridge project.
- Reservation of Canadian Forest.
- Landcare groups for South Ballarat, Miners Rest, Cardigan-Windermere, and Invermay.
- Friends groups for Peady Street Reserve, Sparrow Ground and Pryor Park.
- Advisory committees for Mount Buninyong, Lake Burrumbeet and Lake Learmonth.

Purposed actions to improve biodiversity conservation

- Long-term strategic planning for biodiversity conservation in the region.
- Coordinated approach to biodiversity conservation among government organizations.
- Stronger protection of remnant vegetation and establish ‘no clear zones’.
- Educate the community about the benefits of biodiversity, particularly to health.
- Educate the community about better use of water.
- Encourage younger people to participate in community groups.
- Encourage and financially support revegetation of private property.
- Bring nature back into urban environment e.g. revegetation of Yarrowee River.
- Encourage biodiversity conservation on farms, including creek fencing and revegetation.

3.7 Existing biodiversity strategies

City of Ballarat Environment Sustainability Strategy 2012-2014 had the goal the "The natural environment within the City is well protected and Council staff, businesses and residents show strong support for sustainability through initiatives to reduce resource consumption and waste production" (City of Ballarat, 2012). Objectives relevant to biodiversity conservation included:

- Achieve an ongoing net gain of native vegetation within the municipality.
- Improve the extent and quality of the natural environment.
- Prevent loss of remnant native vegetation and fauna habitat.
- Increase community involvement in protecting and enhancing the natural environment.
- Improve the condition of riparian, semi-aquatic and aquatic ecosystems.
- Ensure viable environmental flows to wetlands and waterways.
- Improve the quality and manage quantity of stormwater runoff entering waterways.
- Reduce the amount of rubbish and pollutants in waterways and wetlands.

DELWP's draft plan *Protecting Victoria's Environment – Biodiversity 2036* outlines a vision for reversing the decline of biodiversity in the State (DELWP, 2016). Some relevant objectives of this twenty-year plan are:

- Increase the number of Victorians acting to protect nature.
- Halt the overall decline of threatened species and secure the greatest possible number of species in the wild in the face of climate change.
- Improve the overall extent and condition of native habitats across terrestrial, coastal, marine and freshwater environments.
- Improve ecological regimes to best support biodiversity in a changing environment.

North Central Regional Catchment Strategy 2013-2019 has the biodiversity vision of "Native vegetation extent and condition is improved across the North Central region (NCCMA, 2013). Ecological processes are maintained and enhanced and the present diversity of species and ecological communities and their viability is maintained or increased across each bioregion." [#areas] The main objectives for woodlands across the catchment were to protect and restore habitat through habitat retention, fencing and grazing management, pest plant and animal control, restoration and revegetation wither by direct seeding or natural regeneration.

Corangamite Regional Catchment Strategy 2013-2019 has the goal of "Increase the protection, enhancement and restoration of valuable natural resources to improve the health and sustainable

productivity of the Corangamite catchment" (CCMA, 2013). The objectives relevant to biodiversity conservation are:

- Retain the ecological function of riverine and estuarine floodplains.
- Halt the decline in quality (condition) and extent of high value native vegetation and enhance its connectivity.
- Manage the threat of species extinction so that key populations are resilient and secure in the longer-term.

Glenelg Hopkins Regional Catchment Strategy 2013-2019 (GHCMA, 2013) has the key objectives for terrestrial habitat of:

- Maintain extent and improve condition of terrestrial habitat
- Improve connectivity of habitat for species populations and communities
- Public land is managed as the core of resilient ecosystems

Greening Australia's *Conservation Without Borders* plan to remove the barriers to effective large-scale conservation in Australia (Greening Australia, 2013). This includes removing barriers from within the organisation, and among public and private lands, state and territory borders, competing environmental organisations and different sectors of the community. An important development of this approach is the drafting of the *Conservation Action Plan for the Victorian Volcanic Plain*.

Leigh Catchment Action Plan 2008-2013 (Milne, 2008), which includes the Yarrowee River, had the vision of "Working together to achieve sustainable ecosystems, agriculture and communities." The Plan proposed the following actions relevant to biodiversity conservation.

- Investigate impacts of climate change on catchment assets and NRM management techniques.
- Undertake targeted control of listed weeds, rabbits and foxes.
- Monitor impacts of other potential pest animals.
- Protect, enhance and restore vegetation and fauna habitat on private land for conservation.
- Assist protection and conservation of remnant vegetation and fauna habitat on roadsides and rail reserves.
- Contribute to fauna and flora surveys.
- Protect, enhance and restore riparian zones and wetlands.

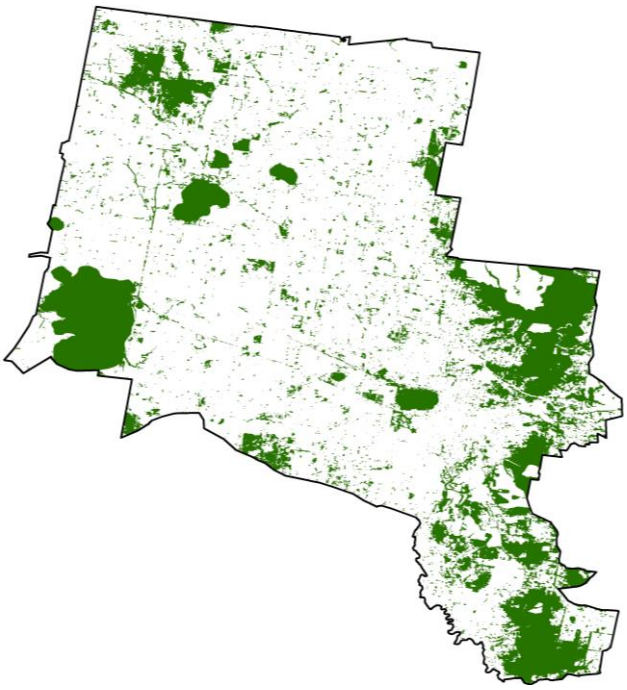

Fig. 1 Current extent of native vegetation across the City of Ballarat.

