PREPARED FOR THE CITY OF BOROONDARA

EAGA BIODIVERSITY MONITORING FRAMEWORK 2015

PART I – DISCUSSION PAPER

30 June 2015

Report by Caragh Threlfall, Lee Harrison, Rodney van der Ree and Nicholas Williams

caragh.threlfall@unimelb.edu.au

Royal Botanic Gardens Melbourne

Australian Research Centre for Urban Ecology

THE UNIVERSITY OF MELBOURNE

State Government Victoria

Executive Summary

The purpose of this Discussion paper is to provide a background for the development of the Eastern Alliance for Greenhouse Action (EAGA) Biodiversity Monitoring Framework. The aim of the Framework is to develop a resource recommending indicators and tools to be used to assist EAGA Councils to monitor urban biodiversity and habitat 'health' under a changing climate.

This Discussion paper forms Part I of the Framework. Part II 'Indicator Implementation Guide' describes the recommended methods to implement the monitoring of the final set of selected indicators.

The Framework was developed through consultation and workshops with staff from all seven Councils that form EAGA, expert advice provided by a Technical Reference Group and other external experts, review of Council strategies and reports, and summarising the primary scientific literature on best-practice biodiversity monitoring.

The specific objectives of Part I: Discussion paper is to:

a. Provide a rationale to guide the development of the Biodiversity Monitoring Framework.
b. Present the methods and outcomes of each stage in the process (e.g. workshops, interviews, literature review) used to guide the Framework development, including discussing key lessons learnt from similar projects.
c. Present examples of indicators considered for selection, and explanations for each.
d. Identify opportunities for monitoring that maximise the use of data already collected, including the use of citizen science where possible.

From these workshops and reviews, the following vision for biodiversity management in EAGA Councils emerged:

1. **The EAGA region has resilient and functioning ecosystems that can adapt to climate change; and**
2. **The community values and actively protects biodiversity in the EAGA region.**

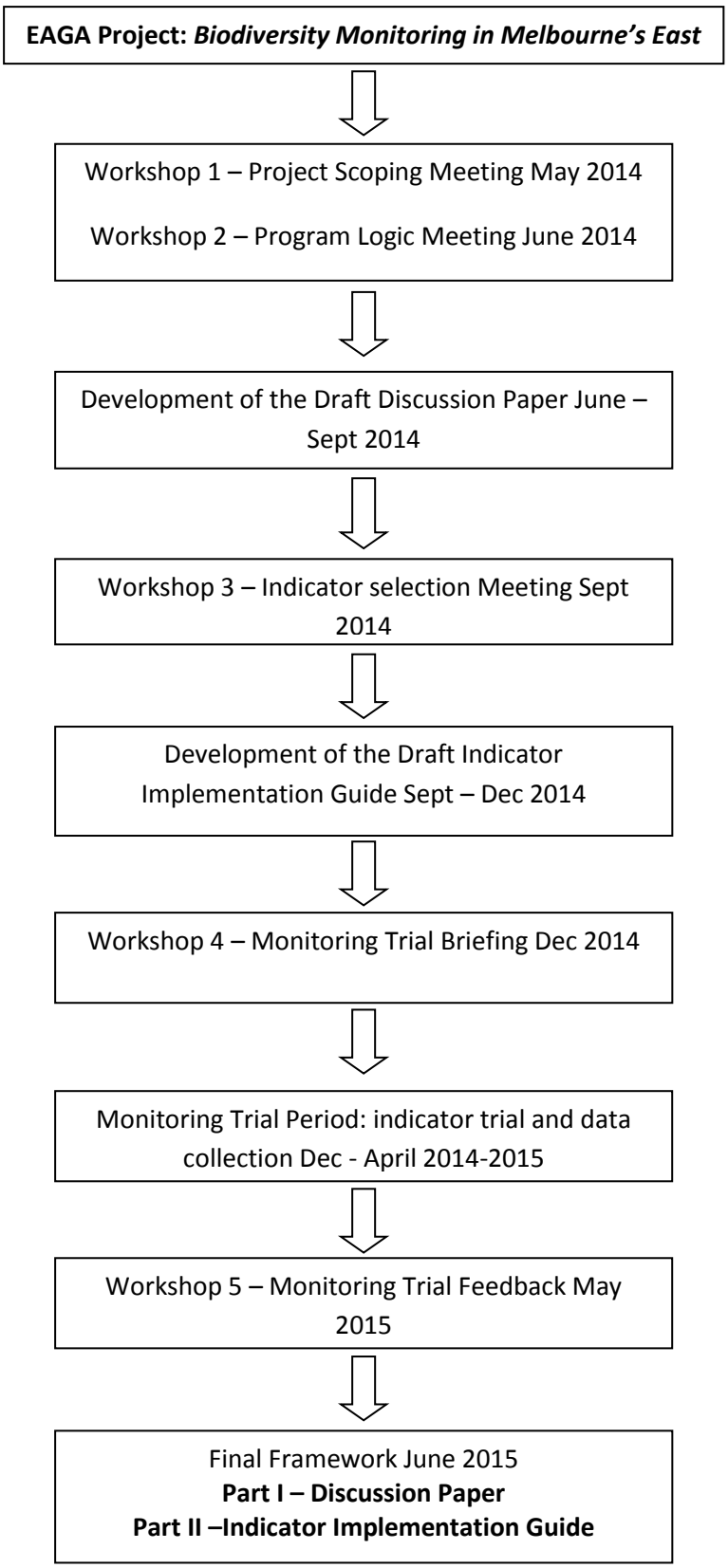
After extensive review of key examples of best-practice from around Australia, as well as review of all EAGA Council policy documents and monitoring currently undertaken by EAGA Councils, we proposed seven possible indicators for inclusion in the final framework. These were: Vegetation extent; Habitat connectivity; Vegetation condition; Vegetation composition; Plant survival; Plant or animal phenology; and Bird communities.

During the second stage of the project, these indicators were discussed and further refined via a trial data collection period, and in consultation with stakeholders. The final set of indicators selected for future monitoring was:

- Vegetation extent
- Vegetation change
- Phenology
- Local bird communities

Part II forms an implementation guide including detailed description of methods, field templates, reporting and data storage procedures for the selected indicators. The indicators each Council use will reflect their resourcing and capacity to undertake monitoring.

Flow diagram of the process:



Contents

1. Introduction

The Eastern Alliance for Greenhouse Action (EAGA) includes the Cities of Boroondara, Maroondah, Knox, Stonnington, Monash, Whitehorse and Shire of Yarra Ranges in the middle- to outer-eastern suburbs of Melbourne (Fig.1). Each of these Councils, together with State Government, is responsible for protecting, restoring and maintaining public land across the region.

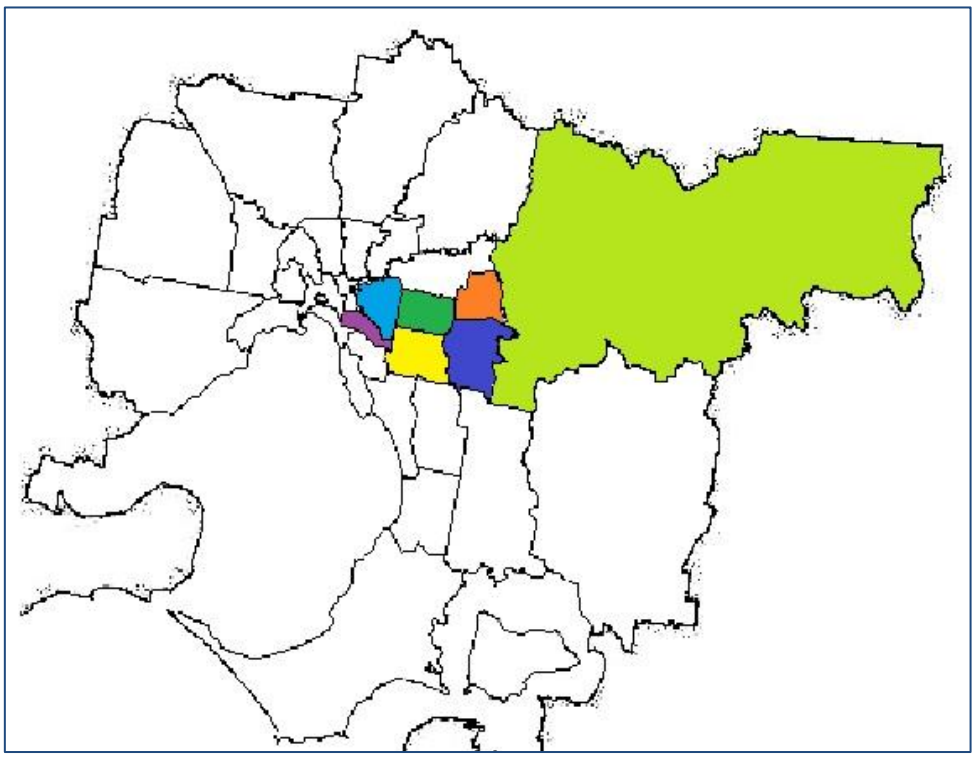


Figure 1. Map of Metropolitan Melbourne with each of the seven Eastern Alliance for Greenhouse Action (EAGA) municipalities shaded in different colours: purple = Stonington, light blue = Boroondara, dark green = Whitehorse, yellow = Monash, orange = Maroondah, dark blue = Knox, light green = Yarra Ranges.

