

# BUILDING BIODIVERSITY

URBAN BIODIVERSITY RESILIENCE RESEARCH PROGRAM









Department of **Biodiversity**, Conservation and Attractions









Government of Western Australia Department of Jobs, Tourism, Science and Innovation



Government of Western Australia Department of Mines, Industry Regulation and Safety



Department of Primary Industries and Regional Development

Government of Western Australia Department of Water and Environmental Regulation

## BUILDING BIODIVERSITY FOR FOR THRIVING URBAN ECOSYSTEMS

Published September 2023

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#### THIS DOCUMENT SHOULD BE CITED AS:

*Mennen, S. (2023). Building biodiversity for thriving urban ecosystems.* The Western Australian Biodiversity Science Institute, Perth, Western Australia.

ISBN 978-0-646-88066-2

#### COVER PHOTO ACKNOWLEDGEMENTS:

MAIN IMAGE: Sonja Mennen INSETS (top and middle): Department of Biodiversity, Conservation and Attractions (DBCA), (bottom) Botanic Gardens & Parks Authority (BGPA)



## ACKNOWLEDGEMENTS

We thank the Swan (Perth) NRM committee and the Urban Development Institute of Australia (Western Australian branch) Environment Committee for their participation in the initial scoping sessions in 2018.

We are particularly grateful to the workshop participants listed in Appendix 3 who participated in an open and respectful way to generate the valuable content upon which this program has been developed.

We acknowledge the support and endorsement of the WABSI Board of Directors and thank Professor Owen T. Nevin (WABSI), Dr Bruce Webber (CSIRO) and Dr Vandana Subroy (WABSI) for their valued input into the development of this program. Thank you to Preeti Castle (WABSI) for assistance with structure, layout and in the publication of this document.

## **Acknowledgement of Country**

We acknowledge the traditional custodians throughout Western Australia and their continuing connection to, and deep knowledge of, the land and waters. We pay our respects to Elders both past and present.

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# EXECUTIVE SUMMARY

Western Australia's South West, including the Perth metropolitan area, is Australia's only recognised global biodiversity hotspot, and is home to a variety of unique flora and fauna. In fact, this region has the highest concentration of rare and endangered species in Australia and contains about 8,000 plant species more than one-third of Australia's known flowering plants. It is also home to many different animals, birds and fungi species, many of which are endemic. As a biodiversity hotspot, the region provides crucial ecosystem services for human life, such as provision of clean water, pollination and climate regulation.

Globally, urban development is causing major landscape changes and is frequently associated with loss of species richness and density, and increased homogenisation of ecological communities. Compared to other cities nationally and internationally, the Perth urban landscape is relatively early in its development, however it is catching up fast and rapid urban growth has caused extensive biodiversity loss since British settlement nearly 200 years ago. Continuing development, especially at the fringes of the city, is the main catalyst for fragmentation of the landscape and the loss of native flora, fauna and ecosystem functions.

Western Australia is also experiencing the impacts of climate change. Perth's climate is expected to become harsher under future climate projections. As Western Australia's urban population density continues to rise, the environment faces greater climate risks, as do governments, industry and the wider community.



The issue of urban biodiversity resilience requires an integrated approach with a clear focus on collaborative opportunities for problem-solving, and tapping into existing resources, knowledge and expertise to apply best practice land management. Collaboration between a broad group of stakeholders provides an opportunity to tackle the most pressing biodiversity challenges that are facing ecologists, policy makers, scientists, urban planners, developers and local governments.

## Identification of knowledge gaps

WABSI consulted with stakeholders through a series of scoping sessions and workshops to develop a program of research for closing knowledge gaps identified by end users with an interest in biodiversity resilience.

The first urban biodiversity workshop was held in November 2021 and was attended by representatives of state and local government, community groups, Natural Resource Management organisations (NRMs) and industry. In this session, five focus areas for research emerged:

- 1. Ecosystem restoration
- 2. Green infrastructure and urban forests
- 3. Climate change resilience
- 4. Fire mitigation
- 5. Traditional knowledge and values

Another potential focus area that evolved was '*Biodiversity in peri-urban and regional urban areas*'. A decision was made to include the topics '*Traditional knowledge and values*' and '*Biodiversity in peri-urban and regional urban areas*' as a consideration under each of the other research focus areas.

## **Development of a prioritised research framework**

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Informed by a second workshop in April 2023 and further stakeholder engagement with end users and researchers, this document sets out a plan for urban biodiversity resilience research in Western Australia. Its objective is to address knowledge gaps identified through end user engagement by the development of a prioritised research framework.

The research framework features four high-level themes. Within each theme a number of research focus areas, outcomes and objectives are identified to address critical knowledge gaps:

	Focus area	Outcome	Objectives	
	Remnant vegetation fauna	Existing natural areas thrive and are abundant with native flora and fauna	Prevent loss of existing natural areas in the Perth metropolitan area, peri-urban and regional urban areas.	
ш			Enhance tree canopy cover in urban areas.	
ERVI			Target areas that benefit most from biodiversity enhancement.	
NS			Practice optimal management of existing urban natural areas.	
1. CO	Native fauna	Herbivore density in urban areas provides optimal benefits to biodiversity resilience	Establish sustainable herbivore populations in urban areas.	
	Habitat restoration Habitat and scapes provide habitat, food resources, land connectivity, healthy waters and soils	Restored urban landscapes provide habitat, food resources, land connectivity,	Enhance landscape connectivity in the urban environment.	
ш			Use native species that bring optimal benefit to biodiversity.	
STOR		Apply fire as a regenerative tool in an optimal way to establish biodiversity resilience.		
2. RE	Water for biodiversity	Water use in urban areas sustains ecosystem services such as ecological health and heat mitigation	Use water effectively to sustain a biodiverse urban environment.	



	Focus area	Outcome	Objectives
DESIGN	Best practice design	Newly designed urban green spaces deliver on-site benefits to native species and ecosystems through the provision of essential habitat and food resources.	Integrate appropriate, biodiversity-focussed design protocols into urban green space development.
Ċ	Climate change resilience	Biodiversity in urban green spaces flourishes in Western Australia's future climate	Introduce nature-based solutions based on species that are appropriate for Perth's future climate.
GUIP	Decision- making tools	End-users make decisions about enhancing biodiversity resilience based on robust and accessible scientific data and information.	Devise and synthesise existing information on biodiversity enhancement, e.g. retaining/increasing tree canopy in urban areas.
4. E	Value of ecosystem servicesCultural and social- science knowledge is used for the management of urban green and blue spaces.	Increase community awareness of the benefits of ecosystem services and a thriving urban biodiversity.	
		Include cultural values and knowledge systems in ecosystem management.	



MAIN IMAGE: Peter Nicholas – DBCA INSETS: Megan Hele To address urban biodiversity resilience in Western Australia, four knowledge gaps were identified by stakeholders as top priorities:

- What parts of the urban landscape/remnant habitats will benefit most from targeted urban biodiversity enhancement?
- How can we prevent loss of tree canopy cover on residential land?
- How connected can the landscape be made
  what are the optimal minimal linkages that can be provided?
- What is the optimal design of service/ infrastructure corridors and assets to support green corridors for biodiversity?

IMAGE: Urban Development Institute of Australia

## What next?

The implementation of this research program will require an effective governance structure and significant resources. A dedicated steering committee would provide the required oversight to facilitate the delivery of this program, a model that works successfully with WABSI research programs. Strong alignment with research initiatives underway locally, nationally and in other states, and with relevant regulatory and policy bodies will enhance outcomes and reduce the risk of overlapping effort.

Multiple sources of funding, including Commonwealth and State Government funding schemes, Lotterywest, Natural Resource Management grants, industry associations and philanthropic sources, are all realistic options that support end user driven research.

We encourage land managers and the research community working in the field of biodiversity resilience in Western Australia to share and discuss their interests, management challenges and opportunities with us and engage with the delivery of this program as we seek to transform this document into tangible on-ground impact.

MAIN IMAGE: Peter Nicholas – DBCA INSETS (from left): Megan Hele, Peter Nicholas – DBCA

## Key benefits of the research program

## ENVIRONMENTAL

- Natural areas thrive and are abundant with native flora and fauna now and in the future.
- End-users make decisions about enhancing biodiversity resilience based on robust and accessible scientific data and information.

## ECONOMIC

- Native and introduced flora and fauna provide optimal benefits to biodiversity resilience.
- Water use in urban areas sustains ecosystem services such as ecological health and heat mitigation.
- Newly designed urban green spaces deliver on-site benefits to native species and ecosystems through the provision of essential habitat and food resources.



## SOCIAL

- Increased community connection to and appreciation of urban ecosystems helps enhance biodiversity resilience.
- Cultural and social-science knowledge is used for the management of urban green and blue spaces.



# INTRODUCTION

The Perth urban landscape is relatively early in its development and retains considerable biological diversity assets in contrast to many other cities nationally and internationally. Significant urban development, including industrial, commercial and residential expansion, has only taken place in Western Australia over the last 150 years. Nowadays about 2.1 million people call the Greater Perth area home (ABS 2022).

Western Australia's South West is known as an internationally recognised biodiversity hotspot because of its high endemicity of flora and fauna species - about half of southwest Western Australia's 8,000 plant species are found nowhere else. However, due to rapid urban growth, biodiversity loss has been extensive (CEPF 2023).

There are few places where the loss of biodiversity is more pressing than our urban landscapes. While we have already lost over 80 per cent of our wetlands on the Swan Coastal Plain (DWER 2022) and endangered remnants of the banksia woodland communities remain under threat, there is a need to increase development to meet population projections. A diverse set of stakeholders and land managers with an equally diverse set of interests, motivations and constraints can make it complicated to achieve outcomes that balance results across social, economic and environmental domains. Each interest group is working within its given remit, often with a focus on asset management rather than an integrated view across all aspects of the urban landscape.



The issue of urban biodiversity resilience requires an integrated approach with a clear focus on collaborative opportunities for problem-solving, and tapping into existing resources, knowledge and expertise to apply best practice land management, which will help achieve multiple benefits with the limited resources available.

It is in this light that WABSI has recognised the value of developing an initiative around urban biodiversity resilience. Within this focus we connected stakeholders, identified and prioritised end user requirements and shared knowledge gaps. The result is this urban biodiversity resilience research program, which aims to facilitate addressing knowledge gaps through targeted and coordinated research.

## **Issues and challenges**

Urban biodiversity is a broad issue and dividing the relevant challenges into logical initiatives will make it easier to identify areas to address.

Urbanisation is one of the most pervasive agents of contemporary landscape change globally and is frequently associated with decreased species richness and density, and increased homogenisation of ecological communities (Ottewel et al. 2019). A major challenge that is confronting ecologists, policy scientists, urban planners, developers and local governments is to find strategies for the optimal management of biodiversity that are compatible with the increasing urban sprawl and need for housing development.



### **REMNANT VEGETATION**

The continuing expansion and population growth of metropolitan Perth has meant that much native vegetation has been, and continues to be, lost to development, especially at the fringes of the city (Hercock et al. 1997). On the Swan Coastal Plain biogeographic region, in which Perth is located, approximately 30 per cent of the former extent of native vegetation remains intact (Pauli and Boruff 2016).