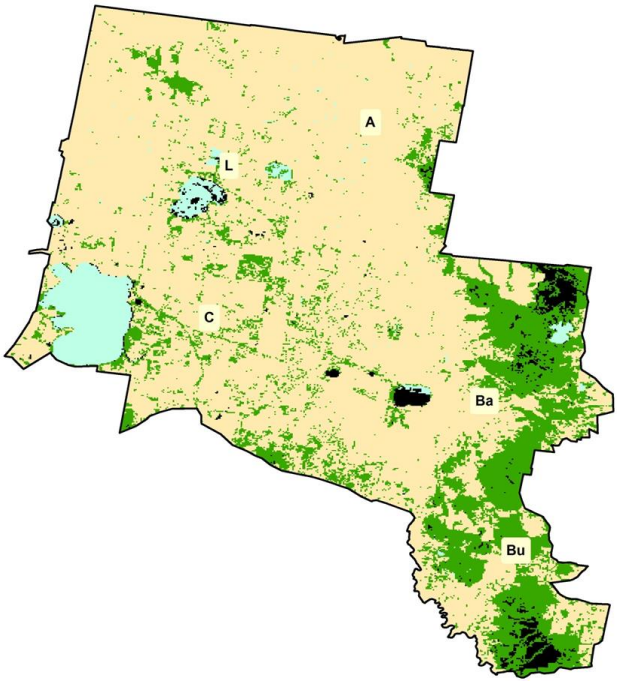

Figure 2 Strategic areas for biodiversity across the City of Ballarat. The strategic values of areas according to *NaturePrint V2* are indicated as high (5.1-7.0, black), moderate (3.1-5.0, green) or low (0-3.0, cream). The locations of Learmonth (L), Cardigan (C), Ascot (A), Ballarat (Ba) and Buninyong (Bu) are indicated.

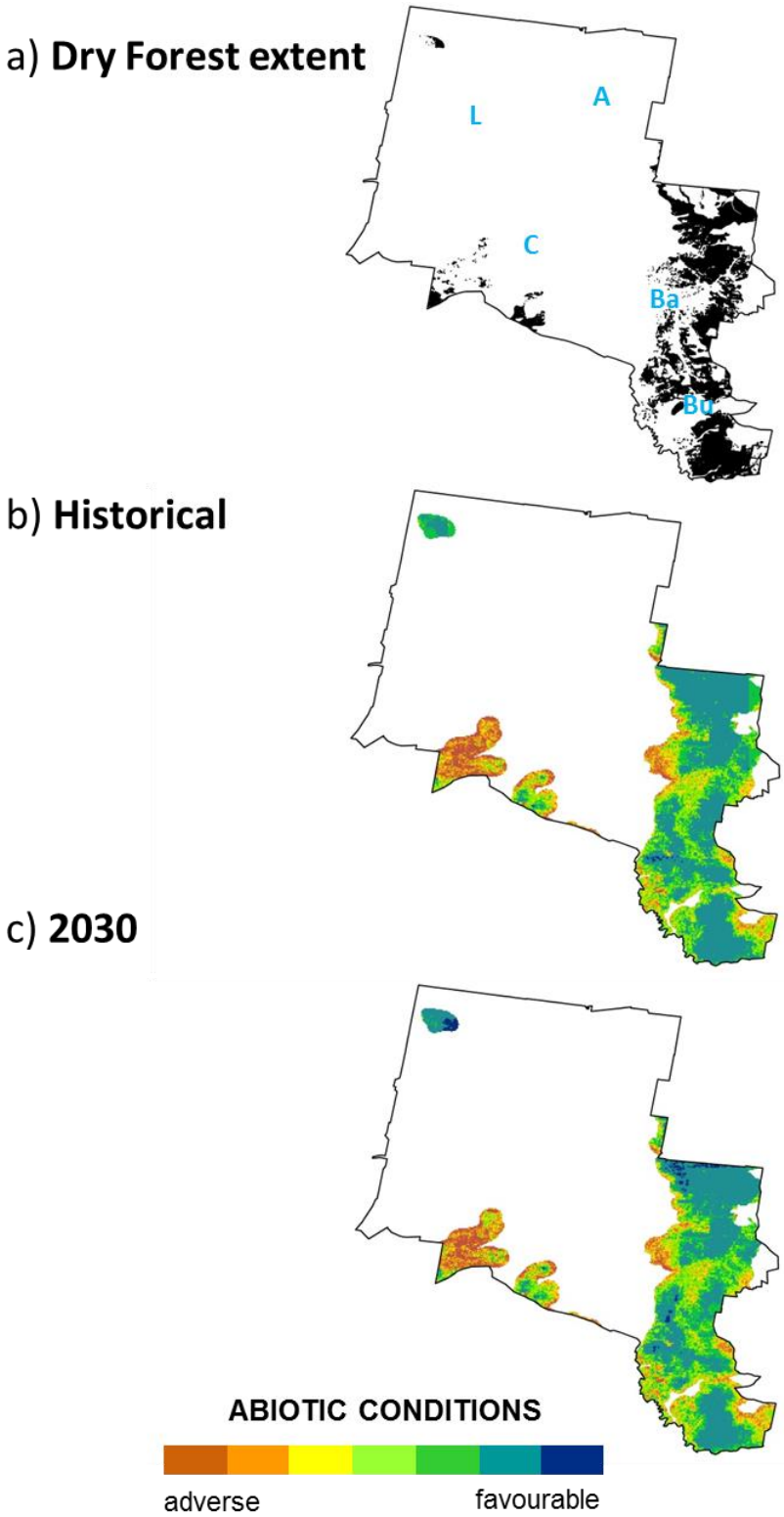

Fig. 3 Dry Forests - Predicted climate suitability across the City of Ballarat in the coming decades. The current distribution of the forests in relation to Learmonth (L), Cardigan (C), Ascot (A), Ballarat (Ba) and Buninyong (Bu) is provided for reference (a). The suitability of the climate (b) historically (1961-1990), (c) in 2030, (d) in 2050 (e) in 2070 and (f) on average across the period is based on probabilities calculated by the program Maxent. Areas with adverse future climates suggest that many species from the ecosystem will not persist. Predictions were restricted to the estimated extent of the ecosystem in 1750.