To this end, the EAGA Councils developed a series of projects in two phases (Phase 1 and Phase 2) to better understand the impact of climate change on the natural assets for which they are responsible (Meacher and Blair 2013). This Framework document is part of Phase 2, where this project was to develop and trial a framework to monitor biodiversity and habitat health in a changing climate, and facilitate development of adaptive management techniques. This project received grant funding from the Victorian State Government.

The Australian Research Centre for Urban Ecology (ARCUE) and the University of Melbourne were engaged to develop the Phase 2 Biodiversity Monitoring Framework during 2014-2015, which included the trialling of select indicators to measure and report on biodiversity under a changing climate.

The purpose of this Discussion paper is to document the rationale and development of the Phase 2 project: *Biodiversity Monitoring in Melbourne's East*.

The specific objectives of this Discussion paper are to:

e. Provide a rationale to guide the development of the biodiversity monitoring Framework.
f. Present the methods and outcomes of each stage in the process (e.g. workshops, interviews, literature review) used to guide the Framework development, including discussing key lessons learnt from similar projects.
g. Present examples of indicators considered for selection, and explanations for each.
h. Identify opportunities for monitoring that maximise the use of data already collected, including the use of citizen science where possible.

This Discussion Paper serves two purposes: it firstly informed Council members during the process of developing framework; and it secondly now provides a summary of the process undertaken.

To develop the Discussion paper and Implementation Guide (i.e. Parts I and II of the Framework), we undertook extensive consultation via workshops, questionnaires and meetings with EAGA Council representatives and an expert group. In addition, we reviewed the key lessons learnt from numerous biodiversity monitoring programs from across Australia, and reviewed key scientific literature on principles and approaches to biodiversity monitoring (see Section 2). Following this review, we collated all relevant documents from each Council related to biodiversity, climate change and natural resource management (see Section 3), such as Biodiversity Strategies, Biodiversity Asset Management Plans, Bushland Management Plans and monitoring frameworks and any other associated documents. The purpose of this process was to gain an understanding of what monitoring is already undertaken by each Council, what conservation activities each Council currently do and for what asset (for example habitat versus threatened plant regeneration activities), and the capacity of the Councils to adopt a regional monitoring framework. This is followed by Section 4 and 5, that document the outcomes of these processed and the methods used to develop the final list of indicators.

1.1 What is biodiversity?

> *"Biodiversity is the variety of all life forms on earth; it is the different plants, animals and micro-organisms; their genes; and the terrestrial, marine and freshwater ecosystems of which they are a part."* (Australia's Biodiversity Conservation Strategy 2010–2030)

Australia has many highly diverse flora and fauna communities, however this diversity is under threat from many large-scale natural and human disturbances. Increasing urbanisation and a changing climate are two of the biggest threats to our unique biodiversity. Many non-indigenous and exotic plants and animals already occur in urban environments, including weeds and pests, but also other less harmful species. A key challenge for land managers in urban environments is to manage and protect native biodiversity, whilst recognising the role that other non-local species play in the ecosystem.

1.2 What is habitat?

Habitat refers to the environment in which plants and animals live. Often, this is in remnant bushland patches, however, in urban environments as elsewhere, habitat can also be provided by native and naturalised vegetation, cultivated vegetation, and made-made structures. The health or utility of habitat for fauna relies on the resources provided by the habitat, such as nesting or

foraging resources. In general, it is considered that vegetation that consists of multiple biological and structural resources (e.g. hollows, dead wood, leaf litter, shedding bark, rocks, and an array of native plant species), will provide habitat to a diverse assemblage of native fauna species. These aspects of habitat are often targeted for monitoring when assessing the 'condition' of vegetation in any given area.

1.3 How will biodiversity and habitat be affected in a changing climate?

Climate change is occurring due to human activity at a global scale; however, adaptive management of bushland impacts must occur at a local scale. The EAGA Councils consist of seven eastern Melbourne Councils (Fig 1), which are predominantly within the Gippsland Plain bioregion.

Climate Change Projections for EAGA Councils, outlined in Phase 1 of this project (Meacher and Blair 2013), predicted that by 2050 the region is most likely to be hotter (+1.7 to +2.5°C) and drier, with precipitation reduced up to 14%. Average temperatures will increase most in summer and least in winter, and extreme hot days and nights will be more frequent in summer. Average rainfall is likely to decrease most in spring, but extreme rainfall events are more likely. Evaporation will increase, relative humidity will decrease, and inflow to streams will decrease. Fire risk will increase as conditions dry, and the fire season will start earlier and end later. Extreme wind speeds are predicted to decrease between spring and autumn, but increase in winter.

As a result of these changes in climate, the distribution and composition of flora and fauna species and communities are expected to change. Change is first expected to occur at the edge of species distribution ranges, with a general shift of suitable climate zones to the north-east of the EAGA region. This may be related to the altitudinal gradient associated with the Great Dividing Range, or shifts in rainfall patterns. Some pests and diseases are likely to become more widespread.

Modelling research conducted as part of Phase 1 of this project (Meacher and Blair 2013) found that the range of some species would change markedly, particularly *Eucalyptus ovata* and *E. rubida.* The research also suggested that species within vegetation communities may respond independently to each other, resulting in changes to community composition and different types of vegetation communities would vary in their vulnerability to climate change.

Consequently, Phase 1 recommended that monitoring for shifts in species distribution and vegetation community composition would be valuable.

1.4 Aim of the project "Biodiversity Monitoring in Melbourne's East"

The overall aim of the project is to develop a resource to assist Councils to monitor urban biodiversity and habitat 'health' under a changing climate and to provide a framework that enables Council officers to interpret monitoring data so results can inform management strategies and adaptive management techniques.

The audience of this discussion paper is the policy officers and members of the bushland, environment and horticultural teams of the seven EAGA Councils that will implement this framework. This discussion paper has been developed to introduce the problem, and present issues considered when deciding upon the final content of the monitoring framework. An interim version of this discussion paper was also written to elicit feedback from Council officers on the feasibility of

conducting monitoring, as well as the relevance of selected indicators to urban bushland management.

1.4.1 Project Participants and Governance

The Phase 2 project participants included the Project Control Group, Project Working Group, Technical Reference Group, and the Project Officer/Team (ARCUE and The University of Melbourne).

The Project Control Group comprised representatives from the City of Boroondara, Shire of Yarra Ranges and the Department of Environment, Land, Water and Planning (DELWP). The Project Manager was Andrea Lomdahl, Senior Sustainability Officer, City of Boroondara.

The Project Working Group is comprised of:

- Project Officer/Team (Caragh Threlfall, Lee Harrison, Rodney van der Ree, Nick Williams and Chris Jones from ARCUE and The University of Melbourne)
- Project Manager, Andrea Lomdahl, Senior Sustainability Officer, City of Boroondara
- Boroondara Council: Michaela Skett, Brad Curtis, Peter Tucker, Adrian Hotchin
- Shire of Yarra Ranges: Marty White, Paul Smitka, Amanda Smith
- City of Monash: Anna Mezzetti, Andrea Fernandez, Chris Gittens
- Maroondah City Council: Craig Mauger, Lynn Hebblethwaite
- City of Whitehorse: David Stewart, Grant McAdam
- City of Knox: Nadine Gaskell, Adam Loy, James Rose
- City of Stonnington: Chloe Horner, Chris Owens

The Technical Reference Group is comprised of:

- Emmaline Froggatt, Team Leader Strategy, Port Phillip and Westernport Catchment Management Authority
- Professor Barbara Downes, Head of Department , Dept of Resource Management and Geography, Faculty of Science
- Dr Leanne Webb, Climate Projections Liaison Manager, Climate Adaptation Flagship
- Darren Wallace, Knox Environment Society
- Karen Lester, Senior Biodiversity Office, Environment & Water, Port Phillip Region Regional Services, Department of Environment, Land and Planning.
- Dr Will Steele, Senior Biodiversity Scientist, Melbourne Water

External experts and organisations were consulted to assist the development of specific indicators, including:

- BirdLife Australia: Dr Kerryn Herman and Dr Golo Mauro
- EarthWatch: Cassandra Nichols and Justin Foster
- Biosphere Pty Ltd: Dr Graeme Lorimer

2. Literature Review of biodiversity monitoring

To understand current best practice, we reviewed the scientific literature on ecological monitoring and identified the critical elements of successful monitoring programs.