Banksia woodlands were once common and formed almost a continuous band of large bushland patches around Perth and other near coastal areas, with most remaining patches now small in size. This fragmentation is leading to the decline of many plants, animals and ecosystem functions (Commonwealth of Australia 2016). Research has shown that it is important to maintain vegetation connectivity in the landscape to enhance resilience for native fauna (Rycken 2021).

### **WEEDS INVASION**

The invasion of weeds poses a serious threat to urban bushland ecosystems. The South West region of Western Australia experiences considerable weed threats (Webber 2021). Bushland weed management comprises working complex natural systems with a long history of varying disturbances. Knowledge and understanding of impacted sites are key to effective weed management, e.g., the distribution of the native plants and the native plant communities, the patterns of disturbance and the distribution of weeds.

Prescribed burning programs can also promote the establishment of weeds, so it is important to incorporate weed management where burning has occurred or is planned to prevent further invasion and degradation.

<complex-block>

### **VERTEBRATES IN URBAN LANDSCAPES**

Fragmentation and loss of connectivity in urban environments has consequences for native fauna. Individual species respond differently to urbanisation and fragmentation. Many disturbance-sensitive species are unable to survive outside of natural habitat in urban areas (urban avoiders), whilst others that are able to exploit resources or novel ecological niches in urban environments can persist (urban utilisers) or may even prosper (urban dwellers) (Ottewell et al. 2019).

Providing ecological connectivity in the heterogeneous urban landscape is seen as a key component of biodiversity conservation, particularly for those species sensitive to urbanisation, to facilitate dispersal and retain functional connectivity.

### **TREES IN URBAN ENVIRONMENTS**

The loss of urban green space and native vegetation is of particular concern in the greater Perth metropolitan area, particularly in those areas where there is clearing of land for infill and greenfield development.

Trees and other vegetation are an essential part of the urban fabric, providing a variety of significant social, economic, and environmental benefits to the community. Some of these benefits include increased shading and cooling of urban areas, improved aesthetics and social amenity. Climate change, with increasing air temperatures and decreasing annual rainfall predicted, will have a significant impact on tree retention and management and the ability for urban forests to sequester carbon (DPLH 2018).

Canopy cover in the Perth metro area currently sits under 20 per cent, the lowest of any capital city in Australia, and it has been declining steadily, down from 22.3 per cent in 2009 (202020 Vision 2017). Research shows that the majority of neighbourhoods in Perth have a percentage of tree canopy cover below 15 per cent (Saunders et al. 2020). Eighty-five per cent of Perth's tree canopy is on private land (DPLH 2018).

The remaining canopy cover can mostly be found in public open space, on verges and utility owned land. Local governments and utilities have the opportunity to use this land to expand green infrastructure throughout the urban area to enhance biodiversity, however they also need to factor in recreational value, safety aspects and asset management.



MAIN IMAGE: Botanic Gardens & Parks Authority (BGPA) INSETS (from left): DBCA, BGPA

### **IMPACTS OF CLIMATE CHANGE**

Perth's climate is expected to become harsher due to the impact of climate change (DWER 2021). Average temperatures are projected to increase in all seasons. By 2030 the mean annual warming is predicted to be up to one degree Celsius above the climate of 1986–2005. Perth's climate will be more like that of Jurien Bay.

The South West of Western Australia has experienced a marked drying trend since 1970, particularly during autumn and early winter. Reduced recharge to the superficial Gnangara and Jandakot mounds due to reduced rainfall is threatening groundwater-dependent vegetation on the Swan Coastal Plain, with likely changes in floristic composition over time (Pauli and Boruff 2016). On the other hand, the intensity of heavy rainfall events is likely to increase.

Sea levels will continue to rise, and coastal waters are projected to warm up to 3.9 degrees Celsius (DWER 2021). Climate change will also account for a harsher fire weather climate in the future.

Climate is an integral part of ecosystem functioning and human health is impacted directly and indirectly by results of climatic conditions upon terrestrial and marine ecosystems. As such climate change will pose a significant risk to Western Australia's biodiversity.

#### **FIRE MITIGATION**

Western Australian landscapes have evolved in the presence of fire, and plants and animals have adaptations that enable them to co-exist with regimes of fire characterised by the season, intensity, frequency, and scale of burning (DBCA 2023).

Regular low to moderate intensity fire in the landscape is a primary mechanism to cycle nutrients through the nutrient-poor soils of the greater Perth metropolitan area. Plant species have a range of adaptations that help them to persist through fire. In some situations, fire can also be an ecologically friendly and cost-effective tool to help regenerate and rehabilitate vegetation on degraded sites. It helps new seedlings by temporarily reducing competition from established vegetation and creating ash beds suitable for germination.

Fire affects fauna distribution and occurrence because it burns fauna habitat. Native animals have adapted to survive and thrive in fire-prone environments. After a fire, the occurrence and abundance of animals is dependent on the rate at which the vegetation recovers.

However, fire regimes can also promote the establishment of weeds, increase erosion by exposing the soil surface and negatively impact water quality in catchments.



## WATER FOR BIODIVERSITY

Water availability can significantly impact urban eco-systems and is a critical issue for survival and longevity of trees, shrubs, bushlands and its inhabiting wildlife. Drier and hotter conditions with less rainfall will lead to decreased soil moisture and runoff due to increased evapotranspiration.

Historically Perth has relied heavily on aquifers to supply groundwater for drinking, farming, industry and public open space. Groundwater resources support nationally significant groundwater-dependent ecosystems, such as wetlands and Banksia woodlands. These groundwater-dependent ecosystems support biodiversity (DWER 2022).

Less rainfall because of climate change, and continued groundwater use have lowered water tables, which are impacting on the health of the urban landscape. The planting of more drought-tolerant species can help creating a landscape that is able to survive with less water.

However, to combat urban heat due to higher temperatures it is important to create green, shady spaces that provide relief from summer heat. Parks and gardens are kept lush and green through irrigation and thus water is integral to keeping urban areas cool, green and sustainable. In future more water will be needed to keep these 'introduced, watered ecosystems' resilient and thriving.

Western Australia is increasingly becoming a multi-cultural society and people from various cultural backgrounds often have their own connection to water. Establishing a connection between various communities and their watered environment may enhance biodiversity by establishing the right conditions for native flora and fauna species to flourish.

The above-mentioned challenges come with opportunities. Research highlights that Australian cities are important for the conservation of threatened species (Ives 2016). Numerous and diverse stakeholders have an interest in enhancing our urban environment so our native flora and fauna can thrive. To date considerable research, strategy and policy work has been undertaken around urban biodiversity.

Collaboration between a broad group of stakeholders provides an opportunity for synergy and to create access to greater resources, knowledge and expertise. Through collaboration, we can identify, prioritise and execute best practice land management and address the knowledge gaps which remain within the research area of urban biodiversity resilience.

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IMAGE: Megan Hele

## PROGRAM OUTLINE

A step change in the quantity and duration of funding and resourcing for urban biodiversity resilience research is crucial to address knowledge gaps and deploy new knowledge generated.

To address these needs, WABSI has acted on end user led momentum to initiate the development of a prioritised research program on urban biodiversity resilience in Western Australia. WABSI research programs bring together a diversity of stakeholders to achieve consensus on the most important factors limiting progress against challenges of great importance for biodiversity conservation.

This program document is written for a broad audience of stakeholders, including research providers, funding bodies, regulatory authorities, industry, utilities, the full range of land managers in the state, as well as members of the general public with an interest in biodiversity threats and land management. As such, the program needs to cover the interests of a very diverse stakeholder group, despite being end user led. This research program, when implemented via a steering committee (or equivalent), will provide a framework for identifying and implementing the highest priority research on urban biodiversity resilience, and a pathway to maximise the adoption of that research to improve on-ground outcomes.

In developing this research program on urban biodiversity resilience, it is clear that:

- Native biodiversity, wetlands and waterways have been particularly affected on the Swan Coastal Plan since British settlement in 1829;
- Perth's natural environment has mostly been degraded due to rapid urban growth; however, the impacts of climate change are increasingly being experienced;
- There is a need to address knowledge gaps as a critical component of enhancing biodiversity resilience; and
- It is essential to improve the value proposition for resourcing the mitigation of biodiversity loss, including understanding the consequences of delaying action or doing nothing.

It is recognised that there is significant complementarity to the program, particularly regarding biodiversity resilience in regional urban areas and the impacts of biodiversity loss on social and cultural values. A program of prioritised research to address knowledge gaps for biodiversity resilience is highly likely to also have shared benefits for a range of ecosystems and contexts in other areas of Western Australia, as well as across all ecosystems nationally and internationally.

## Objective

The objective of this research program is to provide a prioritised framework for identifying knowledge gaps for mitigating biodiversity loss in urban Western Australia. By identifying a clear pathway from knowledge generation to on-ground uptake, this program will encourage complementarity and collaboration, will identify potential targets for resourcing and funding the work, and will provide clarity on how best to translate research findings into improved outcomes for end users.



## Vision

Address priority knowledge gaps in urban biodiversity resilience with new research while facilitating the translation of these insights into effective on-ground outcomes, thereby addressing the threat to native biodiversity due to urban development and climate change and enhancing the conservation and resilience of sustainable ecosystems in Western Australia's urban areas.

## Outcomes

A step change in our understanding of urban biodiversity resilience to facilitate the conservation, restoration and resilience of sustainable ecosystems in Western Australia's urban areas.

Improved urban biodiversity resilience outcomes in Western Australia's urban areas are based on an integrated, collaborative approach focused on delivering multiple benefits for the finite resources available. This will lead to urban environments that are comfortable, resilient and thriving with biodiversity in light of rapid development and the impacts of climate change.

 MAIN IMAGE: DevelopmentWA INSETS (from left): Shutterstock, Megan Hele

# PROGRAM STAKEHOLDERS

A range of stakeholders will benefit from this research program. These include industry, government, non-profit organisations, community groups and land managers.

Collaboration between various stakeholder groups provides an opportunity to tackle the most pressing biodiversity challenges that are facing ecologists, policy makers, scientists, urban planners, developers and local governments.





INSETS (from left): Shutterstock, Megan Hele

MAIN IMAGE: Giles Pickard – City of Canning INSET: Megan Hele T

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## **Stakeholders of this research program**

## Researchers

The research community in Western Australia, nationally and internationally, whose members are working towards more effective, efficient and sustainable tools for enhancing biodiversity resilience.

#### Local, State and Commonwealth Governments

Governments at all levels invest resources into the protection of natural environments through ecological research, on-ground management and education.

## **Utility organisations**

Providers of water, electricity and gas services to urban households who own areas of urban land which can be transformed into natural spaces.

## Natural resource management and non-government conservation organisations

These organisations work with land managers, communities and industries to manage the land, water, coast, plants and animals for biodiversity conservation and their work benefits the community, environment and the economy.

## Indigenous land owners and managers

Including Aboriginal Corporations and ranger groups with an interest in managing their country for biodiversity values (including areas where biodiversity loss is impacting on culturally significant assets).

## **Development and construction industry**

Organisations that are facilitating rapid urban growth and can advocate for sustainable development.

## Nursery and garden industry

Organisations that are pivotal in supplying sustainable seedlings and plantings and adhere to current regulations regarding the importation of correctly labelled and permitted species into Western Australia.

#### Agricultural and forestry sectors

The ability of this sector to productively manage land, may lead to biodiversity enhancement.