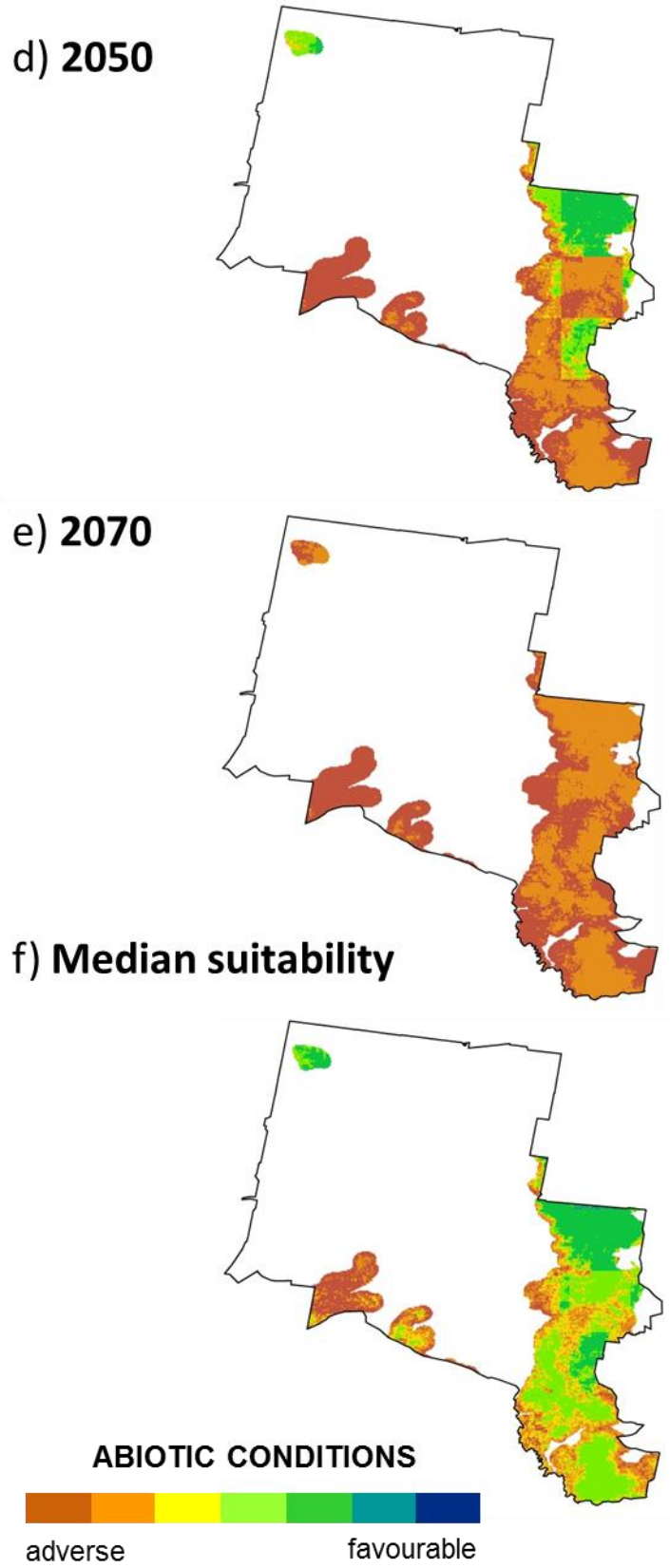

Fig. 3 (cont.) Dry Forests - Predicted climate suitability across the City of Ballarat in the coming decades.

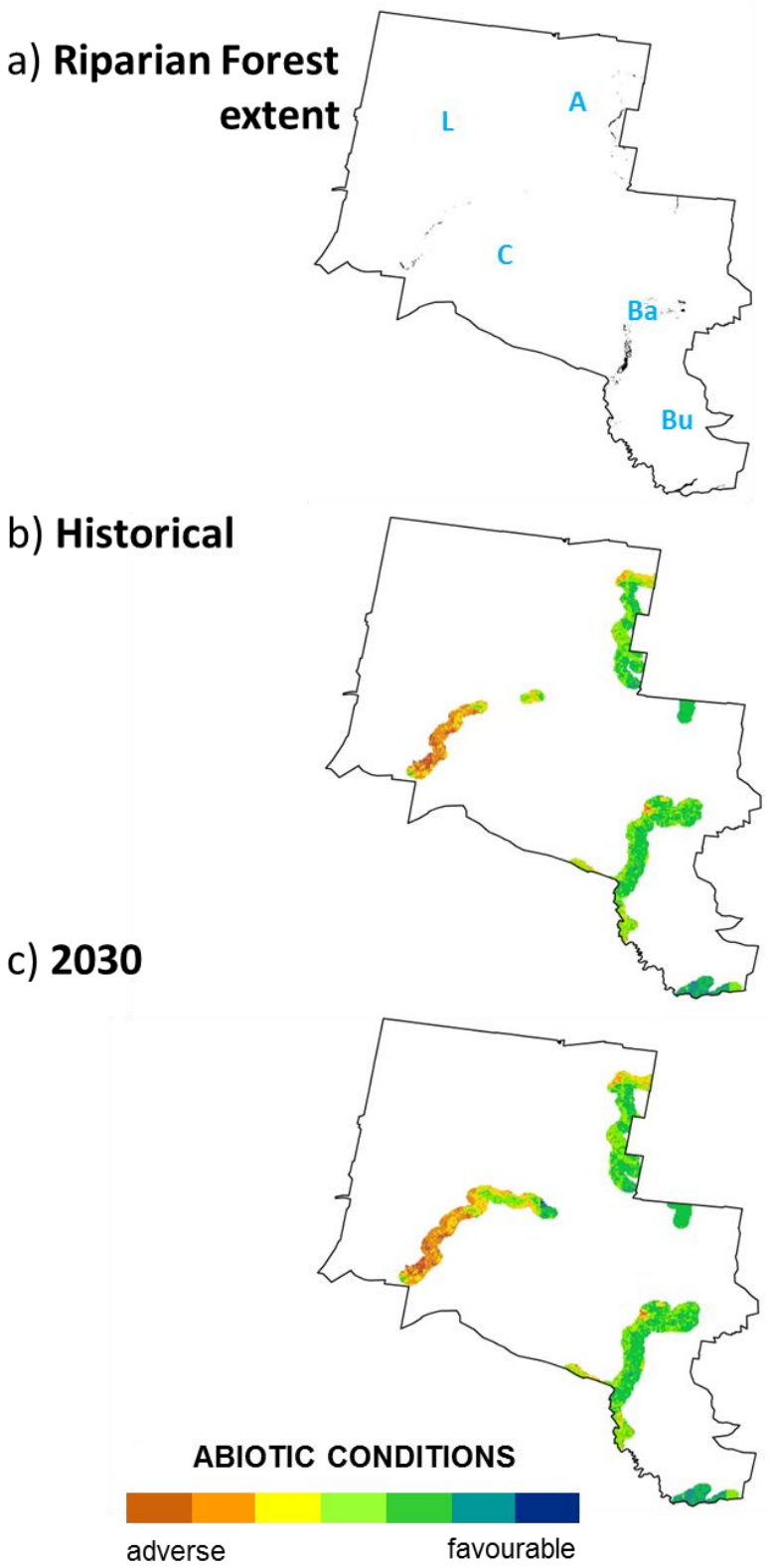

Fig. 4 Riparian Forests - Predicted climate suitability across the City of Ballarat in the coming decades. The current distribution of the forests in relation to Learmonth (L), Cardigan (C), Ascot (A), Ballarat (Ba) and Buninyong (Bu) is provided for reference (a). The suitability of the climate (b) historically (1961-1990), (c) in 2030, (d) in 2050 (e) in 2070 and (f) on average across the period is based on probabilities calculated by the program Maxent. Areas with adverse future climates suggest that many species from the ecosystem will not persist. Predictions were restricted to the estimated extent of the ecosystem in 1750.