2.1 Science of monitoring

What good monitoring should include

Ecological monitoring is defined as the collection of high-quality ecological information over long periods to provide insight into ecosystem structure and function. Good ecological monitoring can be used to assess the effectiveness of management actions, via measuring the state of a system before and after an intervention (Field *et al.* 2007). Unfortunately, many ecological monitoring programs worldwide, and in Australia, fail because they are unable to assess the effectiveness of conservation efforts and conservation return on investment, and therefore struggle to effectively improve biodiversity conservation (Lindenmayer and Gibbons 2012).

Lindenmayer and Likens (2010) describe the three types of common monitoring programs, namely:

- Curiosity driven monitoring: often done out of being inquisitive about a system, where data is collected in a haphazard manner with no real questions to test or sampling design.
- Mandated monitoring: often required by legislation, such as pollution monitoring.
- Question-driven monitoring: often conducted using a model or conceptual framework of the system to be monitored, with carefully crafted objectives and driven by a rigorous experimental design.

The first two types of monitoring programs generally can be described as **surveillance monitoring**. This type of monitoring can be useful to alert managers to a departure from a desired state. However, without predetermined ideas or hypotheses about how an ecosystem functions, or what threat needs monitoring specifically, these types of programs are constrained and often cannot be used to determine what types of actions should follow to return the system to the desired state (Legg and Nagy 2006). In contrast, **question-driven monitoring** is usually more targeted and will allow for adaptive management, as the use of specific objectives and an experimental design allows for the effectiveness of interventions or management activities to be assessed.

A significant body of literature now exists on what constitutes a good monitoring program, and what elements are essential for the success of monitoring projects (Lindenmayer and Likens 2010). These include, but are not limited to:

- The development of a conceptual framework or model of the system to be monitored;
- Development of monitoring questions and program objectives, that can be allowed to evolve as new data comes to hand;
- Design of repeatable and appropriate measurements or indicators;
- Collection of high quality data and implementation of good data management strategies;
- Rigorous and regular analysis and interpretation of data;
- Reporting, reflection and adaptation, and the frequent use of data;
- The development of a database for monitoring results that is accessible to multiple parties;
- The development of partnerships between scientists, resource managers and policy makers;

- Developing long-term funding and commitment.

To implement an adaptive approach, such as that desired by the EAGA Biodiversity Monitoring in Melbourne's East project, several key aspects need to be considered and incorporated. These include a framework that can evolve as new questions and new information come to light; and a framework that can incorporate new methods or protocols without distorting the integrity of the already recorded data (Lindenmayer *et al.* 2011). These approaches can be included in any type of monitoring program; however, in targeted monitoring programs these are likely to be more efficient.

Prior to embarking on a monitoring program, practical issues associated with monitoring need to be considered. The most common practical issues arising from attempting to implement a monitoring program are funding, setting objectives and sampling design (Field *et al.* 2007). Ongoing funding, the ability to detect change in ecological condition, and clear and measurable objectives are all extremely important aspects of the EAGA biodiversity monitoring framework that need to be considered throughout the life of the framework.

2.2 Key examples of biodiversity monitoring projects

There are many examples of biodiversity strategies from all levels of government, and several on-going projects aiming to understand how to better manage biodiversity under a changing climate. There are however, few current and completed Australian examples of best-practice monitoring that demonstrate how and what biodiversity to monitor to track the impacts of climate change. Below we discuss several noteworthy initiatives taken by natural resource managers aiming to conserve biodiversity, initiate monitoring programs, and in some cases account for climate change. Key lessons from each project have been distilled, and are used to highlight the range of issues for consideration during the Phase 2 project.

2.2.1. Accounting for biodiversity using a national accounting system: Accounting for Nature by the Wentworth Group of Concerned Scientists

The Wentworth Group of Concerned Scientists (WGCS) report *Accounting for Nature* describes a national system for accounting for Australia's natural assets, at scales that are relevant to economic and policy decision-making (Wentworth Group of Concerned Scientists 2009). They believe that such an environmental accounting system will:

1. Provide annual national, state/territory and regional (catchment) scale reports which measure the health and change in condition of major environmental assets;
2. Underpin the long-term catchment management and land-use planning decisions by Commonwealth, state/territory and local governments, and regional authorities; and
3. Improve the cost effectiveness of public and private investments in environmental management and repair.

The WGCS report details 10 principles upon which to base a national environmental accounting system, including data collection at regional scales. They propose data should be collected on the 'health' of key environmental assets including native flora, native fauna and soil, rivers and wetlands. The accounting system was trialled at a regional scale in 2010, and subsequently a '*Quick Guide: Guideline for constructing regional scale environmental asset condition assessments'* has been

developed (Sbrocchi 2013). Their approach has been successfully trialled in 10 regions across Australia.

The Quick Guide (Sbrocchi 2013) proposes a process for implementing an accounting system at a regional scale, including documenting the environmental assets in the region, developing indicators for assessment, collecting data and reporting on the condition of each asset. Assets of relevance to the EAGA region include native vegetation and native fauna, and relevant indicators include the extent, condition and connectivity of native vegetation patches.

The approach relies on comparing the condition rating to that expected in a reference site or benchmark condition, much like the Victorian Habitat Hectares method of vegetation condition assessment, described in Part 1 Section 5.1.2. Once the condition of an asset has been assessed, a single measure is then calculated, which is a measure of the relative change of the condition of the asset. This information is then collated, and can be submitted for accreditation and listed in the national accounting system.

This accounting system and process of developing indicators for environmental assets aligns well with the intention of the EAGA region monitoring framework. Guidelines for the selection of indicators are provided, and listed below in Section 5. No strict guidelines for which indicators should be included are given by Sbrocchi (2013), however the following metrics are proposed as useful measures for native flora and native fauna:

- Native flora: should include measures of 1) extent (ha) of native vegetation; 2) condition of vegetation (via bird species observations as a measure of suitable habitat, or diversity of native plant species as a measure of intactness); and 3) connectivity indices of habitat (for example via mapping patch connectivity); and
- Native fauna: should include measures of the extent of habitat for certain fauna groups, or extent of their distribution.

These measures are discussed further (section 5.1.2), and align well with some of the data already being collected in the EAGA region.

2.2.2. How to account for climate change in biodiversity monitoring programs: Climate-ready conservation by the CSIRO

The CSIRO has issued a report on how and why natural resource managers need to review their conservation objectives in light of a changing climate. The report "*Climate-ready conservation objectives: a scoping study*" by Dunlop *et al.* (2013) developed and tested a tool and a set of objectives to help natural resource management (NRM) planners and conservation decision-makers understand and explore the implications of climate-ready framing of their conservation objectives. The proposed 'climate-ready approach' is based on the following three propositions that challenge the current framing of conservation strategies. These are:

1. Conservation strategies accommodate large amounts of ecological change and the likelihood of significant climate change–induced loss in biodiversity.
2. Strategies remain relevant and feasible under a range of possible future trajectories of ecological change.

3. Strategies seek to conserve the different dimensions of biodiversity that are experienced and valued by society.

Dunlop *et al.* (2013) recommends that the first challenge is to set objectives to manage change, rather than attempt to prevent changes in biodiversity from occurring. Preventing change under future climates is not feasible, and instead conservation objectives should seek to minimise the loss of desirable biodiversity features. For example, instead of restoring an EVC, it can be revegetated with species better suited to future climates. Planning to manage change rather than prevent it is more realistic and achievable in relation to inevitable climate impacts.

Given the range of possible future ecological change, objectives that can accommodate a range of future end states are favoured. The report suggests that in urban areas a 'climate-ready' objective may be to maintain habitat in a range of settings, rather than to maintain a particular habitat in a specific place. In this way, under a variety of future climate scenarios, species should still have access to suitable habitat. 'Climate-ready' objectives that accommodate a range of future end states should articulate the characteristics of the preferred end state, such as having structurally complex habitat, rather than specifying the species or vegetation communities it should include.

A wide variety of biodiversity targets should be explored that represent the spectrum of values society associates with biodiversity. Strategies that seek to protect threatened species or certain ecological communities are likely to have a high risk of failure, so other aspects of biodiversity should also be considered. The report stresses that climate ready strategies need to consider multiple dimensions of biodiversity, stating that "climate change will affect many attributes of ecosystems and landscapes, as well as the species in them, which collectively make up biodiversity". Reference is made to strategies that include not only species or communities, but also landscapes and ecosystems, as all of these aspects of biodiversity are valued differently by society. Dunlop *et al.* (2013) goes on to suggest that objectives which maintain "functioning native ecosystems" and "a diversity of native species", rather than particular species or communities, will facilitate better outcomes in the context of a changing climate.

All of these propositions are relevant to the EAGA monitoring framework being developed, and can be used to help define the objectives of the framework. The propositions can assist with planning for conservation whilst taking into account the magnitude and uncertainty surrounding climate change. It is important to consider the maintenance of ecological functions or processes or the broad characteristics of desired end states, such as continued native plant recruitment, rather than specifying particular species or communities as end states.