## The environmental consulting and contractor sector

Consultants can positively impact the many challenges around urban biodiversity as they work with clients from a wide variety of sectors, including construction, water, waste, mining, energy, government and agriculture.

## **Tourism sector**

The sector relies on Western Australia's natural environment, including on reserves and parks, which provide significant habitat for native flora and fauna, for a significant component of their appeal to visitors.

## **Community groups**

These include Landcare, Coastcare, wildflower societies, Friends of and Naturalist groups that have a focus on appreciating natural biodiversity and advocating for issues relating to the conservation and protection of remnant bushland and parks.

## Community

The wider community that has an interest in the health of the environment and the conservation of native biodiversity.

MAIN IMAGE: City of Vincent INSETS (from left): Shutterstock, Lochman Transparencies

## **Economic** value

What are healthy ecosystems and thriving biodiversity worth? Is there an economic benefit in protecting the environment? Conservation outcomes are notoriously difficult to define, partly because there are multiple objectives which are important for conservation. The economic valuation of threatened species can provide valuable information for managers and policy makers to understand the trade-offs involved in prioritising conservation investments. Weighing the benefits and costs of conservation remains challenging since societal utility from pure public goods like threatened species is seldom captured in existing markets (Subroy et al. 2019). To ensure long term social and economic success, increasing value is attributed to preserving biodiversity. A common measure of biodiversity conservation outcomes is the change in the number of threatened species. This is readily understood by the general public and is reflected in many components of regulation (Deloitte 2021). The Australian Government has recently published the *Threatened Species Action Plan 2022 – 2032* and one of its objectives is that new extinctions of plants and animals are prevented (DCCEEW 2022a).

A number of research outputs that put a value on conservation of nature have been published in recent years, in Australia and abroad. A 2021 report by Deloitte Access Economics has found every AU\$1 invested in discovering all remaining Australian species, will bring up to AU\$35 of economic benefits to the nation. The report says that a 10 per cent improvement in taxonomic knowledge could improve conservationists' ability to manage threats and focus effort, reducing the number of species considered threatened between one and five per cent. Biodiversity conservation benefits, measured as the number of no longer threatened species valued by Australians' willingness to pay for conservation, ranges from AU\$74 million to AU\$372 million (Deloitte 2021).

A South Australian study estimated tourism ecosystem service expenditure values for a regional protected area network of 57 parks in the State. It found that protected areas returned AU\$373.8 million in the 2018–19 base year to the South Australian economy (Loch et al. 2023).

In 2018 Swedish researchers looked at assessing, valuing and mapping ecosystem services at city level: The case of Uppsala (Sweden) (Nikodinoska et al. 2018). They found that the average economic value of green urban areas was 20,000 SEK per hectare (in 2023: "AU\$3,000).

A review of five key Australian studies that estimated the willingness to pay for species conservation in Australia showed that values ranged from AU\$11 per year for bird conservation to AU\$118 per year for endangered flora and fauna (in nominal terms). In general, the community is willing to pay more for the conservation of charismatic species such as the Tree Kangaroo or the Koala than less 'cuddly' species (Deloitte 2021).

Nature-based tourism is a significant contributor to Australia's national economy and its annual value can be seen as another measure of biodiversity conservation outcomes. Ecosystem services provided by protected areas in Australia have conservatively been estimated to be worth a minimum of AU\$38 billion per year. (WWF 2021)

In Australia, nature tourists account for 68 per cent of total tourism spending. They also stay longer and spend more than other tourists. In 2021, 20.9 million domestic visitors undertook a nature-based activity during their overnight trip, spending approximately AU\$22.7 billion. And in 2019, AU\$5.8 million international visitors undertook a nature-based activity during their overnight trip, spending approximately AU\$23.6 billion (Ecotourism Australia 2022).

Apart from recreational value, mental health benefits of visiting protected areas are estimated at US\$6 trillion a year worldwide (Buckley et al. 2019). In Australia, mental illness costs society AU\$20 billion a year (Figgis et al. 2015).

## Environmental, health and social benefits

Biodiversity is essential to human survival, wellbeing and economic prosperity (Murphy and van Leeuwen 2021). Healthy communities rely on well-functioning ecosystems (WHO 2023). Our existence is critically dependent on the biodiversity in the landscapes that surround us and underpins our quality of life. Communities derive social, health and economic benefits through our interactions with biological diversity across the landscape.

- Biodiversity is essential for healthy ecosystems to help maintain natural processes, such as soil turnover, water purification, clean air and pest control.
- It also supports economic opportunities, and leisure activities that contribute to overall wellbeing.
- Biodiversity plays a crucial role in human nutrition through its influence on world food production, as it ensures the sustainable productivity of soils and provides the genetic resources for all crops, livestock, and marine species harvested for food.
- The environmental changes that drive biodiversity loss, such as deforestation and climate change, may also contribute to the emergence of other major global health threats, such as infectious diseases.
- Biodiversity is an important source of genetic resources used for the development of many treatments, vaccines and a range of biotechnology products used in both modern and traditional medicines, as well as agriculture and industry.
- There is strong evidence for the benefits of interaction with nature flora and fauna in treatments for depression, anxiety, and behavioural problems.

## The cost of inaction

Over half the world's economic output of US\$44 trillion is moderately or heavily dependent on nature and its services (WEF 2020). Research suggests that Australia would have almost US\$20 billion wiped off its economy every year by 2050 if the world carries on with "business as usual". Australia's yearly loss by 2050 is equivalent to a permanent decline of 1.43 per cent in the nation's annual income. Across all countries, the reduction is 0.67 per cent, therefore Australia is projected to lose at more than twice the global average (Roxburgh et al. 2020).

The Organisation for Economic Co-operation and Development (OECD) reports that a strong business case exists for scaling up action on biodiversity. Business impacts and dependencies on biodiversity translate into risks to business and financial organisations, including ecological risks to operations; liability risks; and regulatory, reputational, market and financial risks (OECD 2019).

Closer to home, the State of the Environment report 2021 assessed the overall state of biodiversity in Australia as being poor with a declining trend. Climate change, pollution, resource extraction, habitat loss, and invasive species were deemed principal causes for this decline (DCCEEW 2022b). For Western Australia mammal extinctions, bushfires and water availability were highlighted to be of particular concern on a business-as-usual scenario (ABC 2022).

The Australian Conservation Foundation's has undertaken research which links every Australian industry sector to the ecosystem services they depend on to thrive. Key findings reveal that roughly half Australia's GDP (49 per cent or AU\$896 billion) has a moderate to very high direct dependence on nature and that Western Australia is the state at greatest risk from nature destruction with 67 per cent of its gross economic value having a moderate to very high direct dependence on nature (ACF 2022).

Given the South West of Western Australia is a biodiversity hotspot, further decline of endemic flora and fauna would negatively impact the tourism industry, which is worth billions to Western Australia, with the 'nature experience' one of the top drawcards for foreign visitors (Lambers and Bradshaw 2016). Ecology and economy can go hand in hand, and lead to diversification of the Western Australian economy and provide a boost to the State's tourism sector.

## URBAN BIODIVERSITY RESEARCH IN WESTERN AUSTRALIA

Research on biodiversity in Western Australia has a long history, with a broad range of research focusing on ecological understanding, conservation and management. An overview of past and current research as it applies to Western Australia includes, but is not limited to, research from the following organisations.



## Department of Biodiversity, Conservation and Attractions (DBCA)

Western Australia's State Government agency DBCA and its predecessors have a long history of undertaking research to conserve, discover and protect biodiversity and to engage with the community to inspire a passion for nature. DBCA consolidates conservation science under one department to build and share knowledge of the State's biodiversity.

The Biodiversity and Conservation Science directorate within DBCA provides science and biodiversity knowledge to support the functions of the Parks and Wildlife Service, Botanic Gardens and Parks Authority, Zoological Parks Authority and Rottnest Island Authority. Their services are delivered from multiple sites across Western Australia, including national and marine parks, Kings Park, Perth Zoo, Rottnest Island, and the WA Herbarium.

## **Commonwealth Scientific and Industrial Research Organisation** (CSIRO)

In collaboration with the Australian Government Department of Climate Change, Energy, the Environment and Water, CSIRO works on projects to improve the knowledge-base and long-term research infrastructure to support biodiversity conservation and natural resource management (NRM). Their *Ecological engineering for biodiversity adaptation to climate change* project is addressing the challenge to manage contemporary environmental needs whilst ensuring natural resource management investment is future-proofed to withstand climate change. The project aims to identify and develop a new generation of climate-smart 'ecological engineering' approaches (CSIRO 2023).



## **Other Western Australian organisations**

Non-government organisations (NGOs) in Western Australia play an integral role in the community to conserve biodiversity, such as:

- Natural Resource Management (NRM) organisations: There are seven NRMs within Western Australia that work from the paddock to the regional scale to address issues that require a landscape perspective. The NRM approach enables the community to better address long term strategic issues of national importance through land care initiatives. A recent initiative from the Perth NRM is *Rewild Perth*, an initiative to 'Bring Nature Home' and encourage people to provide native habitat in their gardens, courtyards or balconies (PerthNRM 2023).
- Bush Heritage: An organisation aiming to conserve biodiversity in Western Australia by buying and managing land of outstanding conservation value, in partnership with other landowners. Through conservation, the organisation helps protect native plants and animals on a range Western Australia's ecologically important landscapes.
- The Conservation Council of Western Australia: Western Australia's peak body for conservation and climate action is working to educate the public about the importance of conservation and lobbies on environmental issues in order to create legislative change. The Council's Citizen Science Program generates engagement at a community level to fill knowledge gaps and contribute to the ecological research and monitoring.
- Greening Australia: Under their Nature in Cities Program, this organisation has worked in partnership with The Behaviour Change Collaborative and three Perth local governments to deliver the Our Park Our Place project with local communities. The project involved residents in greening their local parks, hosted verge makeover events and offered free skills-based workshops, aiming to inspire and equip residents in low-canopy suburbs to plant in their own yards, verges and neighbourhoods, combatting some of the effects of climate change and biodiversity loss at the same time (Greening Australia 2022).

**Universities** in Western Australia have a long history of undertaking biodiversity research in the areas of restoration, fire management, water management and species conservation.

Curtin University's Institute for Biodiversity and Climate, Edith Cowan University Centre for Conservation and Biodiversity Research Centre and Murdoch University's Harry Butler Institute are prime examples of how universities are working to protect and enhance biodiversity in urban environments. The regionally based Centre of Excellence in Natural Resource Management (CENRM) is an Albany based centre providing knowledge necessary to better manage natural resources in collaboration with the University of Western Australia.

**Community groups** are active in undertaking research in the form of trials, restoration, monitoring and analysing biodiversity. The Urban Bushland Council is the Western Australian peak community organisation for urban bushland recognition and protection and is an association of more than 75 community conservation groups concerned about urban bushland. These groups work to ensure their experiential knowledge reaches the broader community through regular engagement with research organisations, reports in the grey literature, departmental papers and workshops.

**Environmental consulting companies** are also undertaking biodiversity research, particularly in relation to clearing for development. However, confidentiality clauses and data intellectual property issues prevent much of this knowledge from being shared in the public domain, and therefore only occasionally contributes to broader progress against mitigating weed impacts across jurisdictions.