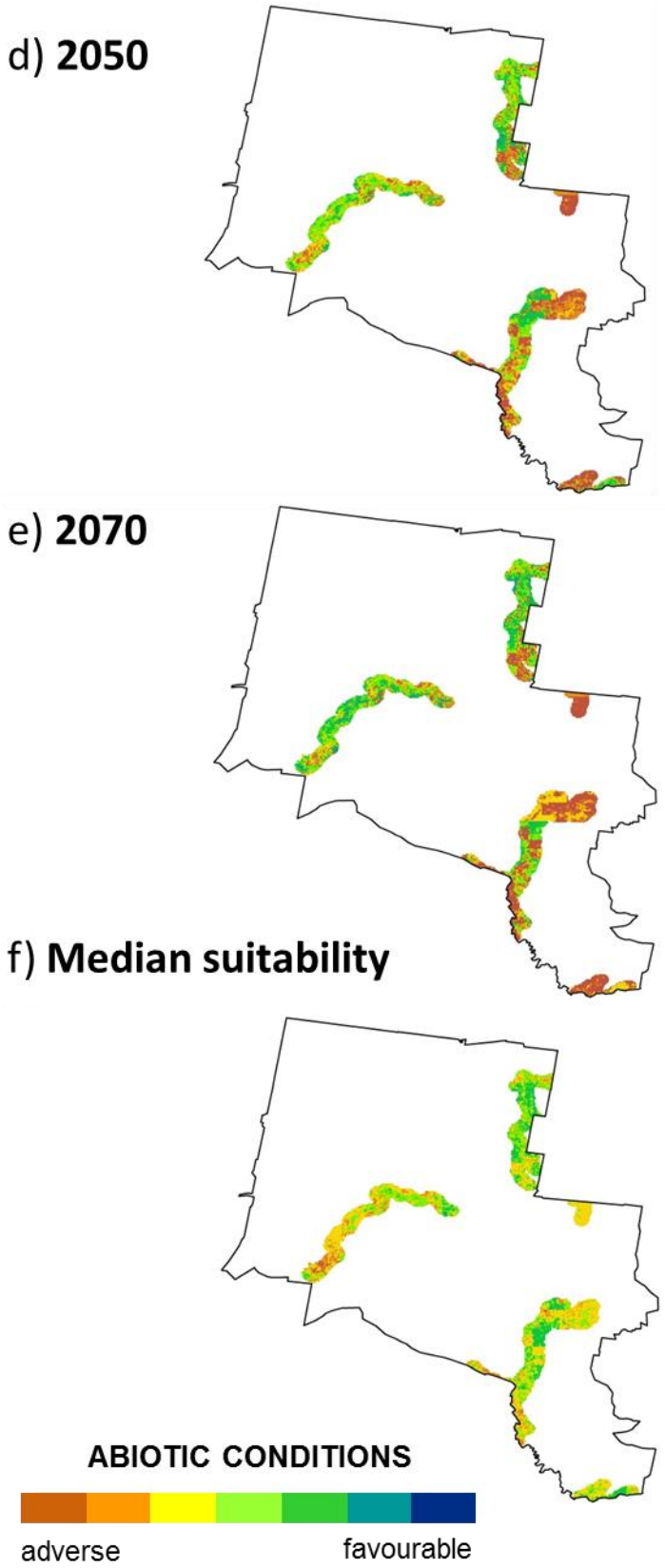

Fig. 4 (cont.) Riparian Forests - Predicted climate suitability across the City of Ballarat in the coming decades.

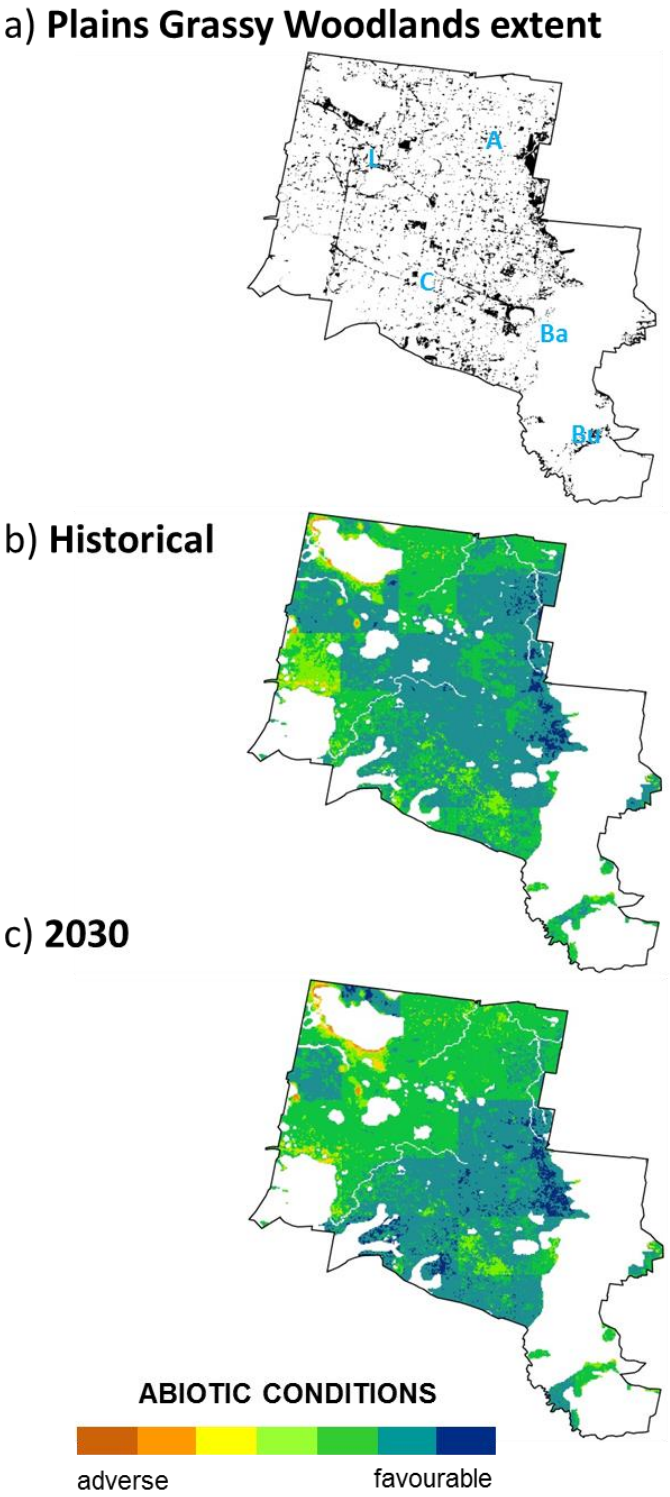

Fig. 5 Plains Grassy Woodlands - Predicted climate suitability across the City of Ballarat in the coming decades. The current distribution of the woodlands in relation to Learmonth (L), Cardigan (C), Ascot (A), Ballarat (Ba) and Buninyong (Bu) is provided for reference (a). The suitability of the climate (b) historically (1961-1990), (c) in 2030, (d) in 2050 (e) in 2070 and (f) on average across the period is based on probabilities calculated by the program Maxent. Areas with adverse future climates suggest that many species from the ecosystem will not persist. Predictions were restricted to the estimated extent of the ecosystem in 1750.