To develop a climate-ready biodiversity monitoring framework, Dunlop *et al*. suggest an approach which includes adaptive management and resilience. For the EAGA region, this could include a learning-by-doing approach, where assumptions and management interventions are tested and refined as new information comes to light. Rather than simply stating that adaptive management can create resilience, a climate-ready strategy should state what is being made resilient. While adaptive management can help to develop more climate-ready management approaches, its use cannot prevent impacts of climate change on biodiversity. Dunlop *et al.* points out the difference between actions to manage climate impacts such as restoring habitat to maintain ecological processes (e.g. seed set or recruitment), and actions to prevent climate impacts such as restoring a

specific EVC in a specific reserve. The former action explicitly acknowledges that change will occur, and seeks to maintain important processes as change is occurring. This thinking has been applied (section 6) in developing the objectives and indicators that are considered most useful in the EAGA framework.

The tool developed by Dunlop *et al.* seeks to assist planners and managers to consider:

- how specific attributes of biodiversity may change under current and future climate change;
- uncertainty in the way climate change will affect species and ecosystems;
- what aspects of biodiversity should be actively managed under climate change; and
- the broad range of ways in which the community values biodiversity.

Ultimately, conservation objectives should be written so they are climate-ready. Dunlop *et al.* provides some excellent examples that can be used for setting objectives for the EAGA region. Examples of climate-ready conservation objectives given by Dunlop et al. (2013) that may be relevant for the EAGA region include:

Objective A: Preserve the abundance and diversity of wetland bird species, as the composition of birds found at the wetland changes over time.

Objective B: Maintain the current area (ha) of native vegetation, as the ecosystem types and species found in these areas change due to climate change.

Objective C: Maintain appropriate levels of key ecosystem functions at a location, as the ecosystem type changes over time.

These aspects of biodiversity and climate change were considered when reviewing the objectives developed during the consultation process of this project.

2.2.3. Biodiversity conservation at a regional scale: The Perth Biodiversity Project

The Perth Biodiversity Project is a Local Government initiative in Western Australia to promote the long-term conservation of natural areas in the Perth Metropolitan Region. It is a partnership between the Western Australian Local Government Association, 32 Perth Metropolitan Region Local Governments and peri-urban Local Governments, the Department for Planning and Infrastructure, the Australian Government's Natural Heritage Trust and the Swan Catchment Council.

The Perth Biodiversity Project supports Local Governments in the Swan Region through direct financial assistance for on-ground works and capacity building projects as well providing expert and technical information, advice and assistance for local biodiversity planning. One main output of the program has been the development of "Local Government Biodiversity Planning Guidelines" for the Perth Metropolitan Region. These Guidelines introduce a four-phase local biodiversity planning process culminating in the preparation and implementation of a Local Biodiversity Strategy. These Guidelines have been prepared for Local Governments to develop strategic approaches to conserving biodiversity, including the development of Local Biodiversity Strategies.

Whilst it is not the intention of EAGA to develop a Biodiversity Strategy for the region, these guidelines provide useful information relevant to the development of an EAGA Biodiversity monitoring framework. The guidelines provide a standardised set of ecological Local Significance

Criteria, which although are for the Perth area, provide a guide to establishing criteria on which a monitoring framework should be based.

These Guidelines focus primarily on ecosystem diversity across Perth, which they define as "the variety of habitats, biotic communities and ecological processes" present across the landscape. They focus on this because they believe that the conservation of ecosystem diversity is the most strategic way to conserve all levels of biodiversity (genetic, species and ecosystem) and aims to prevent these elements of biodiversity reaching the point where they become threatened. A method used to describe ecosystem diversity is the *ecological community concept*. In the Perth Metropolitan Region (PMR) the most common way to interpret and quantify ecological communities are the vegetation complexes (and their groupings into major landform elements), based on WA state government mapping.

Once local biodiversity Strategies have been adopted and implemented, the Perth Biodiversity Project aims to assist Councils to monitor and evaluate their actions. To facilitate this, a series of field templates for ecological assessment have been developed, and are available on-line at http://lbp.walga.asn.au/Tools/NaturalAreaInitialAssessmentTemplates.aspx.

Importantly, the Guidelines advocate the use of extent, condition and composition targets in relation to biodiversity, which are key aspects of interest in the development of the EAGA biodiversity monitoring framework. The Guidelines suggest the adoption of an 'area' (ha) target for local vegetation. The Guidelines state that Local Governments need to plan to 'retain ecological communities at thresholds that may prevent the exponential loss of species and maintain ecosystem processes', which equates to retention of 30% of any given ecological community. They do specify that this should represent pre-European communities, however, in light of the above-mentioned CSIRO climate-ready approach; we recommend that the use of such a target may need further revision. Condition assessment follows a similar format to that used in QLD, NSW and VIC (discussed in indicators Section 5), and includes recording the cover of the dominant species from each growth form layer (trees, shrubs, herbs etc.), weed species present and their distribution and the presence of threats and disturbances (such as foxes, rabbits, pests and diseases).

Key suggestions from the Perth Biodiversity Project that should be considered for adoption by the EAGA Councils include:

- The use of area (ha) and condition targets for each Council area, at the level of 'ecological communities'. **They recommend that measures for bushland condition should include area, shape, condition, perimeter to area ratio and connectivity.** For example:
    - **high edge to area ratios** may indicate that bushland patches may be subject to greater edge effects and hence be less resilient to a range of threats;
    - **low vegetation condition scores** may be achieved if a patch has fewer species, or a different composition of species than expected based on a reference community, if there are high levels of weeds or disturbances (fire, grazing etc.), or if the vegetation has been subjected to other impacts such as pests and disease;
    - **low connectivity scores** may result from bushland patches that are more isolated than desired levels, or are surrounded by patches in low condition.

2.2.4. Biodiversity in the Local Government context: Brisbane City Council

Brisbane City Council (BCC), Australia's largest local government area, has recently (2010) completed a process of investigating, trialling and finalising a biodiversity monitoring approach, which has now resulted in the development of a Vegetation Asset Management Plan.

This process included the development of a scoping paper, which proposed a method of capturing information to report on the progress of conservation objectives for many different Council programs. BCC has several programs in place to achieve biodiversity outcomes, all carrying different management activities and reporting against different objectives, such as Wipe Out Weeds (WOW), the Biodiversity Research Partnerships Program (BRPP), the Wildlife Conservation Partnerships Program (WCPP), and several more. The goal of the scoping paper was to propose a way to monitor the progress being made by each of these programs and develop indicators to report against each program objective.

This proposed method was peer reviewed in 2010 by scientists at the CSIRO (Fuller *et al.* 2010), and a set of recommended changes were proposed. The main recommendations of the review process focussed on setting program objectives, re-assessing the feasibility of indicators and sampling design, and ensuring data management procedures were in place. Some of the recommendations made by Fuller *et al.* (2010) were as follows:

- Clear and measurable objectives needed to be set for the overall monitoring program, including broad overall objectives, and more specific and targeted objectives for each of the Council programs.
- The major components of a monitoring program needed to be agreed upon by all parties within the Council, as many components were proposed, however under-resourcing and budgetary restrictions, meant it would be unlikely that all components could be included. Instead, the authors recommended monitoring fewer indicators, in a more comprehensive manner, rather than attempting to monitor many things badly.
- An analysis of the number of sites and frequency of visits that would be required to detect changes in biodiversity, to understand how much effort would be required for their program to deliver sufficient information.
- A data storage and interrogation plan needed to be developed, as the long-term success of a program would depend on future users being able to understand all past data collected.
- An establishment document needed to be developed, which states monitoring objectives, methods, data recording and storage protocols and reporting requirements.

Subsequently, BCC has reviewed their objectives, resourcing and sampling design, and over several years have developed their current Vegetation Asset Management Plan. The goal of this Plan is:

> "to maintain and restore a diversity of healthy habitats and wildlife across Brisbane, in a safe and responsible manner while balancing the influences and expectations of the Brisbane community and its visitors (pg. 5)."

To achieve this goal, BCC has now committed to measuring only one metric of habitat condition across the vegetation assets in the Council area, once every three years. They have set a desired

level of condition for their vegetation assets, and any deviation of the condition of the habitat from these desired levels reflects the effectiveness of their management strategies.

The condition of habitat is assessed using a modified, rapid version of The Queensland Herbarium's 'Bio-condition' methodology, called the 'Rapid Condition Assessment' (see Appendix A). This method results in a score from 1-5 for each vegetation asset, and has subsequently been assessed for all Council assets and mapped, creating a baseline 'rapid condition map'. Using this baseline (developed in 2013, Council has now started a process to assess general trends in vegetation change over time. To more fully monitor the effectiveness of specific management actions, BCC recognises that they will need to implement more specific, targeted and comprehensive monitoring in select locations, which they could link back to their programs listed above, such as Wipe Out Weeds. Hence, BCC acknowledge that their current rapid condition assessment cannot be linked specifically to their management actions. This is because in an urban context, vegetation condition in one area is subject to many external factors such as fire, pollution, rubbish dumping, water quality, connectivity, patch size and feral animals, many of which are outside the control of Council. They aim to incorporate further indicators in the future to account for this, or to develop specific targeted monitoring programs where required.