## **Cooperative Research Centres**

Federally funded Cooperative Research Centres (CRCs) have provided the resources for biodiversity research in Western Australia of relevance to this program. They are an Australian Government initiative that was established in 1990 and funds industry-led collaborations between industry, researchers and end users.

The CRC for Water Sensitive Cities is now operating as Water Sensitive Cities Australia and continues to fund relevant biodiversity research for urban environments. One of its current projects is investigating the viability of a NatureLink between Kings Park and Bold Park (WSCA 2023).

The Bushfire and Natural Hazards CRC, like the Bushfire CRC before it, has been conducting coordinated and interdisciplinary research to work with communities to improve disaster resilience and reduce amongst others the environmental costs from bushfires and other natural hazards.

## Interstate and overseas research and expertise relevant to Western Australia

Research undertaken both interstate and overseas is likely to be informative for delivering this prioritised research program, even if the work does not take place within Western Australia. For example, due to climatic similarities and many biodiversity problems, opportunities exist across Australia and our wider region for improved collaboration in researching and implementing biodiversity conservation and management practices and knowledge sharing.





MAIN IMAGE: Sonja Mennen INSETS (from left): BGPA, Peter Nicholas – DBCA

## PROGRAM DEVELOPMENT

The WABSI research program development pathway is an iterative process, engaging both end users and researchers. Stakeholders help scope, define and set research priorities (Figure 1).



FIGURE 1. The WABSI research program development pathway.

A process to scope, define and prioritise research needs was undertaken broadly following the WABSI program development pathway. This approach follows an iterative model with stakeholder engagement led by end users, but with ongoing engagement between end users and research expertise throughout a series of workshops to define and refine the program scope and priorities.

In the process of refining feedback after the workshop, challenges have been grouped into five solution components: Research (including Social Research), Funding, Communications, Policy and Management (Figure 2). WABSI's remit in this space relates specifically to the research category, as well as where the other four categories interact or overlap with research to improve outcomes.



**FIGURE 2.** Urban biodiversity challenges can be grouped into five solution components; Research, Funding, Communications, Policy and Management.



## **Program workshops**

Stakeholder mapping identified a broad range of research experts, all levels of government, industry and other end users, regulators and community members with relevant interests in an urban biodiversity resilience research program for Western Australia.

## **INITIAL SCOPING SESSIONS 2018**

Two initial scoping sessions were held in 2018; the first one was organised in March by the Swan NRM committee and facilitated by WABSI.

A second session was held as part of the Urban Development Institute of Australia (Western Australian branch) Environment Committee bi-monthly meeting in July 2018.

The objective of these initial scoping sessions was to begin documenting high level initiatives and knowledge gaps and identify synergies relating to urban biodiversity resilience.

## URBAN BIODIVERSITY WORKSHOP 1: 30 NOVEMBER 2021

To progress the urban biodiversity resilience topic as a focal issue in 2022, WABSI organised a first stakeholder workshop on 30th November 2021. The workshop invited key end user groups across business, government and the not-for-profit sectors (refer to Figure 3) to:

- 1. Gain an updated understanding of current and future challenges in urban biodiversity management in the Perth and Peel region;
- 2. Identify synergies relating to urban biodiversity management; and
- 3. Document problems that can be addressed by new collaborative research.


The workshop was undertaken as a single group facilitated discussion, generating considerable discussion on a wide range of issues, including current core challenges for urban biodiversity in the Perth and Peel regions, the uniqueness of Western Australia and Perth in the context of urban biodiversity management, and future challenges to urban biodiversity conservation. A full overview of issues discussed can be found in Appendix 1.

#### **OUTCOMES WORKSHOP 1**

A total of 14 key issues emerged relating to current challenges, Western Australian specific challenges and future challenges, refer to Appendix 1

These challenges were grouped under each solution component (Research, Funding, Communications, Policy and Management refer to Figure 2). The challenges that were not grouped under Research were not taken further, as these challenges do not fall under WABSI's remit.

The remaining challenges were overlain with WABSI's *Biodiversity Knowledge Priorities* (WABSI 2022, refer to Table 2). These priorities were established during comprehensive stakeholder consultation, which forms part of WABSI's strategic forward planning to identify and respond to emerging issues.

Five focus areas for research topics emerged:

**TABLE 1.** Emerging focus areas for urban biodiversity resilience research

1.	Ecosystem restoration
2.	Green infrastructure and urban forests
3.	Climate change resilience
4.	Fire mitigation
5.	Traditional knowledge and values

After internal discussions it was decided to not have '*Traditional knowledge and values*' as a separate focus area, but instead to weave the theme into the other research focus areas.

Another potential focus area that emerged was 'Biodiversity in peri-urban and regional urban areas'.



			WABSI	Biodiversity Kn	owledge Prior	ities		
Urban Biodiversity workshop 1	Measuring biodiversity	Carbon and biodiversity issues	Biodiversity data and cumulative impact	Incorporating traditional knowledge/ values	Restoration	Climate adaptation/ resilience	Mitigating impact from key threats	Urban forests and biodiversity
Connectivity and restoration								
Trees in urban environment								
Carbon capture and storage/carbon sequestration								
Invasive pests/weeds and their control								
Planning for new devel	opments							
Restoration through climate resilient native species								
Fire mitigation								
Vertebrates in urban landscapes								
Non-conservative values of biodiversity								
WA SPECIFIC								
Ecological and geograp	hic issues							
Urban planning issues								
FUTURE CHALLENGE	.0							
Climate change, threat mitigation								
<b>Population pressures</b>								
Changing infrastructure requirements								
Ecosystem restoration	n Green ir urban fo	nfrastructure and prests	Climate change resilience	Fire mitigat	ion Tradit and v	ional knowledge alues		

After analysing the outcomes of workshop 1 four focus areas emerged, each with their own research topics. Under each research topic, several research questions were formulated, based on issues raised during workshop 1 and further engagement with end users, refer to Table 3.

1.	Ecosystem restoration
1.1	Connectivity and restoration
1.2	Control of invasive pests and weeds
1.3	Vertebrates in urban landscapes
2.	Green infrastructure and urban forests
2.1	Trees in urban environments
2.2	Carbon capture and storage / carbon sequestration
2.3	Expansion of green infrastructure
2.4	Non-conservation values of urban biodiversity
З.	Climate change resilience
3.1	Climate change resilient native species (animals, plants and trees)
3.2	Threat mitigation and adaptation
4.	Fire mitigation
4.1	Fire for regeneration
4.2	Fire for risk mitigation

#### TABLE 3. Urban biodiversity research focus areas and research topics



#### URBAN BIODIVERSITY WORKSHOP 2: 5 APRIL 2023

WABSI organised a second workshop and invited end users and researchers with the aim to:

- Define/further refine research questions under topics established during initial workshop:
  - Ecosystem restoration
  - Green infrastructure and urban forests
  - Climate change resilience
  - Fire mitigation
  - Need to divide program into urban, peri-urban, regional urban?
- Prioritise research topics and questions according to end user requirements.

Participants completed an online exercise asking them to prioritise research focus areas and research topics based what they considered most important from their perspective.

The exercise was later emailed to stakeholders who were unable to attend the workshop on the day. Refer to Appendix 2 for the full list of questions from the online exercise, and a list of participants can be found in Appendix 3.

#### **OUTCOMES WORKSHOP 2**

In total 27 stakeholders took part in the prioritisation exercise. Twenty participated in the workshop on the day and another seven completed the exercise afterwards online.





#### **Ranking focus areas**

Participants were asked to rank the four focus areas (refer to Table 3) from most important to least important, according to their interests. Focus area 'Green infrastructure and urban forests' was found most important, followed by 'Ecosystem restoration', 'Climate change resilience' and 'Fire mitigation'.



FIGURE 5. Outcomes prioritisation of research focus area after workshop 2 (weighted).

#### **Ranking research questions**

Stakeholders were also asked to prioritise research questions that would address gaps in urban biodiversity resilience research and knowledge. Each research question is grouped under one of the four focus areas and its corresponding research topics.

### **TABLE 4.** Prioritised research questions to address gaps in urban biodiversity resilience research and knowledge, grouped by focus area and research topic. Rankings are based on feedback gathered through workshops and an online exercise

FOCUS AREA 1	ECOSYSTEM RESTORATION	RANKING
Research topic 1.1	Connectivity and restoration	
Research question 1.1.1	How connected can the landscape be made — what are the optimal minimal linkages that can be provided	High
Research question 1.1.2	Connecting the landscape — remnant vegetation versus the matrix	High
Research question 1.1.3	What are the best practice novel nature habitat infrastructure designs	Medium
Research question 1.1.4	How to quantify the value/resilience/viability of very small remnants of urban bushland	Medium
Research question 1.1.5	Are there 'supercharger' species that provide the greatest habitat value	Medium
Research question 1.1.6	What parts of the urban landscape/remnant habitats will benefit most from targeted urban biodiversity enhancement	High
Research topic 1.2	Non-conservation values of urban biodiversity	
Research question 1.2.1	How to manage highly problematic invasive species e.g. weeds escaping from gardens, feral cats	Medium
Research question 1.2.2	Risks, resource requirements and effectiveness of different herbicides	Low
Research question 1.2.3	What are optimal methods of control - research into less toxic and more targeted pest control alternatives and its correct use	Medium
Research question 1.2.4	How do we determine the urgency/prioritisation of weeds and pest control (immediate/ urgent/non-urgent)	Medium
Research question 1.2.5	How to manage the spread of weeds when connectivity is improved	Low
Research topic 1.3	Vertebrates in urban landscapes	
Research question 1.3.1.	How do we manage herbivore density (including reintroduction and culling) in urban remnants to optimise fuel reduction benefits	Medium
Research question 1.3.2	How do we appropriately manage large vertebrates	Low
Research question 1.3.3	How do we manage people versus animal conflicts	Low

(Table 4 continues following page...)

FOCUS AREA 2	GREEN INFRASTRUCTURE AND URBAN FORESTS	RANKING
Research topic 2.1	Trees in urban environments	
Research question 2.1.1	How can we prevent loss of canopy cover on private property	High
Research question 2.1.2	How can we align urban canopy targets for different organisations involved	Medium
Research question 2.1.3	How to address the lack of information on co-benefits of trees in urban areas (biodiversity, health and well-being, heat island effect, carbon sequestration)	Medium
Research question 2.1.4	Research on height and root depth and spread to enable informed decision-making for tree asset management	Medium
Research question 2.1.5	Develop a generalist species list which species provide optimal infrastructure compatibility/carbon value/biodiversity value	High
Research question 2.1.6	How to manage the understory in urban forests	Medium
Research topic 2.2	Carbon capture and storage / carbon sequestration	
Research question 2.2.1	How to quantify carbon capture of different tree species to achieve net zero	Medium
Research question 2.2.2	Biodiversity and carbon offsets serve different purposes — how to optimise biodiversity and carbon capture through quantitative benefits of offsets	High
Research question 2.2.3	Optimal grow area to grow carbon sequestration plantings	Low
Research topic 2.3	Expansion of green infrastructure	
Research question 2.3.1	What is the optimal design of service/infrastructure corridors and assets to support green corridors for biodiversity	High
Research question 2.3.2	How can we effectively provide, use and situate public open space to maximise value for biodiversity enhancement	Medium
Research topic 2.4	Non-conservation values of urban biodiversity	
Research question 2.4.1	Social research on the health, economic, social and cultural values of retaining urban biodiversity (trees, native flora and fauna species) and waterways and wetlands	High
Research question 2.4.2	How do we establish greater community connection to and care for ecosystems (research linking species composition and structural diversity in vegetation with particular ecosystem service outcomes	Medium
Research question 2.4.3	How do we increase understanding of traditional ecological knowledge and Aboriginal values associated with environmental management	High

(Table 4 continues following page...)