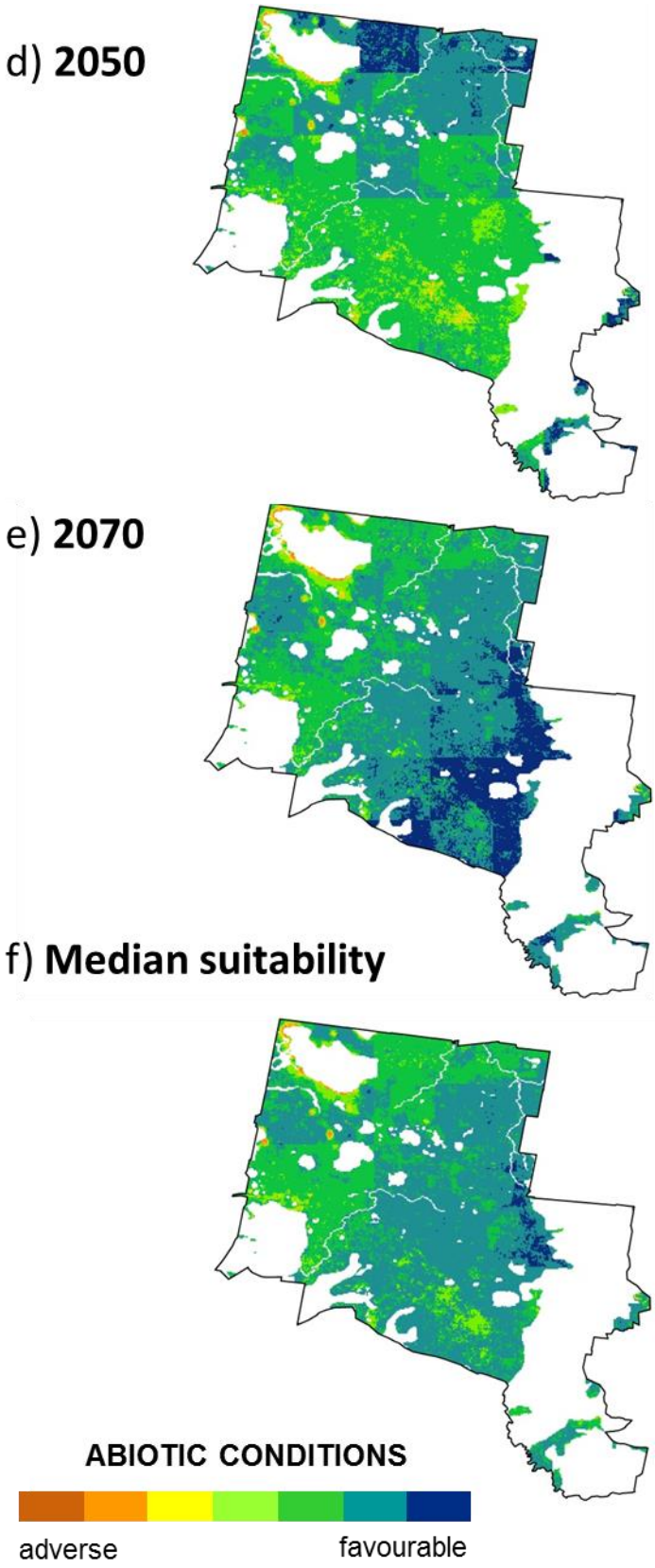

Fig. 5 (cont.) Plains Grassy Woodlands - Predicted climate suitability across the City of Ballarat in the coming decades.

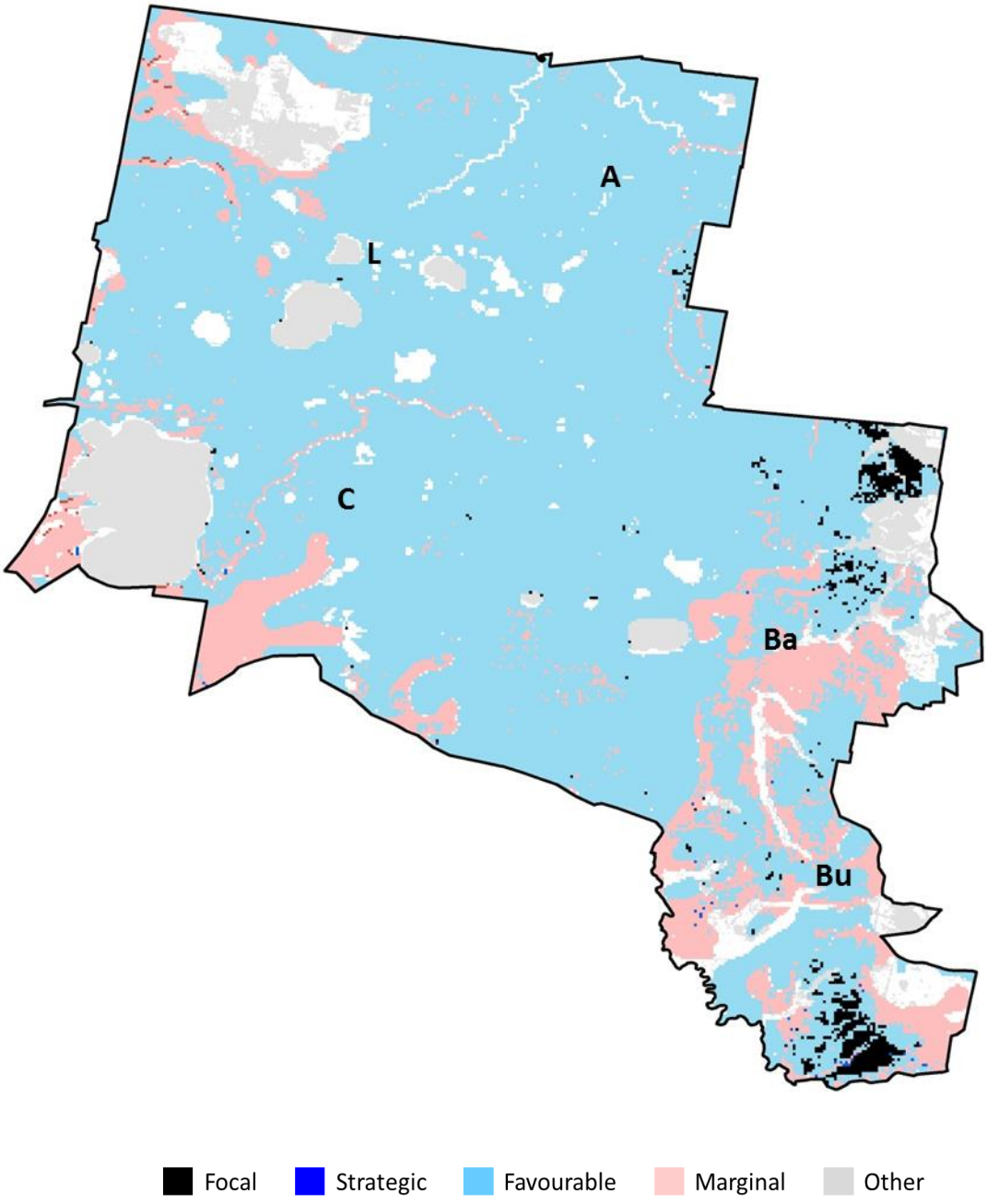

Fig. 6 Potential areas for the target ecosystems categorised into Focal (black), Strategic (dark blue), Favourable (light blue) and Marginal (rose) areas based on their strategic value for biodiversity conservation and the suitability of predicted future climate. Ecosystems not considered in the climate modelling are indicated in grey. The towns of Learmonth (L), Cardigan (C), Ascot (A), Ballarat (Ba) and Buninyong (Bu) are indicated.