Key lessons learnt from the process undertaken by BCC include:

- **Less is more.** With limited resources and personnel, all staff responsible for delivering each of their conservation programs agreed that one rapid condition assessment was the only feasible metric they could include.
- **Use scientifically robust metrics.** The rapid condition assessment was developed in conjunction with The Queensland Herbarium, was field trialled at hundreds of sites, and revised accordingly, to ensure the data collected was of a high standard. They also recommend that a formal plan for data analysis and reporting be devised, in addition to undertaking an assessment to determine the number of sites required in their program.
- **Develop sound data management procedures.** All data collected must be accessible to all Council staff, and in a useable format. To facilitate this they developed a spatial data layer for storage in their corporate GIS system, and have procedures in place to store the raw data captured as well as any updates.

3. Review of current practice and policy context of each Council

A review of all EAGA Council policy and supporting documents pertaining to NRM within their LGA were compiled and reviewed. The primary purpose of this review was to develop an understanding of what monitoring was already undertaken by each Council, what variables were measured, how frequently, and under which policy document. This information was then themed, and is summarised below in Table 1. For the full summary of all Council documents reviewed please see Appendix B.

Table 1. Summary of the main types of monitoring programs undertaken in each Council, summarised by program type, or monitoring data type. For the full list of programs and measurement, see Appendix B. X = conducted by Council to some extent. ? = unsure from document review if activity is conducted. D = stated in a document that Council desires to undertake this activity, but is currently not doing so. Monitoring programs are undertaken or coordinated by councils unless otherwise stated.

Description of programs that collect data on natural or community assets	Boroondara	Knox	Maroondah	Monash	Stonnington	Whitehorse	Yarra Ranges	Other
Broad Council Programs/activities or data recording methods								
Street tree database	X	X	D	X		D	X	
Individual Reserve Management Plans	X	X	X	X		X	X	
Water quality monitoring (Water Watch (Melbourne Water and DELWP), EPA, Friends groups, Consultant, IRC)	X	X	X	X	X	X	X	Not necessarily managed by Councils
Friends Groups membership (no. participants)	X	X	X	?	?	X	X	
School Environmental Education Program		X			X	X	X	
Information for Residents (websites, signage, booklets)	X	X	X	X	X	X	X	
Resident Survey	X	X	X		X	X	X	
Tree Planting (usually with community)	X	X	X	X		X	X	
Habitat corridor restoration	X	X	X	X	X	X	D	
Backyard biodiversity program/incentives	X	X					X	
Planning Application for Vegetation removal/lopping	X	X				X	X	
Significant Tree Register	X	X	X		D	X		
Nature strip permits	X		X			X		
Connectivity program eg Living Links, Yarra for Life, Corridors of Green, Lower Yarra River Biodiversity Linkages Project : Reveg, weed control, community engagement	X	X	X	X	X	X	X	
Fauna programs or fauna monitored								
Turtle Monitoring (Demographics, aquatic veg and invertebrates)		X	X	X		X	X	ARCUE and Earthwatch conduct in

Description of programs that collect data on natural or community assets	Boroondara	Knox	Maroondah	Monash	Stonnington	Whitehorse	Yarra Ranges	Other
								these Council areas
Nest box monitoring				X	X			
Platypus Monitoring	X	X					X	Australian Platypus Conservation and Melbourne Water (separately)
Bird Surveys	X	X	X	X	X	X	X	BirdLife Australia has many sites in every municipality
Frog Census	X	X	X	X	X	X	X	Melbourne Water coordinate
Spotlight Surveys			X			X		
Vegetation Monitoring Variables								
Condition rating (different to habitat hectares method)	X	X	X	?	X	X	X	
Habitat Hectares				?		X		HH data collected for planning applications on private land
Flora Species List (variable methods used, transect, quadrat etc)	X	X	X	X	X	X		Also State-based Flora Information System (FIS)
Sites of conservation significance	X	X	X	X	X	X	X	
Area regenerated	X	X		X			X	
Connectivity Metric		X	X	X		D	X	
Threatened species list	X	X	X		X		X	
Tree Cover Ratio	X	X	X	X			X	
Vegetation quality map (often just reserve specific)	X	X		X	?	X	X	
Weed Cover	X	X	X	X	X	X	X	

4. Biodiversity monitoring framework development

The information for this discussion paper was collated and synthesised from a number of sources and consultation processes. We liaised with staff from the EAGA Councils in several ways, including workshops, written questionnaires and telephone interviews. Below we list each of the key meetings and workshops conducted to date, and summarise their purpose and outcome.

4.1 Meetings and workshops

4.1.1 Initial Working Group Meeting 5th February 2014

Members of the project working group and technical reference group came together in February 2014 to begin Phase 2 of the overall project. The group discussed the key lessons learnt from Phase 1 of the project, the scope, administration and governance of Phase 2, and the key points they wanted included in the biodiversity framework to be developed.

Desired elements of a successful framework from the Initial Working Group Meeting

Discussion focussed on what a successful framework might include, and the following major points have been summarised from the meeting minutes:

- The framework should a have clear purpose and defined objectives;
- The framework should be user friendly;
- The framework should focus mostly on natural habitat, indigenous flora and native fauna, rather than elements of exotic vegetation such as street trees;
- It must acknowledge differences in resources and natural assets between the EAGA Councils;
- It should be flexible and have different levels of complexity, where Councils could opt in or opt out of different sections;
- Provide a learning tool for other NRM managers;
- Provide hooks or good news stories to promote the message of urban biodiversity conservation.

In addition to these elements, the framework should include indicators that have a strong cause and effect association, to be able to detect any changes in habitat in relation to management actions, and/or climate change.

4.1.2 Workshop 1: Biodiversity Monitoring Scoping, 12th May 2014

Members of the project working group, technical reference group and representatives from grounds staff from each EAGA Council met with the project team in May 2014, to discuss the objectives and scope of the framework. Specifically, we wanted to gain a better understanding of the desired objectives of the framework; engage in a conversation about what effective monitoring is; discuss options for indicator development and; explore citizen science models to understand their potential utility in this framework. As part of this workshop, each Council was asked to complete a questionnaire that detailed their resources and ability to undertake a monitoring program, their expectations for the project and to document what monitoring they already do. The questions asked are presented in Appendix C and results are presented in Table 2.

The list of objectives for the project generated from discussions during Workshop 1, in addition to the Questionnaire completed by each Council, have been summarised in Table 2. Here, we synthesised the discussion into a series of similar objectives. We have also assessed where each of these objectives fit under three broad categories of activities, including biodiversity and climate change, management or community activities.

Table 2. Objectives for the EAGA Biodiversity Monitoring Framework summarised from Workshop 1 and the Council Questionnaire (i.e. Appendix C).

Objective	Biodiversity, and/or climate change	Management actions	Community engagement
Help with informing future decisions, and justify current ones (to themselves and others)		X	X
To get data to inform future grants – and data that is accessible to all		X	X
To assess if their actions are successful		X	
Build partnerships and capacity (between Councils, research, community) to build a better picture of this part of the world		X	X
To understand future risks (e.g. to guide plantings decisions to provide resilience)	X	X	
Monitoring response to major climate events	X		
Monitor response of ecosystem processes to climate	X		
Increase community engagement in the environment and biodiversity		X	X
Explicitly account for spatial elements (corridors, backyards, species movement)	X	X	X
To develop something that can be used elsewhere		X	

4.1.3 Workshop 2: Program Logic, 19th June 2014

Members of the project working group met to develop a Program Logic of common biodiversity activities, and the outcomes expected to contribute towards protecting and conserving biodiversity in the region. A Program Logic exercise builds a picture of why and how participants think their program or policy will work. This workshop was co-ordinated by an external consultant. During this workshop participants aimed to develop a shared set of objectives that conservation activities fall under, and interrogate the logic linking those activities to the objectives. A major outcome of this workshop was a list of key assumptions about the outcomes of activities currently undertaken, which was used to highlight opportunities for monitoring activities that have some relevance to a changing climate. The Program Logic and assumptions developed can be found in Appendix D.

During Workshop 2, a series of end of program outcomes were articulated for each Council, in addition to the development of broader goals for the EAGA region. There was significant overlap between Councils in the end of program outcomes for each Council, and this can be seen in the resulting Program Logic that emerged (for the full outcome of the Program Logic Workshop see Appendix D).