FOCUS AREA 3		RANKING
Research topic 3.1	Climate change resilient native species (animals, plants and trees)	
Research question 3.1.1	How and where to source individual plants, trees and animals for restoration (local/mixture, similar environment, climate resilient)	Medium
Research question 3.1.2	Consideration of future climate when planting – considering Perth's climate in 2050	Medium
Research topic 3.2	Threat mitigation and adaptation	
Research question 3.2.1	How to raise awareness of biodiversity resilience when it comes to climate change adaptation — it is often forgotten	Medium
Research question 3.2.2	How do we adapt to changing infrastructure requirements and protect biodiversity during extreme weather events (water security, urban heat island, storms, floods)	Medium
Research question 3.2.3	To what degree should we accept the novel ecosystems — risk assessment	Medium
Research question 3.2.4	Develop a triage process to inform decision-making on which biodiversity elements to protect	High
Research question 3.2.5	How to reduce loss of important conservation values due to shrinking coastal reserves (sea water level rises)	Medium
Research question 3.2.6	How do we set water quality/quantity targets — dropping groundwater levels and reduced streamflow are a threat to the health of aquatic and groundwater dependent ecosystems	Medium
FOCUS AREA 4	FIRE MITIGATION	RANKING
Research topic 4.1	Fire for regeneration	
Research question 4.1.1	What is the optimal use of fire to regenerate and maintain high quality landscapes	Medium
Research question 4.1.2	How do we introduce cultural burning practices in urban areas	Medium
Research topic 4.2	Fire for risk mitigation	
Research question 4.2.1	What is the optimal fire risk mitigation regime for urban bushland	Medium
Research question 4.2.2	What is the impact of fire regimes on urban biodiversity	Medium
Research question 4.2.3	What is the impact of fire regimes on the urban environment (erosion, weeds, water quality, wetlands)	Medium
Research question 4.2.4	What is the impact of fire regimes on the urban bushland value	Medium

At the end stakeholders were asked to review all focus areas, research topics and their questions again, and to rank the overall top three research questions they felt were most urgent to be answered. The outcomes of the overall ranking exercise can be found in Table 5 below. Research questions highlighted in green in both Table 4 and 5 were identified as 'high' as well as 'most urgent in question 17.

RANKING QUESTION 17	RESEARCH QUESTION NO.	RESEARCH QUESTION	RANKING PREVIOUS QUESTIONS
1.	1.1.6	What parts of the urban landscape/remnant habitats will benefit most from targeted urban biodiversity enhancement	High
2.	1.2.1	How to manage highly problematic invasive species e.g. weeds escaping from gardens, feral cats	Medium
3.	1.1.1	How connected can the landscape be made — what are the optimal minimal linkages that can be provided	High
4.	2.1.1	How can we prevent loss of canopy cover on private property	High
5.	2.3.1	What is the optimal design of service/infrastructure corridors and assets to support green corridors for biodiversity	High
6.	1.1.2	Connecting the landscape — remnant vegetation versus the matrix	High
7.	2.1.3	How to address the lack of information on co-benefits of trees in urban areas (biodiversity, health and well-being, heat island effect, carbon sequestration)	Medium
8.	3.2.2	How do we adapt to changing infrastructure requirements and protect biodiversity during extreme weather events (water security, urban heat island, storms, floods)	Medium
9.	1.1.3	What are the best practice novel nature habitat infrastructure designs	Medium
10.	1.1.4	How to quantify the value/resilience/viability of very small remnants of urban bushland	Medium

**TABLE 5.** Outcomes question 17 where stakeholders were asked to review all research questions again and rank their overall top three according to urgency

#### Additional focus areas

#### Peri-urban and regional urban areas

Stakeholders were also asked whether they thought a fifth focus area focussing specifically on peri-urban and regional urban areas should be added. The majority thought it was important to recognise that peri-urban and regional urban areas require specific consideration.

They were also asked about the kind of research questions they would like to see answered, relating to a potential fifth focus area on 'peri-urban and regional urban areas'. Most respondents saw value in questions relating to connectivity and fire mitigation in the rural-urban interface, e.g., a minimum patch size of retained vegetation and minimum connectivity to maintain ecological function within a developed landscape. Peri-urban scenarios need to consider room for houses and roads and bushfire fuel load management and setbacks.

Another issue raised was the need to provide decision-making support to the alternatives of fragmented natural areas within low density development, compared to higher density development that conserves a greater proportion of retained habitat to establish an optimal situation for biodiversity retention/ resilience.

After discussion during the workshop stakeholders could see most value in including 'biodiversity in peri-urban and regional urban areas' as a consideration under each of the other focus areas, rather than having it as a separate fifth focus area.

#### Water for biodiversity

During workshop 2 a discussion emerged on a potential other focus area around 'understanding the impact of water use on the value for biodiversity'.

There was discussion about the fact that although Perth is naturally quite a dry city, the community is creating a 'novel habitat' by watering gardens and establishing lush green spaces. Watered spaces might in future be the only areas of wetted habitat or watered environment within the urban landscape. Watering has a positive impact and is needed to make a more liveable and resilient environment.

Additional research questions that were identified:

- How much more water is needed to keep urban areas resilient to sustain native flora and fauna?
- How can we best design urban areas to create watered spaces that enhance biodiversity?
- Where is water use most beneficial to sustain a biodiverse urban environment, what is the best use of available water to benefit biodiversity?
- What value is provided to biodiversity by watering gardens?
- How can increased community connection to and appreciation of urban water environments help enhance biodiversity resilience?

# RESEARCH PROGRAM FRAMEWORK AND DETAILS

#### **Research program structure**

Stakeholder engagement during program development helped to build a framework for research priorities.

The section on the following pages describes four themes covering the critical gaps in knowledge about urban biodiversity resilience as highlighted by end users. Within each of these themes, research focus areas and associated knowledge gaps are identified.





**Restoration Economy** (WABSI 2023)

- Addressing Weed Threats to **Biodiversity (WABSI 2021)**
- Increasing Knowledge to Mitigate Cat Impacts on **Biodiversity (WABSI 2020)**

FIGURE 6. A framework for WABSI's research program to address knowledge gaps in urban biodiversity resilience research.

#### THEME 1

Conserve

#### Rationale

The first step in creating a biodiversity rich urban landscape is to conserve as much of the existing environment as possible. Remnant vegetation, such as trees, shrubs and understory, is fundamental to biodiversity and underpins landscape resilience. Ecological landscapes that have not been significantly altered from its original state have less chance of weed invasion and feature less feral animals.

Despite the growth of Western Australia's urban areas, there are still an array of natural areas with conservation significance present in Perth and regional urban centres, and many are protected from development, including wetlands, coastal dune systems and urban bushland reserves (Pauli and Boruff 2016).

#### FOCUS AREA 1: REMNANT VEGETATION

Conserving a connected landscape is necessary for the functionality of ecosystems and is key to the survival of flora and fauna. It enables biological processes such as pollination and seed dispersal, predator/prey relationships and food webs, water and nutrient flows. Two linked patches of bushland can help native animals move more freely between these areas to find food, shelter and opportunities to breed.

The loss of urban tree canopy is of particular concern in the Perth metro area. Eighty-five percent of tree canopy is on residential land and that is where most of the canopy loss is occurring (DPLH 2018). Another area of concern is the shrinking size of coastal reserves, which contain important conservation values. The size of coastal reserves will continue to decrease as sea levels rise from climate change.

Fire plays an important role in environmental ecology, and is needed to trigger natural processes, such as stimulating seed germination and bringing benefits to biodiversity. Research shows bushfires help provide nutrients that native vegetation specifically needs to rejuvenate and seed (DEW 2020).

OUTCOME	OBJECTIVE	KNOWLEDGE GAPS	RANKING
Existing natural areas thrive and are abundant with native flora	Prevent loss of existing natural areas in the Perth metropolitan area, peri-urban and regional urban areas	What parts of the urban landscape/remnant habitats will benefit most from targeted urban biodiversity enhancement	Тор
and tauna	Enhance tree canopy cover in urban areas	How to prevent loss of canopy cover on residential land	Тор
	Target areas that benefit most from biodiversity enhancement Practice optimal management of existing urban natural areas	How to reduce loss of important conservation areas due to shrinking coastal reserves	Medium
		How to manage the understory in urban forests	Medium
		How to introduce cultural burning practices in urban areas	Medium
		What is the optimal fire risk mitigation regime for urban bushland	High
		What is the impact of fire regimes on the urban environment (erosion, weeds, water quality, wetlands)	Medium

MAIN IMAGE: WA Local Government Association INSETS (from left): Megan Hele, Lochman Transparencies

#### FOCUS AREA 2: NATIVE FAUNA

Herbivores play an important role in maintaining a healthy ecosystem by preventing an overgrowth of vegetation. Additionally, many plants rely on herbivores such as bees to help them reproduce. And these plants provide food and habitats for shelter to herbivores.

Management techniques such as introducing kangaroos into urban bush areas can limit the establishment of targeted weeds postfire. Research into postfire grazing found that manipulating herbivores in time and space following prescribed fire could be an important and cost-effective way of maintaining biodiversity values (Kirkpatrick et al. 2011).

However, when certain herbivore species populations become too big in numbers, they can provide management challenges. Examples are kangaroo-vehicle collisions and potential for conflict between humans and kangaroos (Herbert et al. 2021), and the damage introduced corellas and other flocking cockatoos cause to trees that are potential nest sites for threatened black cockatoo species (DBCA 2016).

OUTCOME	OBJECTIVE	KNOWLEDGE GAPS	RANKING
Herbivore density in urban areas provides optimal benefits	Establish sustainable herbivore populations in urban areas	How to manage herbivore density (including reintroduction and culling) to optimise vegetation cover	Medium
resilience		How to appropriately manage large vertebrates	Low
		How to manage human versus wildlife conflicts	Low





IMAGES: Shutterstock

BUILDING BIODIVERSITY FOR THRIVING URBAN ECOSYSTEMS

IMAGE: BGPA





#### Restore

#### Rationale

Restoration of degraded ecosystems is the next step after conservation. Restoring biodiversity involves bringing back lost species that have been identified as living naturally in the area. It also incorporates removing unwanted plants and animals known as weeds and pests. WABSI has already two established research programs that aim to address the problems of weeds and unwanted animals such as feral cats, Addressing Weed Threats to Biodiversity (Webber 2021) and Increasing Knowledge to Mitigate Cat Impacts on Biodiversity (Webber 2020). Research questions relating to these topics will be covered under these programs.

#### FOCUS AREA 3: HABITAT RESTORATION

Ideally, bush areas will regenerate naturally from falling seeds, or those carried in by wind or birds, but other times active restoration planting and seeding through ecosourcing is needed. Ecosourced plants will be suited to local conditions and more likely to survive. They will also help maintain the area's unique local characteristics and avoid the risk of planting species which are not native to the local area, and which could become invasive.