4. Biodiversity strategy for the City of Ballarat

4.1 Guiding principles

Native ecosystems continue to decline throughout the Shire from increasing disturbance and ultimately clearance for other land uses. Although revegetation is crucial and provides important habitat within a decade, development of mature forests and woodland takes over a century. The Biodiversity Strategy outlines where biodiversity conservation efforts are best focused given the size of the challenge and the available resources in the Shire and wider region (Figs. 8 & 9). The guiding principles were to:

1. BUILD on the community's commitment to conserve biodiversity.
2. IMPROVE our knowledge of local biodiversity and threats to it.
3. PROTECT remnant native ecosystems from further clearance and degradation.
4. MANAGE threats to biodiversity.
5. RESTORE the habitat structures and resources within remnant native ecosystems.
6. PLANT native species on cleared areas, so that they provide functional habitat in the future.

4.2 Strategies for building on the community's commitment to and knowledge of biodiversity conservation

The Council recognises the wealth of knowledge amongst the community and the strength of commitment to biodiversity conservation in the Shire. The strategy aims to build on these strengths by engaging with local leaders in biodiversity conservation in ongoing engagement to increase the flow of information between practitioners, the Council and community.

4.3 Priority areas for biodiversity conservation

Given the size of the challenge of conserving biodiversity under climate change, the continued dominance of production systems and the expansion of urban areas across the region, we must be very strategic about the management actions that are initiated today. Consequently, the Strategy prioritises areas of native ecosystems that were predicted to be a) of higher strategic value for conservation (*NaturePrint*) and b) less vulnerable to the effects of climate change (modelling presented here). Using these principles, the Shire was categorised into:

1. *Focal Areas* that are strategic for biodiversity conservation and are predicted to have a favourable future climate.
2. *Favourable Areas* that are predicted to have a favourable future climate but a low strategic value for biodiversity conservation.

3. *Strategic Areas* that are predicted to have a high strategic value for biodiversity conservation but an adverse future climate.
4. *Marginal Areas* that have a low value for biodiversity conservation due to a lack of strategic value and an adverse future climate.

4.4 Strategies for biodiversity conservation

The Biodiversity Plan for Ballarat City has six key strategies for conservation of biodiversity assets across the Shire (Fig. 8).

1. Protect native ecosystems from clearance across the Shire.
2. Create 'Environmental Zones' around strategic areas where threats to biodiversity are managed and revegetation is used to buffer, extend and link existing remnant vegetation.
3. Within Focal Areas, restore historical ecosystems and plant historical dominant species.
4. Within Strategic Areas, recreate the ecosystem structure with resistant local species.
5. Within Favourable Areas, restore historical ecosystems and plant historically-dominant species.
6. Within Marginal Areas, recreate the ecosystem structure with 'climate ready' species.

It should be noted that this strategy was limited to the extent of the ecosystems for which climate-change modelling was performed (i.e. Dry Forests, Riparian Forests and Plains Grassy Woodlands). Modelling the full range of native ecosystems across the Shire would provide a more comprehensive strategy.

4.5 Protect native ecosystems across the City

The main cause of biodiversity decline is the continuing loss of habitat. In particular, the loss of remnant native ecosystems should be avoided wherever possible. Clearance of native ecosystems represents a substantial loss to biodiversity in the region that cannot be replaced easily or within our lifetime. Off-setting with planting of new vegetation, although an improvement from clearance alone, does not replace the habitat resources provided by the mature vegetation that was lost. The Council will consider the irreplaceability of an area of native vegetation in the planning process.

4.6 Environmental zones

Given the extent of native ecosystems is likely to remain small, 'Environmental Zones' are proposed around Focal Areas and Strategic Areas for biodiversity conservation (Fig. 8). The objective of Environmental Zones is to reduce the threats to biodiversity within these significant areas of native ecosystems and in the surrounding landscape (Cunningham et al., 2015). Native ecosystems within a zone are of high conservation significance and, consequently, should be the focus of management actions and protected from further clearance and developments such subdivision or urbanization.

To address habitat fragmentation in a zone, revegetation will be used to increase the area of existing remnants, to provide a buffer from surrounding land use and to increase links among remnants. Revegetation would be used to improve long-distance links between the different zones (Fig. 8). These long-distance links pragmatically would be established across areas with higher native vegetation cover or along waterways. The aim would be to restore the native ecosystems by planting the historically dominant species.

Reducing other threats to biodiversity within the Environmental Zone is equally important as revegetation. Land-use intensity would need to be reduced within an ecosystem (i.e. logging, grazing, firewood collection, water diversion) and in the surrounding landscape to minimise the impacts of production ecosystems on biodiversity (i.e. fertilizers, pesticides, stocking rates, erosion). Programs to control pest plants and animals should have a focus in the Environmental Zone, with consideration of the potential negative impacts on native plants and animals. Fuel-reduction burning would be best excluded from the Environmental Zones and instead ecological burning used where the structure of the ecosystem had decline due to an absence of historical burning. Where possible, historical flows should be returned to waterways and floodplains, and pollution entering the waterways minimised.

4.7 Restoration of Focal Areas

The Focal Areas are both strategic for biodiversity conservation and predicted to be least vulnerable to future climates. Consequently, these are the best parts of the City to focus efforts to restore native ecosystems. Restoration of these ecosystems would involve increasing habitat structure within existing remnant, with understorey enhancement plantings and provision of animal habitat (e.g. nesting box, fallen timer, etc.). Given the climatic conditions are predicted to be more favourable, replanting across these areas should be based on plants currently found in local remnants and taking into account landscape position (i.e. riparian, plain, slope, gully, ridge).