The broader goals for biodiversity in the region were:

1. **The EAGA region has resilient and functioning ecosystems that can adapt to climate change**

To achieve this broader goal, the area managed by EAGA Councils must have:

- Diverse indigenous habitat, including native flora and fauna
- Reduced weed cover
- Increased or sustained species numbers
- Greater connectivity among habitat patches
- Improved habitat quality (condition and extent)
- Increased or greater value placed on biodiversity by the community

2. **Communities actively protect biodiversity in the EAGA region**

To achieve this broader goal, the EAGA must have:

- Industry, Council and communities that better understand the health, wellbeing, and economic values of biodiversity (amenity, services, intrinsic value)
- Industry recognition and understanding of the importance of bushland restoration and management
- Governments of all levels that see investment and policy as critical to the health and ecosystems and wellbeing of communities.

4.1.4 Workshop 3: Indicator Selection, 3rd September 2014

Members of the project working group, technical reference group and Council policy officers and members of the bushland, environment and horticultural teams met with the project team in September 2014, to discuss selection of the final indicators for the framework. A list of seven potential indicators were short-listed from feedback received, and after a process of discussions and indicator ranking it was agreed that this list be reduced to four indicators, that were subsequently used in the indicator trial. The selected indicators were, Vegetation Extent, Vegetation Condition, Phenology and Bird Communities.

4.1.5 Workshop 4: Indicator Trial, 2nd December 2014

The project working group and technical reference group met with the project team in December 2014 to discuss the methods for collecting trial indicator data. Prior to this workshop, ARCUE devised methods of data collection for each indicator and the final methods adopted are described in Part II – Indicator Implementation Guide. As part of the method development, we summarised work undertaken by EAGA Councils as part of their existing vegetation condition data collection methods (Appendix E). This summary formed the basis for vegetation condition data to be collected during the trial, aiming to take the condition attributes most commonly collected by all Councils and make them compatible. Appendix E outlines the process of devising a compatible vegetation condition

rating system that leveraged currently used methods within the region. Appendix E subsequently outlines the methods used during the trial period to collect vegetation condition data. During this workshop the Part II document was outlined, and each Council given instructions and the data sheets required for completion of data collection during the trial period. After the trial period some of the methods were revised (including the collection of vegetation data), as indicated in Section 4.1.8 below.

During this stage of the project, EarthWatch was engaged to assist in the development of methods to capture phenological data, and EarthWatch staff member Cassandra Nichols gave a presentation outlining their ClimateWatch program, designed to collect phenology data using citizen science engagement. BirdLife was also engaged to assist in the development of methods to collect bird community data.

4.1.6 Framework trial period January – April 2015

The methods developed were trialled in the field, where Council staff and the community collected data for each indicator between January and April 2015. This included data collection for the four selected indicators, including vegetation extent, vegetation condition, phenology and bird communities. As part of the trial, the Cities of Knox, Stonnington and Monash developed ClimateWatch trails with assistance from EarthWatch. During the trial, Council officers worked with BirdLife Australia to develop a project webpage for data collection on BirdLife Australia website. The results of this engagement, method refinement and collaboration are reflected in the methodologies detailed in Part II.

4.1.7 Training Workshops March and April 2015

During the trial period, BirdLife ran two training workshops to train members of the Project Working Group and members of the public in bird identification and survey methods to be used in this Framework. During these workshops Dr Kerryn Herman from BirdLife guided participants through the use of bird field identification, binocular use, Bird Atlas data recording requirements, and the requirements for bird surveys under this Framework. Further training workshops can be provided by BirdLife if required, and the details of this are provided in Part II.

4.1.8 Workshop 5: Trial Feedback, 5th May 2015

Members of the project working group, technical reference group and representatives from Council environment staff met with the project team in May 2015 to discuss the outcomes of the indicator trial. Data collected under the vegetation extent indicator was reviewed, and a more complete process for capturing meaningful categories of vegetation and areas of restoration were agreed. Similarly the process of data capture for phenology and bird communities were reviewed, and refined methods for data collection were agreed upon. Lastly, the data collected under the vegetation condition indicator were reviewed, and extensively discussed with vegetation assessment experts from the University of Melbourne (Dr Chris Jones and Zoe Stevens).The vegetation condition data collected during the trial was found to be highly variable among assessors, and many attributes were poor indicators of management actions, and therefore of limited value for monitoring purposes. Chris Jones discussed an alternative method for monitoring vegetation change for consideration, and it was subsequently agreed by the EAGA Councils that a new method be adopted. These refined methods are detailed in Part II – Indicator Implementation Guide.

A summary of the key lessons learnt during the development phase of Part I are listed below:

Key lessons and principles that emerged during the development of this project were:

- Less is more: placing greater effort into monitoring fewer indicators will lead to more reliable outcomes;
- Monitoring may be broad and encompass many indicators or can be quite specifically focussed on a small number of parameters, with each strategy producing different outcomes;
- Where possible, capturing existing formal and informal monitoring will be the most productive way forward.

5. Considerations for the biodiversity monitoring framework

5.1 Selection of Indicators

5.1.1 General indicator selection principles

It is always best to directly measure the species or environmental condition that we are interested in. However this is not always possible and the use of indicators are an alternative approach. Indicators are 'surrogates for environmental end points' (Noss 1990), and can be used to indicate the health of a system. It is recommended that a suite of indicators be used over a single indicator, so that all facets of the regional ecosystem are considered, including composition, structure and function, as no one indicator alone will capture all of these components (Noss 1990).

The selection of indicators should be based upon the objectives of the program, and the available resources of each Council. Consideration needs to be given to both the depth and breadth of the selected indicators, to ensure they will deliver the type of information required for a successful monitoring program.

The following principles have been proposed when selecting indicators for ecological projects (Noss 1990; Dale and Beyeler 2001):

- Indicators should be sensitive to perturbations in a predictable manner;
- Indicators should be widespread in the region, or applicable across a wide range of conditions;
- Indicators should be easily measureable;
- Indicators should be able to differentiate between natural trends or cycles versus anthropogenic stress (such as light pollution, urbanisation etc.); and
- Indicators should be statistically valid and reproducible

To address the impacts of climate change, other considerations are required (Noss 1990). These include: 1) the climatic factors controlling major vegetation patterns, such as rainfall and

temperature; 2) the availability of suitable habitat and corridors; 3) what climatic factors control regional disturbance regimes, such as fire; 4) the physiological tolerances of species and their life histories, such as breeding requirements, day length requirements, or dispersal abilities; and 5) genetic variation within and between populations and how this may change in response to the climate.

These principles and considerations have been incorporated into the discussion of which indicators to include for the EAGA region below in Section 5.1.2.

5.1.2 Considerations for the selection of vegetation and fauna-based indicators

Native vegetation

Our literature review suggests an indicator of change in native vegetation should include a measurement of one or all of the following: extent, condition, connectivity and function.

Extent: In a regional context, many of the EAGA Councils have already committed to maintaining the extent of native vegetation within their LGA's, as listed under the Port Phillip and Westernport (PPWP) Regional Catchment Strategy (found at http://www.ppwrcs.vic.gov.au/assets-areas/whole-region/native-vegetation/targets/?I1=0&I2=0&I3=3), however extent targets without condition assessments as well, may not ensure quality habitat is provided in the region under a changing climate. Extent of vegetation communities, measured in hectare's using GIS mapping, will provide the EAGA Councils with a direct measure of how much native vegetation remains in their area. In this context, extent is a direct measure of how much habitat occurs in the area, and is therefore better than an indicator. This variable is already being measured by many Councils.

Condition: Vegetation condition has been measured in many different ways currently, both in the scientific literature, and by practitioners. Each Council within the EAGA region has different approaches to measuring bushland condition. Federally, there is no standard measure of vegetation condition, however the eastern states of VIC, NSW and QLD have all implemented very similar methods to standardise the measurement of vegetation condition. These are BioCondition, BioMetric and Habitat Hectares, respectively. Many aspects of these methods are already implemented within each Council area, as highlighted in Table 1.

The most consistent method for calculating vegetation or habitat condition in a single time period in the EAGA region is via the use of the DELWP Habitat Hectares (HH) method (Department of Sustainability and Environment 2004). Habitat Hectares provides detailed method for the measurement of Victorian native vegetation which is currently extensively used in the EAGA region. The condition score used is based on an assessment of habitat structure and diversity, in relation to a benchmark.

There are several constraints to the use of this approach for this project. These include the use of benchmark EVC communities, the applicability of this in an urban context and under future climates, and the utility of this method for monitoring change over time. Under this method, assessors are asked to record only species that are indigenous to the area, as non-indigenous native species are considered weeds. If the HH score was to be used in the EAGA framework, the recording of ALL species in each plot should be considered, as the proportion of indigenous natives to non-indigenous native species may provide a very useful indicator, as is suggested in Table 3. Further, there is great

variability of scores between assessors due to the use of cover estimates and categorisation of continuous variables (Appendix E; also Gorrod and Keith 2009; Z. Steven unpub). It is for these reasons that a new quantitative method has been developed, and is described in Section 3 in Part II of this framework.