Fire can be an ecologically friendly and cost-effective tool to help regenerate and rehabilitate vegetation on degraded sites. It helps new seedlings by temporarily reducing competition from established vegetation and creating ash beds suitable for germination (DBCA 2023).

Working with nature to conserve, manage and restore ecosystems – known as nature-based solutions – is one of the most cost-effective approaches to both mitigating and adapting to climate change. Nature-based solutions such as restoration are particularly effective because, unlike infrastructure-based interventions, actions that boost biodiversity can help to tackle climate change in two ways at once: through mitigation and adaptation. As well as sequestering and storing carbon, ecosystems can help communities adapt to the negative impacts of climate change, as well as providing multiple other benefits (UNEP-WCMC 2023).

WABSI has recently published a roadmap towards a sustainable restoration industry: <u>The Western</u> <u>Australian Restoration Economy</u> (Young et al. 2023). Research questions about carbon capture and offsets, and ecosourcing will be an integral part of a future WABSI research program based on the recently published roadmap for the Western Australian restoration economy.

OUTCOME	OBJECTIVE	KNOWLEDGE GAPS	RANKING
Restored urban landscapes provide habitat, food	Enhance landscape connectivity in the urban environment Use native species that bring optimal benefit to biodiversity Apply fire as a regenerative tool in an optimal way to establish biodiversity resilience	How connected can the landscape be made — what are the optimal minimal linkages that can be provided	Тор
resources, land connectivity, healthy waters and soils		Which 'supercharger' species provide the greatest habitat value	Medium
		What is the optimal use of fire to regenerate and maintain high quality landscapes	Medium



1. Martin

17

#### FOCUS AREA 4: WATER FOR BIODIVERSITY

Water for the environment is used to target specific outcomes for plants or animals by providing the right amount of water at the right time for them to feed, breed and grow. It is a critical tool to support the health of rivers and wetlands and supports the communities that rely on them. Healthy functioning coastal, estuarine, freshwater and wetland habitats support thriving species populations, deliver services that influence the availability of water and its quality, and provide resilience to changing climate conditions.

Mainstreaming biodiversity in water management can be done by strengthening and expanding the potential for ecological approaches in integrated water resource management (SCBD 2015). Restoring natural systems and the maintaining watered green infrastructure such as parks and private gardens can reverse current degradation of aquatic ecosystems, maintain and restore biodiversity and safeguard against climate change impacts.

OUTCOME	OBJECTIVE	KNOWLEDGE GAPS	RANKING
Water use in urban areas sustains ecosystem	Use water effectively to sustain a biodiverse urban environment	How much more water is needed to keep urban areas resilient to sustain native flora and fauna	No ranking – raised during workshop
as ecological health and heat mitigation		What is the best use of available water to benefit biodiversity What value is provided to biodiversity by watering gardens	No ranking – raised during workshop
		What value is provided to biodiversity by watering gardens	No ranking – raised during workshop
		How do we set water quality/ quantity targets – dropping groundwater levels and reduced streamflow are threatening the health of aquatic and groundwater dependent ecosystems	Medium



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Design

#### Rationale

The impact of both urbanisation and climate change on biodiversity is welldocumented. Recent research is suggesting that it is time to move to a design paradigm of positively and proactively shaping the types of changes that are taking place rather than continuing in a conservation paradigm of protecting the earth. What is needed is the historically informed management of emerging novel ecosystems to ensure the maintenance of ecological goods and services in a world with a changing climate (Boivin et al. 2016).

#### FOCUS AREA 5: BEST PRACTICE DESIGN

To achieve beneficial outcomes for both people and urban nature it is important to integrate appropriate, biodiversity-focussed design protocols into mainstream urban planning and development. Biodiversity Sensitive Urban Design (BSUD) is a protocol that aims to create urban areas that deliver on-site benefits to native species and ecosystems through the provision of essential habitat and food resources. Novel habitat analogues such as artificial nesting cavities are options, along with encouraging wildlife gardening in residential gardens and creating public open space that maximises value for biodiversity. This supports natural ecological processes by providing resources for target species beyond traditional 'green infrastructure' (Kirk et al. 2021).

MAIN IMAGE: DevelopmentWA INSETS (from left): Shutterstock, Megan Hele

OUTCOME	OBJECTIVE	KNOWLEDGE GAPS	RANKING
Newly designed urban green spaces deliver	Integrate appropriate, biodiversity-focussed design protocols into urban green space	What are best practice novel nature habitat infrastructure designs	High
to native species and ecosystems through the	development	Which species provide optimal infrastructure compatibility and biodiversity value	High
provision of essential habitat and food resources		What is the optimal design of service/infrastructure corridors and assets to support green corridors for biodiversity	Тор
		How can we effectively provide, use and situate public open space to maximise value for biodiversity enhancement	Medium
		How can we best design urban areas to create watered spaces that enhance biodiversity	No ranking – raised during workshop
		To what degree should we accept the novel ecosystems — undertake a risk assessment	Medium

#### FOCUS AREA 6: CLIMATE CHANGE RESILIENCE

Ecologists are advising that now, more than ever, it is essential to plan for the future and not base everything on the past, as changes in climate conditions will need to be a key factor in decision making about ecosystem restoration. Many species have a narrow climate tolerance, especially endemic species that are unique to a particular habitat and climate. With changes in the temperature, rainfall, evaporation and humidity, some species may no longer be able to survive in their current locations.

Nature-based solutions are now being strongly advocated worldwide to help deliver a range of services to help cope with climate change, including regulating water flows, reducing the heat island effect, treating wastewater, reducing stormwater run-off and improving water supplies. These applications have many benefits for enhancing biodiversity and these solutions are often more cost-effective to build and maintain than conventional infrastructure (UNEP 2021).

OUTCOME	OBJECTIVE	KNOWLEDGE GAPS	RANKING
Biodiversity in urban green spaces flourishes in Western Australia's future climate	Introduce nature-based solutions based on species that are	Which species are appropriate for Perth's future climate	Medium
	climate	Which species can adapt to Perth's future climate	Medium
	-	How to adapt to changing infrastructure requirements while protecting biodiversity during extreme weather events (water security, urban heat island, storms, floods)	High



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IMAGE: Sonja Mennen



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#### Rationale

Accelerating biodiversity loss coupled with limited data, time and monetary resources necessitates careful allocation of conservation activities (Bower et al. 2018). Conservation managers often face pressures to prioritise conservation of iconic species over those in greater need. While the number of threatened species continues to grow, access to scientifically robust and well-presented information and data can go a long way in helping address the challenges faced by end users due to resource limitations, biological and socioeconomic trade-offs and involvement of diverse interest groups.

#### FOCUS AREA 7: DECISION-MAKING TOOLS

A significant factor in determining the impact of actions to enhance biodiversity are robust research outcomes that help underpin decisions on how to conserve, restore, design and manage urban nature spaces. In a world of constraint resources choices need to be made where to invest to get the best results in biodiversity enhancement, e.g., when retaining or increasing tree canopy in urban areas. Future climate conditions should be included in the prioritisation process.

OUTCOME	OBJECTIVE	KNOWLEDGE GAPS	RANKING
End-users make decisions about enhancing biodiversity resilience based on robust and	Ake out sed d a ion	How to address the lack of information on co-benefits of trees in urban areas (biodiversity, health and well- being, heat island effect, carbon sequestration)	High
accessible scientific data and information		Research on height and root depth and spread to enable informed decision-making for tree asset management	Medium
		Develop a triage process to inform decision-making on which biodiversity elements to protect	Medium

#### FOCUS AREA 8: VALUE OF ECOSYSTEM SERVICES

A better understanding of the extent of value of the services provided by urban ecosystems in relation to native vegetation, groundwater, rivers and wetlands can help quantify the importance of Perth's natural resources. Once a value is attributed to an ecosystem service, investments can be directed towards protecting and conserving those areas that are most valued and will benefit most from targeted biodiversity enhancement.

OUTCOME	OBJECTIVE	KNOWLEDGE GAPS	RANKING
Cultural and social-science knowledge is used for the management of urban green and blue spaces	Increase community awareness of the benefits of ecosystem services and a thriving urban biodiversity Include cultural values and knowledge systems in ecosystem management	How can increased community connection to and appreciation of urban ecosystems help enhance biodiversity resilience (social research on the health, economic, social and cultural values of retaining urban biodiversity)	Medium
		How to increase understanding of traditional ecological knowledge and Aboriginal values associated with environmental management	Medium
		How to raise awareness of biodiversity resilience when it comes to climate change adaptation	Medium
		What is the impact of fire regimes on the urban bushland value	Medium
		How to quantify the value/ resilience/viability of very small remnants of urban bushland	High

MAIN IMAGE: Sonja Mennen INSETS (from left): BGPA, Shutterstock

BUILDING BIODIVERSITY FOR THRIVING URBAN ECOSYSTEMS

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#### In summary

Consultation with stakeholders and end users identified the following knowledge gaps as having the highest priority in our quest to tackle the most pressing urban biodiversity challenges in Western Australia:





# PROGRAM IMPLEMENTATION

#### **Funding strategy**

Due to the large scope of this research program, a variety of funding models can be targeted. The research program is likely to involve a combination of short (one year), mid (five year) and long (>10 year) term projects, depending on the priority being addressed.

#### **ARC LINKAGE PROJECTS**

The Australian Research Council (ARC) Linkage Projects scheme promotes collaboration and research partnerships between key end users in research and innovation including higher education institutions, government, business, industry and end users. Research and development are undertaken to apply advanced knowledge to problems, acquire new knowledge, and as a basis for securing commercial and other benefits of research. The Linkage Projects scheme provides funding to eligible organisations (higher education institutions) to support research and development projects which are collaborative, are undertaken to acquire new knowledge and involve innovation. Proposals for funding under the Linkage Projects scheme must include at least one partner organisation. The partner organisation must make a contribution in cash and/or in-kind to the project. The combined (cash and in-kind) partner organisation contributions must at least match the total funding requested from the ARC. The Linkage Projects scheme provides projects projects scheme provides project funding of AU\$50,000 to AU\$300,000 per year for two to five years.



#### THE COMMUNITY STEWARDSHIP GRANTS

The Community Stewardship Grants prioritise the direct involvement of local community groups in all project stages of design, planning and implementation, through which efficient and effective partnerships between government, industry, and community can be fostered.

Community Stewardship Grants are available for community-based projects that help conserve, restore, rehabilitate or enhance a local natural area, conserve Western Australia's biodiversity and maintain or build the capability of NRM community groups across the State.

Over the past five years, AU\$38.5 million worth of Community Stewardship Grants have supported 409 grassroots not-for-profit and volunteer groups that care for the State's diverse and valuable natural assets, from the Kimberley to the South Coast with small grants of up to AU\$50,000 for up to 18 months' duration and large grants of up to AU\$450,000 — intended for more strategic, complex projects for up to three years duration.

#### LOTTERYWEST

Lotterywest funds environmentally focused projects of a range of size and duration that help understand and/or conserve the Western Australian environment. Projects must be community focused, not-for-profit, end user led and involve a strong element of delivering on-ground outcomes. This funding structure is well suited to encourage stronger collaborations between community groups and researchers to undertake applied research and management programs.