4.8 Restoration of Strategic Areas

For areas predicted to have high strategic value for biodiversity but an adverse future climate, the historical composition of the ecosystem is unlikely to be retained. It is suggested to maintain the structure characteristic of the historical ecosystem (e.g. Dry Forest) but with a different species composition. Species choice for revegetation should be guided by the climatic range of species, and their resistance to and recovery from disturbance events such as fires and droughts. The strategy is advocating a pragmatic approach of focusing on local species from the ecosystem that have shown a capacity to cope with climate change (e.g. resistance to the Millennial Drought).

4.9 Restoration of Favourable Areas

Where future climate is predicted to be favourable but native remnants are considered to have a low strategic for biodiversity, there would less effort to manage threats and reduce land-use intensity. Restoration in these areas should aim to replant historical ecosystems guided by plants currently found in local remnants in a similar landscape position.

4.10 Restoration of Marginal Areas

Areas predicted to have an adverse future climate and low strategic value are considered to be the least important to biodiversity conservation in the City. The strategy is advocating recreating the structure of the historical ecosystem in Marginal Areas. The restoration approach would be to focus on replanting with species known to ‘climate ready’. This would include local resistant species but may have a greater focus on native species from hotter and drier areas of Victoria.

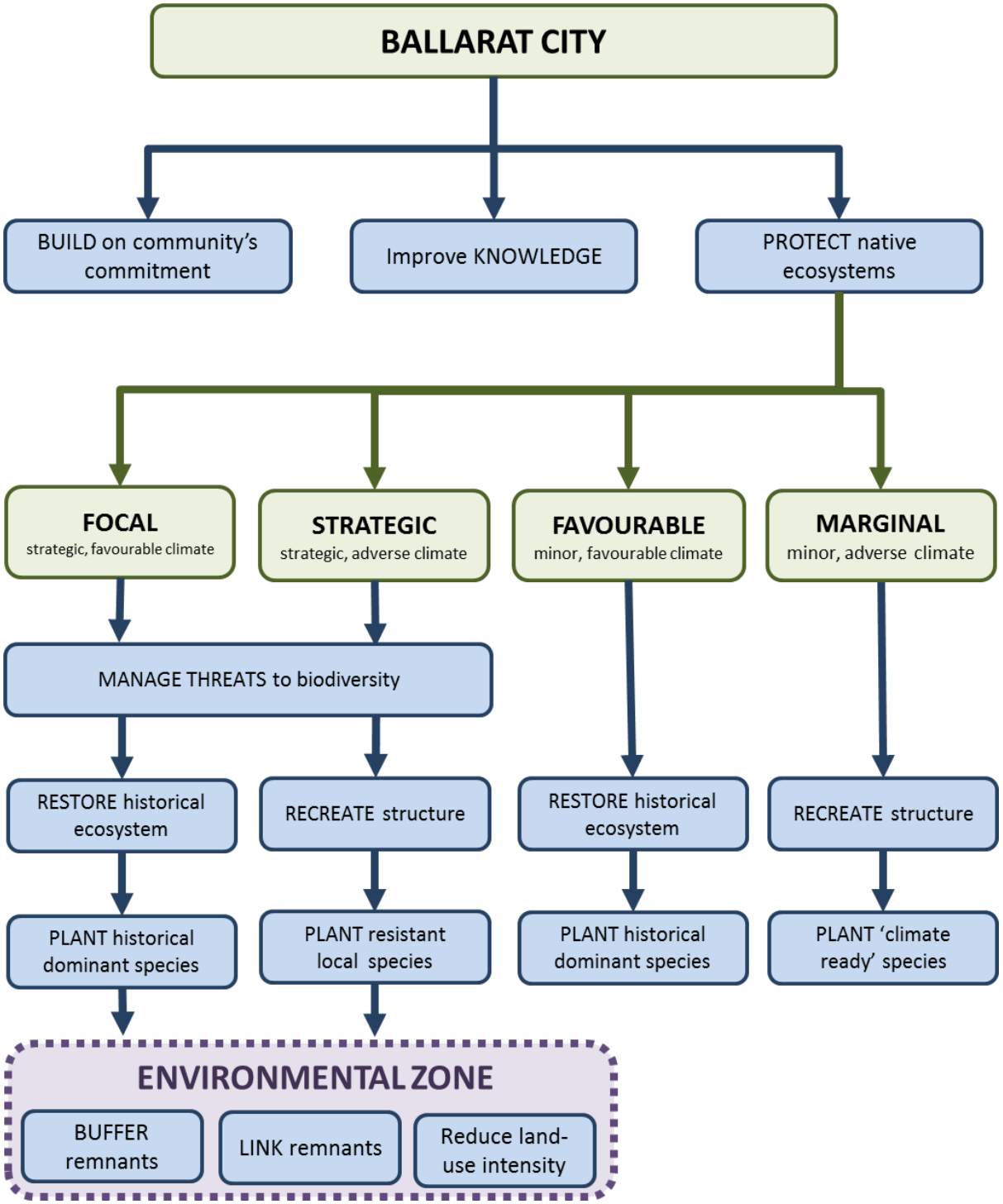

Fig. 7 Conceptual diagram of the Biodiversity Strategy for the City of Ballarat. Areas are categorised based on differences in strategic value and climatic condition in the future (green), and actions to maintain biodiversity are indicated (blue).