Connectivity: Connectivity can be measured in various ways. Methods proposed in other biodiversity programs in Australia include:

- Measurement of the distance (m) between patches of mapped habitat, to ascertain how isolated patches are. Under the 2004 HH method, a 'distance to core' variable is measured, which is the distance from the centre of a habitat patch to the nearest patch of remnant vegetation, 50 ha in size or more. However, due to the extent of clearing in urban areas, the size of the "core" patch in urban areas will need to be re-considered.
- Measurement of the number, size and condition of mapped habitat patches surrounding a focal patch could also indicate connectivity, and the quality of habitat connections in the surrounding landscape. Again for example, in the HH approach, a 'neighbourhood analysis' included measuring the amount (ha) of mapped remnant vegetation within circular buffers surrounding each patch.
- The ratio of linked to unlinked habitat patches is also another connectivity indicator currently being measured by Knox City Council.
- Connectivity may also be indicated by the presence of migratory fauna species, or by the arrival of new plant species in a patch.
- However, urban and suburban backyards and street trees also contribute to connectivity for some species, and this is currently not accounted for in these connectivity measures.

Function: Very few biodiversity monitoring projects currently use a vegetation function indicator, largely due to the difficulty in measuring many facets of function, and the ease with which other suitable indicators can be measured. Recruitment of key species in a plot can be a very useful indicator for adequate seed set, dispersal and site disturbances. As assessment of recruitment has been removed from the revised HH assessment (yet to be released), due to its difficulty in implementation, lack of appropriate benchmarks and difficulty in assessing what adequate recruitment for a site should be. However, we propose two variables related to function, namely plant survival or recruitment and phenology (described further in Table 4) as they can provide a useful indication of either climate impacts or the effect of management activities.

Native fauna

Our literature review found that native fauna is rarely included in monitoring programs across Australia. Both the *Accounting for Nature* and the Brisbane Biodiversity approaches consider the use of bird diversity as an indicator of habitat quality, however indicators beyond the use of birds have not been fully considered in many current monitoring examples, other than those for research purposes.

The Port Phillip and Westernport Draft Regional Catchment Strategy (2014) has proposed a list of indicator fauna species for monitoring in the region, in addition to proposing native fauna targets surrounding desired diversity levels of fauna that currently occur in the region. The PPWP Catchment Management Authority based the selection of their indicator fauna on the following criteria:

1. Include animals from various taxonomic groups.
2. Include fauna that are relatively widespread and inhabit many of the region's environments.
3. Include fauna that share habitat, breeding and food requirements with other species in the same environments.
4. Include fauna that share, with other species, sensitivity to extent and/or quality losses in their habitats.
5. Include fauna that are sensitive to other common threats such as introduced predators.
6. Include fauna that are (as far as possible) easy to identify so monitoring can be done by landholders and community groups.

From this process, a list of reptile, mammal, amphibian and aquatic species were proposed, which may be considered as focal indicator species for use in the EAGA biodiversity monitoring framework. However, to be consistent with the climate-ready CSIRO approach, the use of a specific fauna species as an indicator may not be the most useful approach. In addition, further analysis is required to ensure the selected indicator species do in fact reflect the response of wider groups of species.

In the EAGA context, several Councils and organisations already measure various aspects of fauna occurrence including bird species, turtles, platypus, and nocturnal mammals. Comprehensive fauna surveys can be time- and cost-intensive however, and may only be considered appropriate if significant external support was provided, such as via the use of citizen science programs, existing volunteer surveys (such as bird surveys) or partnerships with a researcher (such as developing a partnership with the platypus monitoring program listed in Table 1 above).

Current fauna monitoring in the EAGA region includes:

- Whitehorse has several long term Birds Australia (BA) monitoring sites, and many other BA sites occur in all other EAGA Councils areas
- Platypus monitoring through the Platypus Conservancy
- Frog Census by Melbourne Water that spans all EAGA Councils
- Turtle monitoring though ARCUE and Earthwatch project, which spans five EAGA Councils
- Spotlight surveys have been conducted in Whitehorse and Boroondara
- Nest box monitoring in Monash

5.1.3 Expanded list of indicators suggested in each workshop

The following list of indicators was compiled from all of the available sources of information (Table 3).

Table 1. List of potential indicators for consideration. Workshop 1 (W1), Workshop 2 (W2), Document Review (DR). This list was subsequently refined during the project. Data already collected in some way by some or all of the Councils in the EAGA region is summarised in the last column. For specific methods and participating Councils, see Table 1 and Appendix D.

Suggested Indicator	Source	Justification	Measurement	Data collectors	Data already collected by each Council?
Regional Landscape					
Vegetation or habitat extent	DR, W2	Indicates amount of habitat in the landscape. If conducted at the level of vegetation class (such as woodland, heathland, wetland) instead/in addition to EVC's this will indicate compositional change over time	Area (ha) of mapped habitat patches.	Council GIS Officers, consultants	Yes, but not consistent between Councils
Habitat connectivity	DR, W1	Indicates amount and quality of habitat connections in the landscape	Distance to nearest patch (m), number and quality of surrounding habitat patches, area (ha) of habitat in buffers surrounding a patch	Council GIS Officers, consultants	Yes, but not all Councils
Community support for biodiversity protection	DR, W1	Indicates increased community engagement	Number of people involved in biodiversity projects and the value the community places on nature	Council Biodiversity officers or researchers	Yes, but not consistent between Councils
Biodiversity habitat in residential gardens	DR, W1	Indicates increased community engagement	Number of residents providing biodiversity habitat in their yard, and measurement of which biodiversity is benefited.	Council Biodiversity officers, consultants	Only two Councils: Knox and Boroondara
The presence of plant and animal species in new locations	W1, W2	Dependent upon the species located, may indicate adequate corridors, or	Presence records, opportunistic or targeted	Council Biodiversity	Yes, from plant species lists

Suggested Indicator	Source	Justification	Measurement	Data collectors	Data already collected by each Council?
		species movements	surveys	officers, Bush crews, consultants	and condition assessments
		Vegetation or fauna communities			
Vegetation condition	DR, W1	Indicates habitat condition, standardised methodology already exists	Habitat hectares or modified version	Council Biodiversity officers, Bush crews, consultants	Yes, currently use different methods
Weed cover and diversity	DR, W1,W2	Indicates habitat condition, could indicate weed species of concern if new species are recorded in new sites	Habitat hectares or modified version	Council Biodiversity officers, Bush crews, consultants	Yes, currently use different methods
Proportion of existing versus new plant species (vegetation composition)	DR	Indicates compositional change over time, and new species arrivals. Will also indicate if new weed species are establishing.	Plant species list (could be part of HH assessment)	Council Biodiversity officers, Bush crews, consultants	Yes, could be generated from plant species list
Presence and diversity of plants that favour wet condition	W1	If new species are recorded it new areas it may indicate a vegetation composition shift in response to climate. This is likely to be highly affected by drainage re-direction works.	Targeted and opportunistic presence records	Consultants, researchers, bush crews, friends groups	Not specifically
Presence and health of plants sensitive to heat events	W1	Use species indicated in Phase 1 to be climate sensitive. Can indicate potential loss of species or composition shift in response to	Targeted assessment of species health (pests and disease). Record observations of flowering	Consultants, researchers, bush crews, friends	Not specifically

Suggested Indicator	Source	Justification	Measurement	Data collectors	Data already collected by each Council?
		climate	start, duration, fruit and seed production. Record success/survival of revegetation efforts.	groups, indigenous nurseries	
Seed production of targeted species	W1	Use species indicated in Phase 1 to be climate sensitive. Can indicate potential loss of species or composition shift in response to climate. Could indicate inadequate pollination.	Successful seed set and seed viability	Consultants, researchers, bush crews, friends groups, indigenous nurseries	Not specifically
Survival of targeted plant species in remnant and revegetation areas (plant survival)	DR, W2	Use species of concern, or those indicated in Phase 1 to be climate sensitive. Can indicate potential loss of species or composition shift in response to climate.	Record survival in quadrats (% survival of different cohorts). Record success/survival of revegetation efforts.	Consultants, researchers, bush crews, friends groups	Not formally, anecdotal records exist
Natural recruitment of remnant and revegetated plant species	W2	Can indicate inadequate pollination, seed set, or disturbance regimes	Recruitment as measured using the habitat hectares method	Consultants, researchers, bush crews, friends groups	Yes, as part of old HH method
Successful propagation of targeted flora	W2	Can indicate if new species or propagation techniques are needed	Plant survival measured in nurseries	Consultants, researchers, bush crews, friends groups, indigenous nurseries	Not formally, anecdotal records exist