#### **NRM GRANTS**

State NRM grants as well as NRM group small grants can be used to fund components of research, usually embedded in a bigger management program primarily focused on delivering on-ground management outcomes.

#### NATIONAL LANDCARE PROGRAM GRANTS

National Landcare Program 2017-2023 invested AU\$1.1 billion to support community managed projects of one to five years duration that deliver on-ground improvements in biodiversity and sustainable agriculture. Included was the Environment Small Grants scheme for projects between AU\$5,000 and AU\$50,000 for on-ground weed management. Similar to NRM grants, National Landcare Grants can be used to fund components of research as part of a larger management program.

#### NATIONAL ENVIRONMENTAL SCIENCE PROGRAM (NESP)

The National Environmental Science Program Phase 2 (NESP2) will allocate AU\$149 million between 2021 to 2027 of which AU\$47 million has been allocated to the Resilient Landscapes Hub. This hub, led by Professor Michael Douglas of The University of Western Australia, will provide research to inform management of Australia's terrestrial and freshwater habitats to promote resilience, sustainability and productive practices.

#### PHILANTHROPY AND STRATEGIC ALLIANCES

Collaborative alliances with land managers linked to NGOs or philanthropic partnerships are an option for co-investing in complementary research. Not-for-profit groups such as the Australian Wildlife Conservancy and Bush Heritage Australia, Indigenous ranger groups, and the Centre for Invasive Species Solutions (CISS) all present well-aligned collaborative options in this regard.

#### PAYMENT FOR ECOSYSTEM SERVICES

Payments for ecosystem services can occur when the beneficiaries or users of an ecosystem service make payments to the providers of that service, e.g. for planting trees or reintroduction of a species. In practice, this may take the form of a series of payments in return for receiving a flow of benefits or ecosystem services (Fripp 2014).

#### Governance

The successful delivery of this research program is dependent on an appropriate governance structure. The WABSI research program framework specifies that a steering committee be established to administer the program. Steering committees should comprise key stakeholders, researchers and at least one representative from the regulatory sector to ensure that outcomes are consistent with policy objectives. Following the WABSI approach will ensure that this prioritised program is translated into research outputs and, in turn, on-ground outcomes. While WABSI will play an active role in the implementation of the research program via the steering committee, the appointed group will ensure that delivery of the research program endures should WABSI involvement be either reduced or withdrawn.

The primary role of a steering committee that will guide the implementation of the research program is to facilitate that:

- Projects developed under the research program are well integrated and engaged and will deliver on a shared vision;
- The scope of projects and intended outcomes meet the requirements of end users;
- The science being delivered is of a high standard without duplication of research effort;
- Outcomes are able to be translated effectively to all end users of the knowledge to encourage adoption of research findings;
- The research program plan is up to date and best reflects the current end user needs and research capability;
- Activities are aligned to relevant state and Commonwealth objectives; and
- Proposed outcomes are achieved.

#### **Risk management**

This section outlines key risks identified in relation to the urban biodiversity resilience research program.

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#### GOVERNANCE

DESCRIPTION	LIKELIHOOD	IMPACT	MITIGATION ACTION
Steering committee not able to represent the interests of all	Possible	Moderate	<ul> <li>Membership comprises key stakeholders who have a long-term interest in the intended outcomes of the program</li> </ul>
stakenolders			<ul> <li>Where possible, prioritise remuneration for those who cannot engage as part of their current professional workload</li> </ul>
Sub-standard collaboration and communication	Possible	Moderate	<ul> <li>Steering committee liaises with project leaders throughout the projects to facilitate effective collaboration</li> </ul>
between research providers			<ul> <li>Project agreements clearly indicate the collaborative nature of projects and communication requirements</li> </ul>
Projects do not deliver against identified research	Possible	Major	<ul> <li>Project planning to be established at project commencement and evaluated by the steering committee</li> </ul>
priorities			<ul> <li>External independent peer review of project proposals and reporting as appropriate</li> </ul>
Indigenous engagement is	Unlikely	Major	<ul> <li>Research projects are aligned with WABSI Indigenous engagement principles</li> </ul>
not conducted appropriately			<ul> <li>Indigenous engagement is enabled via steering committee membership and/or other suitable engagement mechanisms</li> </ul>
			<ul> <li>Research projects meet the requirements of their own organisation's Indigenous engagement policy</li> </ul>
Misuse of funds	Unlikely	Major	<ul> <li>Project proposals are clear as to how the funds will be expended against each milestone</li> </ul>
			<ul> <li>Organisations managing project funds must provide evidence of appropriate financial management systems and protocols</li> </ul>
Insufficient funds are realised to implement	Possible	Major	<ul> <li>Program components are carefully and strategically prioritised</li> </ul>
key components of the program			<ul> <li>Options for funding are fully explored</li> </ul>
			<ul> <li>Significant effort put into community outreach to justify the program and its implementation, and to chart its successes</li> </ul>

#### **RESEARCH DELIVERY**

DESCRIPTION	LIKELIHOOD	IMPACT	MITIGATION ACTION
Lack of capability and expertise	Unlikely	Major	<ul> <li>Sufficient research capability in partner organisations is able to cover the expanded requirements needed to deliver the program</li> </ul>
			<ul> <li>Succession planning and knowledge transfer is supported across organisations</li> </ul>
			<ul> <li>Research partners collaborate effectively to ensure capability is available to deliver against research projects</li> </ul>
Loss of key personnel	Possible	Moderate	<ul> <li>Sufficient research depth in partner organisations allows for substitution of expertise</li> </ul>
			<ul> <li>Project resources are prioritised for multi- year projects accompanied by multi-year contracts for key personnel</li> </ul>
			<ul> <li>WABSI research provider network knowledge is leveraged by the steering committee</li> </ul>
Research outputs are of sub-standard	Possible	Moderate	<ul> <li>Steering committee maintains close oversight throughout research projects</li> </ul>
quality			<ul> <li>External peer review of project proposals and reporting as appropriate</li> </ul>
Research not able to deliver on objectives	Possible	Moderate	<ul> <li>Scope of work and risks are clearly articulated</li> </ul>
			<ul> <li>The steering committee helps to find an optimal balance between aspiration and reality in regard to project scope</li> </ul>
			<ul> <li>Mitigation strategies are included in project risk assessments</li> </ul>
Research outputs do not directly address a	Unlikely	Major	<ul> <li>Steering committee maintains close oversight on research project scoping</li> </ul>
prioritised information gap			<ul> <li>Scope of work and path to impact are clearly articulated</li> </ul>
			<ul> <li>End to end consultation with key stakeholders on the development of priorities, scoping of research, implementation and outputs</li> </ul>

DESCRIPTION	LIKELIHOOD	IMPACT	MITIGATION ACTION
Research outputs are not delivered on time or on budget	Possible	Major	<ul> <li>Adoption of a proactive project management process with steering committee involvement</li> </ul>
			<ul> <li>Early interception of timeline deviations before milestones are missed</li> </ul>
			<ul> <li>Clear contractual obligations relating payments to milestones</li> </ul>
Research is being duplicated by others	Possible	Moderate	<ul> <li>Research program communicated to the research community including new initiatives</li> </ul>
			<ul> <li>Research program communicated to end users</li> </ul>
			<ul> <li>WABSI website (and others as appropriate) includes up-to-date information on each project</li> </ul>
Research outputs are not shared appropriately with end users	Possible	Moderate	<ul> <li>Research proposals clearly articulate a path to impact approach, including how the research will be translated into a user- friendly format for all end users</li> </ul>
			<ul> <li>Intellectual property and information sharing agreements are clearly articulated in project agreements</li> </ul>
			<ul> <li>There will be an assumption that all results will be made public with open access publication unless there is sufficient justification for privacy</li> </ul>



#### **IMPACT AND ADAPTATION**

DESCRIPTION	LIKELIHOOD	IMPACT	MITIGATION ACTION
Communication plans do not address adoption of research outcomes	Possible	Major	<ul> <li>All projects to have a communication plan that includes an adoption strategy</li> </ul>
			<ul> <li>Relevant stakeholders are consulted when forming research adoption plans</li> </ul>
			<ul> <li>End-to-end project communications with stakeholder groups</li> </ul>
Social licence is not secured, maintained	Possible	Major	<ul> <li>All projects consider social licence issues in their scoping and risk assessment</li> </ul>
and enhanced for all planned activities			<ul> <li>All projects take a proactive approach to engagement with stakeholders and interested parties during project scoping and delivery</li> </ul>
Active interference with research program goals by special interest	Possible	Moderate	<ul> <li>All projects take a proactive approach to engagement with stakeholders and interested parties during project scoping and delivery</li> </ul>
groups			<ul> <li>Research projects take a proactive, neutral and respectful approach to communicating results and engaging with the public, including paying careful attention to language and framing</li> </ul>
Research outcomes are not adopted by end users	Possible	Major	<ul> <li>All projects take a proactive approach to identifying end users during project scoping</li> </ul>
			<ul> <li>Project leaders to work with the steering committee to ensure optimal adoption by end users</li> </ul>
			<ul> <li>Research is conducted in tandem with applied projects and ongoing engagement with stakeholder groups to facilitate transfer of knowledge and ownership of outcomes</li> </ul>
			<ul> <li>Adoption milestones are included in all projects, and developed in consultation with the steering committee</li> </ul>
Insufficient funds are realised to implement	Possible	Major	<ul> <li>Program components are carefully and strategically prioritised</li> </ul>
кеу components of the program			Options for funding are fully explored
· -			<ul> <li>Significant effort put into community outreach to justify the program and its implementation, and to chart its successes</li> </ul>

#### POLICY

DESCRIPTION	LIKELIHOOD	IMPACT	MITIGATION ACTION
Policy changes work against the research outcomes of the program	Possible	Moderate	<ul> <li>Ensure that the regulatory sector is represented on the steering committee</li> </ul>
			<ul> <li>Ensure effective communication between the steering committee and policy makers/ regulators</li> </ul>
			<ul> <li>Ensure that policy makers and regulators have access to the latest evidence-based knowledge</li> </ul>
Policy changes alter the likely impact of the research outcomes	Unlikely	Major	<ul> <li>Ensure that the regulatory sector is represented on the steering committee</li> </ul>
			<ul> <li>Ensure effective communication between the steering committee and policy makers/ regulators</li> </ul>