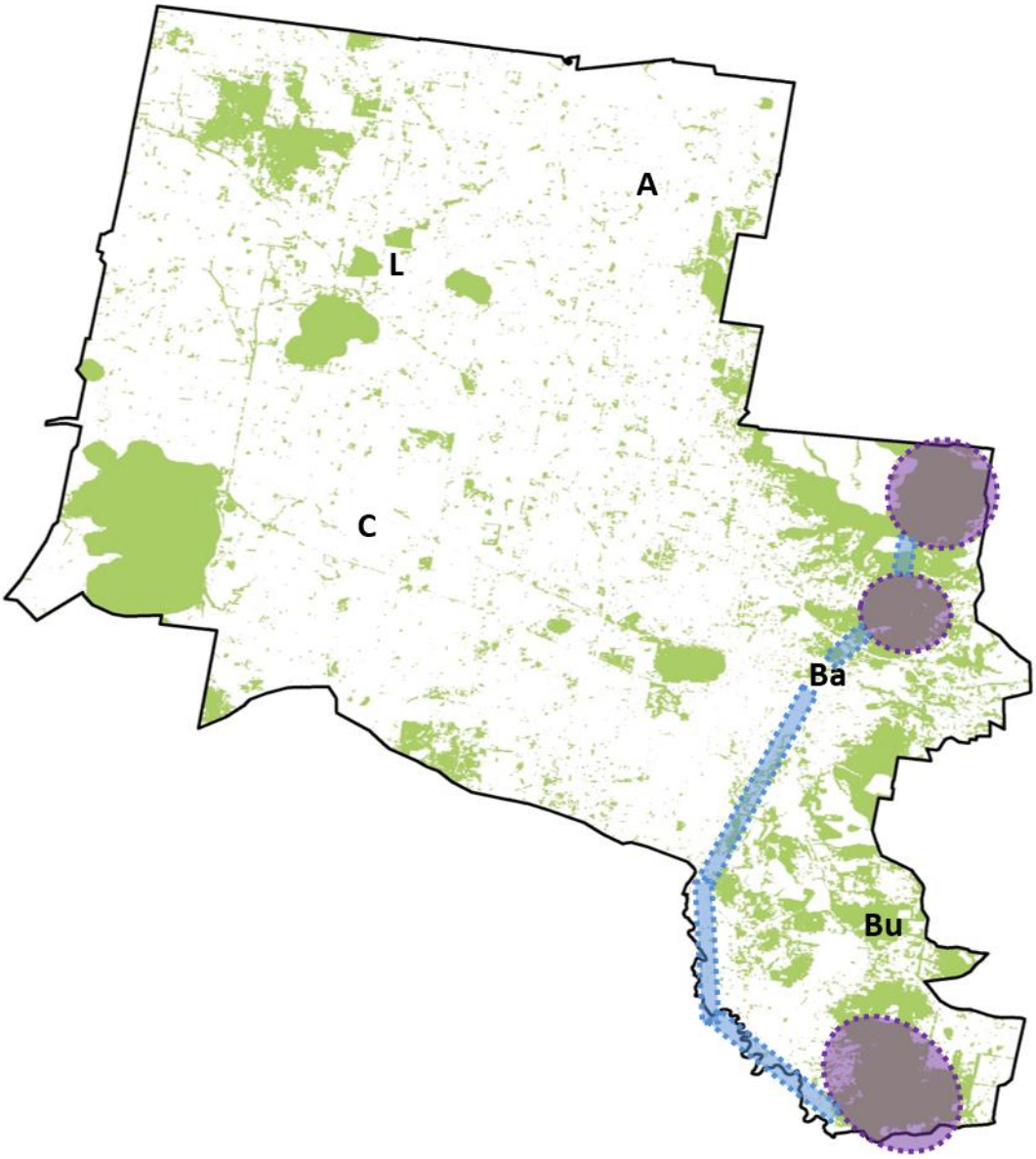

Fig. 8 Proposed Strategy for biodiversity conservation for the City of Ballarat. Native vegetation throughout Ballarat (green) should be protected from clearance, and the public educated to minimise threats and restored where possible. Environmental zones (purple) cover large areas of focal and strategic native ecosystems where conservation efforts should be focused. These zones are connected within and among by increased habitat linkages (blue). The towns of Learmonth (L), Cardigan (C), Ascot (A), Ballarat (Ba) and Buninyong (Bu) are indicated.

5. Implementation of the Plan

The Council will take action to improve biodiversity conservation using the *Ballarat Biodiversity Action Plan 2016* as a guide. The Plan will be implemented with the community using three essential tools:

1. COMMUNICATION of information about biodiversity conservation to the community.
2. PROTECTION of the biodiversity values of the City.
3. RESTORATION of the biodiversity values of the City.

5.1 How to build on the community's commitment to conserve biodiversity

Critical to the success of the Strategy is widespread understanding among the community about the importance of biodiversity to their lives, the vital need to conserve biodiversity and how individuals can take to help improve biodiversity in the City. In collaboration with local leaders in biodiversity conservation, the Council will develop a biodiversity education program through information on their website, leaflets provided to the community and information days.

ACTION 1 – Engage with local leaders in biodiversity conservation to develop a biodiversity education program

ACTION 2 - Produce information sheets about biodiversity values in the City and practical ways for the community to help protect biodiversity.

ACTION 3 – Promote biodiversity conservation activities of local land managers and conservation groups.

ACTION 4- Keep Councillors and Council staff informed of the issues surrounding and best practice for biodiversity conservation.

5.2 How to improve our understanding of local biodiversity

The proposed strategy was based on available knowledge and modelling performed as part of the project. A more rigorous strategy could be developed by increasing our fundamental understanding of native ecosystems in the City. There is a wealth of biodiversity knowledge amongst the community that could be drawn and built upon. Experts could be consulted to determine the status of all native ecosystems (not just the key ones explored here), including their current condition, known threats and the predicted impacts of climate change.

ACTION 5 - Organise regular biodiversity forums to increase the flow of information between the Council and community, including the learnings of local land managers and conservation groups.

ACTION 6 – Audit the condition and species composition of all Council land.

ACTION 7 - Model the climate change impacts for all the broad vegetation types of the City

5.3 Where to implement actions for biodiversity conservation

The primary goal of the Strategy is "to improve the biodiversity values of Ballarat City for future generations", so we must increase the protection of native ecosystems throughout the City. The Council will ensure that any future land-use change in the City considers whether the clearance or disturbance of native ecosystems can be first avoided or second minimised. In particular, areas considered to be strategic for biodiversity conservation should not be cleared or degraded to provide resources.

Given the size of the challenge and the limited extent of immediate feasible actions, we must be very strategic about the management actions that are initiated today. It would be pragmatic to focus conservation efforts on strategic areas for biodiversity, regardless of the predicted impact on climate change on them. The classification of native ecosystems into categories according to their strategic value and the likely impact of climate change were proposed to guide the prioritization of conservation across the City. It is important that this classification acknowledges the existing conservation efforts across the City and adds to them. Further consultation among the Council, land managers and the community will be needed to refine this classification.

An important feature of the Strategy is the proposal of Environmental Zones where efforts are focused to both reduce the threats to biodiversity and increase the condition and extent and native ecosystems. This acknowledges that effective long-term improvement to biodiversity can only be achieved if the impacts of surrounding land use are reduced. The community needs to be made aware of the importance of these Environmental Zones and the need to manage the intensity of land use in the landscape. This progressive approach to conservation will be another distinguishing feature of the region, which could increase the community's ownership of biodiversity and of great value for residents and visitors.

ACTION 8 – Incorporate protection of native ecosystems in the planning process.

ACTION 9 – Define minimum level of protection for native vegetation on Council land.

ACTION 10 – Classify all areas of native vegetation in the City according to their strategic value for biodiversity conservation, in consultation with land managers and the community.

ACTION 11 – Establish 'Environmental Zones' where the goal is to increase protection and management of biodiversity.

5.4 How to support biodiversity conservation

Funding is a major impediment to biodiversity conservation. Collaborative projects amongst the Council, landholders, community groups, and both government and non-government land managers are an effective way to pool resources. Such projects will develop strategic partnerships to secure longer-term investment and collaboration. Council will support the efforts of these groups by a) encouraging involvement of local land holders in biodiversity conservation and b) promoting funding opportunities and facilitating applications.

ACTION 12 – Form strategic partnerships with local leaders in biodiversity conservation.

ACTION 13 – Promote and facilitate funding opportunities for biodiversity conservation.

ACTION 14 – Explore financial incentives as an option for reducing threats to biodiversity on private land.

6. REFERENCES

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