Suggested Indicator	Source	Justification	Measurement	Data collectors	Data already collected by each Council?
Presence and density of large old trees	DR, W1	Critical keystone structure for fauna, indicates presence of critical habitat	Number of trees in different age and size classes	Council Biodiversity officers, Bush crews, consultants, friends groups	Yes, as part of HH
		Species			
Phenology of targeted flora (plant phenology)	W1	Can indicate changed climatic conditions if flowering time or duration changes over time	Observations of first and last flowering times and flowering duration	Bush crews, consultants, friends groups, community	No
Presence of targeted fauna species (birds, butterflies, birds, frogs, platypus)	DR, W1	Can indicate habitat health	Targeted and opportunistic presence records	Existing Council surveys (consultants), Birdlife, Frogwatch and PlatySPOT, community	Yes, restricted to birds, platypus, turtles, frogs
Presence of targeted fauna species in revegetation sites	W2	Can indicate revegetation success and habitat health. Could be incorporated into above targeted monitoring.	Targeted and opportunistic presence records	Bush crews, consultants, friends groups	No

Suggested Indicator	Source	Justification	Measurement	Data collectors	Data already collected by each Council?
Aquatic species diversity (macro inverts, frogs, platypus)	W1	Can indicate habitat health	Targeted and opportunistic presence records	Consultants, researchers, PlatySPOT	Yes, restricted to platypus, turtles, water quality
Presence of the powerful owl	W1	Indicates adequate breeding and/or foraging resources are present.	Record nesting or breeding activity	Consultants, researchers, bush crews, friends groups	Not specifically
Presence of foxes	W1	Indicates a threat to native fauna	Record population density	Consultants, researchers, bush crews, friends groups	Not specifically
Presence of the Superb Fairy Wren	W1	Indicates sufficient habitat structure	Targeted and opportunistic presence records	Bush crews, consultants, friends groups, schools	No
Presence and emergence of the Common Brown Butterfly	W1	Can indicate changed climatic conditions if emergence time changes over time	Targeted and opportunistic presence records and observation of emergence dates	Bush crews, consultants, friends groups, schools	No

5.1.4 Short list of indicators proposed for consideration in the EAGA biodiversity monitoring framework

From the above table (Table 3), we short-listed indicators we believe will give the most robust results for the EAGA project. We proposed the following indicators for consideration and discussion following the review of this document by the Project Working Group and Technical Reference Group. After Workshop 3, this list was then further refined, and the final four indicators with supporting methodology have been included in Part II. These were:

- Vegetation Extent
- Vegetation Condition (subsequently revised to Vegetation Change)
- Phenology
- Local bird communities

Table 2. Short-listed indicators for consideration in the EAGA Biodiversity Monitoring Framework. Table details the ease of measurement and if the variable captures the intentions of the framework. * Indicates this variable addresses a risk identified in the EAGA Climate Risk Assessment (Eastern Alliance for Greenhouse Action (2014) Adapting to climate change in Melbourne's east: A regional risk assessment for member Councils of the EAGA.)

Suggested Indicator	Ease/expense of measurement	Does it address climate change specifically?	What influences change in this variable?	Will this inform management?	Measured already?
Vegetation or habitat extent *	Relatively easy, requires GIS mapping and field verification of defined vegetation classes.	Yes. Indicates amount of habitat in the landscape, but only if broken into vegetation classes likely to change under climate change.	Loss due to land clearing. Loss due to climate change. Addition due to restoration. Addition due to new plant species establishment.	Yes. If desired vegetation classes are being lost over time, revegetation and restoration efforts could be reviewed to re-instate desired elements of habitat.	Yes
Vegetation or habitat connectivity	Relatively easy, requires GIS mapping of habitat patches, and quality of patches if desired.	No. Indicates habitat available for movement of species. May indicate success of revegetation efforts. May be useful to assess resilience of the landscape.	Loss due to land clearing. Addition due to restoration. Addition due to new plant species establishment.	Yes. If levels of connectivity are declining over time, revegetation efforts could be directed to areas identified as requiring greater connectivity.	Yes
Vegetation condition *	Difficult, and expensive, however already conducted to some extent by all Councils.	Not directly. Declines in condition can be attributed to changes in composition and structure, as recorded using the HH method.	Decrease due to many external factors (weeds, climate, feral animals, human disturbance). Increase due to management actions.	Yes, if conducted in permanent plots. Can be used to direct management actions to aspects of declining condition.	Yes

Vegetation composition *	**Moderately difficult and expensive, however already conducted to some extent by all Councils.**	**Yes. If changes in the expected species composition are occurring this may indicate the arrival and establishment of new plant species.**	**May change due to changed climate, and increased weeds.**	**Yes, if conducted in permanent plots. Can be used assess the extent of compositional change occurring, and used to assess if actions are required to replace certain vegetation forms in the landscape.**	**Yes**
Plant survival *	Moderately difficult and expensive, however could be done during condition and composition assessment. Likely to be most useful in sites of revegetation.	Not directly. If all reasonable actions are taken to ensure survival, unexpected loss of plants may be due to climate change.	Plant death or survival due to maintenance actions (watering, weeding, disease). However, if all reasonable actions are taken to ensure good growth conditions, plant death may be due to climate change.	Yes, if conducted in permanent plots. Can be used to direct management actions to areas of unexpected low plant survival.	No. Would need to develop method.
Plant or animal phenology	Relatively easy. Could be conducted during above surveys, or by the community.	Yes. Changes in the timing and length of flowering or breeding events are directly linked to climate change.	Plants/animals may flower or breed earlier, or for longer if climatic conditions change. Plants may not flower at all if climatic conditions are inappropriate.	No. Few on-ground management actions can be taken to alter plant or animal phenology.	No. Opportunity to use Earthwatch Climate Watch Program.
Bird communities *	Relatively easy. Already conducted by many Councils, could be conducted by the community.	No. Changes in bird diversity may be caused by many factors.	Loss due to lowered habitat condition or extent. Loss due to predation, competition, lack of resources. Increase due to species migrations. Increase due to improved habitat conditions.	Yes. Can be used to asses 'health' of habitat, and direct management to improve habitat condition.	Not everywhere. Opportunity to use BirdLife sites and programs.

5.2 Final development of the framework – Part II Indicator Implementation Guide

The purpose of this discussion paper was to document and explain the development of the final framework. During the review of the proposed indicators we discussed their suitability in relation to current Council resourcing. During the January – April 2015 trial period, data for the four selected indicators namely, vegetation extent, vegetation condition (subsequently revised to vegetation change), bird communities and phenology were collected. This reduced list was agreed upon during Workshop 3. The subsequent document developed, Part II – Indicator Implementation Guide, includes the following information:

- Recommended methods for data collection to measure the state of the reduced set of indicators, including methods for data recording and storage.
- Recommendations for the sampling design, and the number of sites required for each indicator.
- How indicators can be used to feedback into management.

Part II describes the survey methods, provides field templates for recording data, and outlines a reporting procedure. The indicators each Council uses will reflect their resourcing and capacity to undertake monitoring. It is expected that for the success of the project a minimum set of indicators are monitored by all Councils, and additional indicators can be selected on a case by case basis.

6. References

Dale VH, Beyeler SC (2001) Challenges in the development and use of ecological indicators. Ecological indicators 1(1):3-10

Department of Sustainability and Environment (2004) Vegetation Quality Assessment Manual–Guidelines for applying the habitat hectares scoring method. Version 1.3. . Victorian Government Department of Sustainability and Environment, Melbourne, Australia

Dunlop M, Parris H, Ryan P, Kroon F (2013) Climate-ready conservation objectives: a scoping study. National Climate Change Adaptation Research Facility, Gold Coast

Field SA, O'Conner PJ, Tyre AJ, Possingham HP (2007) Making monitoring meaningful. Austral Ecology 32(5):485-491

Fuller R, Rhodes J, Martin T (2010) Brisbane City Council Biodiversity Monitoring Framework Peer Review: Final Report. Prepared for Brisbane City Council. CSIRO

Gorrod, E, Keith, D. (2009) Observer variation in field assessments of vegetation condition: Implications for biodiversity conservation. Ecological Management and Restoration 10(1):31-40

Legg CJ, Nagy L (2006) Why most conservation monitoring is, but need not be, a waste of time. Journal of environmental management 78(2):194-199

Lindenmayer D, Gibbons P (2012) Biodiversity monitoring in Australia. Collingwood, Vic. : CSIRO Publishing

Lindenmayer D, Likens G (2010) Effective ecological monitoring. Csiro publishing

Lindenmayer DB, Likens GE, Haywood A, Miezis L (2011) Adaptive monitoring in the real world: proof of concept. Trends in ecology & evolution 26(12):641-646

Noss RF (1990) Indicators for Monitoring Biodiversity: A Hierarchical Approach. Conservation Biology 4(4):355-364

Port Phillip and Westernport (2014) Draft Regional Catchment Strategy. Available from http://www.ppwrcs.vic.gov.au/ accessed July 2014

Wentworth Group of Concerned Scientists (2009) Accounting for Nature: A Model for Building the National Environmental Accounts of Australia. Wentworth Group of Concerned Scientists