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## **Appendix 1**

Issues that emerged from urban biodiversity workshop 1

			SOLUTION				
NO.	ISSUE	RES	MAN	POL	FUN	сом	
	Current challenges						
1.	Connectivity and restoration						
	How connected can the landscape be made?	Х	Х	Х	Х		
	How to decide between development and connectivity?		Х	Х		Х	
	Prioritising remnant vegetation versus the matrix:						
	• How to optimise where resources and effort are invested.	x	x	х	x	x	
	<ul> <li>Decisions on what areas of existing bushland need to be retained.</li> </ul>			~			
	Better quantification of the value and resilience/viability of very small remnants of urban bushland.	х	×	Х	х	x	
	Ongoing and ever declining lack of funding for managing/ restoring the conservation estate.			Х	Х	x	
	When taking a regional approach, defining what the 'region' would be — biological/ecological versus an administrative or jurisdictional boundary.	х	x	Х		x	
2.	Trees in urban environments					1	
	Loss of canopy cover on private property due to (perceived) safety issues.	Х	x	Х		x	
	No across-government agreement on canopy targets nor a coordinated, strategic approach on how to achieve these targets.	х	×	Х	х	x	
	Social, health and economic co-benefits of trees not adequately considered in planning.	х	x	Х			
	Trees in urban landscapes work well to reduce carbon footprint as more local governments work towards implementing net zero targets.	х	x	Х			
	More information needed on height and root depth and spread for different trees/plant species to enable informed decision- making about where to plant which species, often in relation to energy, water and other assets.	X				x	
	More information needed on the value of co-benefits from trees, such as biodiversity, health and well-being, heat island effect mitigation.	Х		Х		x	

			sc	ON			
NO.	ISSUE	RES	MAN	POL	FUN	сом	
3.	Carbon capture and storage/carbon sequestration	1		1	1	1	
	How to quantify the additionality of carbon capture of different tree species for local governments to achieve net zero.	x	х	х		х	
	Where is the best place to undertake plantings for carbon sequestration?	х		Х	х	х	
4.	Invasive species/weeds and their control						
	There are a number of highly problematic invasive species that threaten urban biodiversity, including weeds (often garden escapees) and cats (both pets and strays)	х	x	х	х	x	
	The use of herbicides within local governments is a controversial issue relating to (perceived) health risks, treatment effectiveness and cost-effectiveness.	х	x	х	х	x	
	Connectivity is a double-edged sword, with spread risk to new areas increasing for invasive pests and weeds.	x	×		x	×	
	The use of pesticides is a big issue for electricity infrastructure – vast majority of chemical pesticide treatment for termites is highly toxic to waterborne vertebrates when leaching into waterways.	x	x	х		х	
	Research on preferably biological control options for invasive species.	х	x		х	х	
5.	Planning for new developments to include design for retaining bu corridors and linkages	bushland and providing					
	Refrain from clearing additional urban bushland and trees to achieve 30 per cent tree canopy in local governments. Build on land that has already been cleared or damaged.		x	x		x	
	Don't develop new infrastructure through remnant bushland.		Х	Х		Х	
	What extra value does existing bushland and biodiversity have on marketability of new developments.	х		х		х	
	What is the minimum amount of vegetation required to be retained to preserve various ecosystem values?	х	x			Х	
	Rethink design streetscapes to accommodate trees, service corridors, foot/bike paths etc.	х		х	х	х	
	When preparing land for new development, rethink current approach to clear and flatten building lot, and in waterlogged areas to import large volumes of sand fill.	х		х		x	

		SOLUTION				
NO.	ISSUE	RES	MAN	POL	FUN	сом
6.	Restoration of climate resilient native species through horticultur	e				
	Apathy/lack of awareness towards urban biodiversity.		Х	Х		Х
	Lack of knowledge/information on what can be done to bring native fauna (birds/bees) back into people's gardens.	Х				х
	Ensure native plants and trees are resilient to future climate circumstances.	Х		Х	Х	х
7.	Fire mitigation					
	Urban bushland needs fire to regenerate which may pose danger to nearby residential areas.	Х	Х	Х	Х	Х
	Conflicting advice from State Government agencies on fire management for local governments.		х	Х	Х	х
	Cultural burning an important issue but not addressed by DBCA or other agencies.	Х	х	Х	Х	х
	Fire risk mitigation regime for urban bushland	Х	Х	Х		Х
8.	Vertebrates in urban landscapes					
	The impact of vertebrates on vegetation quality and fire fuel loads	×	х	Х		х
	Appropriate management of large vertebrates in urban settings	Х	Х	Х	Х	Х
	People-animal conflicts in urban remnants	Х	Х	Х		Х
9.	Non conservation values of biodiversity (social, health, economic	and cu	ultural)			
	Non-conservation values not adequately captured/included in urban planning.	х		Х		х
	Research shows strong link between ecological health and human wellbeing. Conserving biodiversity would help improve human physical and mental health. Include quantification of value (monetise) of benefits to support business cases.	x	х	Х	х	x
	Need for increased understanding of Traditional Ecological Knowledge and Aboriginal values associated with environmental management	х	х	Х	х	х
	Social research to understand community values and benefits and the most effective approaches to influence behaviour change to encourage greater connection to and care of ecosystems.	х	х	х	х	х
	Introduce financial incentives for sustainable housing design (e.g. retaining trees on property).		х	Х	х	х

		SOLUTION		SOLUTION			
NO.	ISSUE	RES	MAN	POL	FUN	сом	
	Western Australia specific context						
10.	Ecological and geographic issues						
	Perth is unique due to very high percentage of endemic species within urban borders (67 per cent).	х	×			×	
	The biodiversity environment has evolved to adapt to nutrient-poor soils and circumstances.		x				
11.	Urban planning issues						
	Local governments have limited decision-making powers and partial involvement in decision-making around urban planning.		×	Х		×	
	Lack of coordination between government agencies. Top-down approach to planning.		x	Х		x	
	Inverse imbalance — Federal Government has the capacity to provide funding, but long-term contributions from the Federal government are difficult to obtain, whereas State Government funds for biodiversity are constrained and limited.			х		x	
	Future challenges						
12.	Climate change, threat mitigation and adaptation						
	When thinking about adapting to climate change, we often do not think about biodiversity.	х	×	х	x	x	
	The size of our coastal reserves, which contain important conservation values, will decrease as sea levels rise from climate change.	x	x	х		x	
	Link between climate change and dropping water levels in wetlands and reduced streamflow in rivers and creeks.	х	х	Х	х	x	
	More heavy downpour rain events will lead to increased stormwater drainage.	х	x	х		x	
	What knowledge gaps remain to make better decisions on urban conservation values when explicitly factoring in climate change? What will factoring in climate change alter beyond current business as usual priorities?	x	x	х	x	x	
	Can we use a triage process to identify which biodiversity values are going to be non-functional with climate change, and use this to inform development and remnant retention prioritisation?	x	x			x	
	Temperatures will rise due to climate change, which will lead to urban heat-island effect.	x	x	х	x	x	

		SOLUTIC			ION		
NO.	ISSUE	RES	MAN	POL	FUN	сом	
13.	Population pressures						
	Increasing population will mean increasing pressure on land in urban areas, infrastructure etc.	Х	х	Х		х	
	Get more people to live in existing housing stock more efficiently.		х	Х		×	
	How can we mitigate the impacts of 'infill' development on public open space, particularly when there are differing values placed on outcomes by different levels of government?	х	х	х			
	Vertical housing design — helps address population density and conserve urban bushland and biodiversity.	Х	х	Х	х	x	
14.	Changing infrastructure requirements						
	How can we better use service/infrastructure corridors and assets to support biodiversity and green corridors?	Х	х	х	х	x	
	How can we more effectively provide, utilise and situate public open space to maximise value?	Х	х	Х	Х	х	
	Increased density may require more green space requirements as private garden areas decrease. Where possible stormwater drainage areas and redundant power pole corridors could be converted into biodiversity areas.	x	x	х	x	x	



## **Appendix 2** Outcomes of urban biodiversity workshop 2

## **PRIORITISATION EXERCISE**

## Introduction

## WABSI - URBAN BIODIVERSITY RESEARCH PROGRAM

The issue of urban biodiversity resilience requires an integrated approach with a clear focus on collaborative opportunities for problem solving, and tapping into existing resources, knowledge and expertise to apply best practice land management, which will help achieve multiple benefits with the limited resources available. Within this focus, WABSI proposes to connect stakeholders, identify and prioritise end user requirements and knowledge gaps, and facilitate addressing these knowledge gaps through targeted and coordinated research.

### Aim of this survey is to:

- Define/further refine research questions under topics established during the initial urban biodiversity workshop
- Prioritise research topics and questions according to end user requirements

## **Respondent details**

Q1. Name

**Q2.** Organisation



## **Ranking focus areas**

#### Q3. Focus areas

During the first urban biodiversity workshop a number of research focus areas were established, to help address end user knowledge gaps when it comes to enhancing urban biodiversity resilience.

Please rank the research focus areas below from 1 to 4 by dragging and dropping the focus areas in the right order. (1 is most important and 4 is least important)

- Ecosystem restoration
- Green infrastructure and urban forests
- Climate change resilience
- Fire mitigation

## Focus area 1 — Ecosystem restoration

### Q4. Please rank the urgency for each of the research questions below

#### **Research topic 1: Connectivity and restoration**

1.	How connected can the landscape be made — what
	are the optimal minimal linkages that can be provided

- 2. Connecting the landscape remnant vegetation versus the matrix
- 3. What are the best practice novel nature habitat infrastructure designs
- 4. How to quantify the value/resilience/viability of very small remnants of urban bushland
- 5. Are there 'supercharger' species that provide the greatest habitat value
- 6. What parts of the urban landscape/remnant habitats will benefit most from targeted urban biodiversity enhancement

	ingi (i)	Medium (2)	2011 (3)	
andscape be made — what nkages that can be provided				
e — remnant vegetation				
e novel nature habitat				
/resilience/viability of very bushland				
species that provide the				
ndscape/remnant habitats geted urban biodiversity				

High (1) Madium (2) Low (3)



### Research topic 2: Control of invasive pests and weeds

- 1. How to manage highly problematic invasive species e.g. weeds escaping from gardens, feral cats
- 2. Risks, resource requirements and effectiveness of different herbicides
- What are optimal methods of control research into less toxic and more targeted pest control alternatives and its correct use
- 4. How do we determine the urgency/prioritisation of weeds and pest control (immediate/ urgent/non-urgent)
- 5. How to manage the spread of weeds when connectivity is improved

### **Q6.** Focus area 1 — Ecosystem restoration

### Research topic 3: Vertebrates in urban landscapes

- How do we manage herbivore density (including reintroduction and culling) in urban remnants to optimise fuel reduction benefits
- 2. How do we appropriately manage large vertebrates
- 3. How do we manage people versus animal conflicts

High (1)	Medium (2)	Low (3)

 High (1)
 Medium (2)
 Low (3)

 Image: Image

## Focus area 2 — Green infrastructure and urban forests

## Q7. Please rank the urgency for each of the research questions below

### **Research topic 1: Trees in urban environments**

		High (1)	Medium (2)	Low (3)
1.	How can we prevent loss of canopy cover on private property			
2.	How can we align urban canopy targets for different organisations involved			
3.	How to address the lack of information on co-benefits of trees in urban areas (biodiversity, health and well- being, heat island effect, carbon sequestration)			
4.	Research on height and root depth and spread to enable informed decision-making for tree asset management			
5.	Develop a generalist species list which species provide optimal infrastructure compatibility/carbon value/ biodiversity value			
6.	How to manage the understory in urban forests			

### **Q8.** Focus area 2 – Green infrastructure and urban forests

#### Research topic 2: Carbon capture and storage / carbon sequestration

		High (1)	Medium (2)	Low (3)
1.	How to quantify carbon capture of different tree species to achieve net zero			
2.	Biodiversity and carbon offsets serve different purposes — how to optimise biodiversity and carbon capture through quantitative benefits of offsets			
3.	Optimal grow area to grow carbon sequestration plantings			



#### Research topic 3: Expansion of green infrastructure

		High (1)	Medium (2)	Low (3)
1.	What is the optimal design of service/infrastructure corridors and assets to support green corridors for biodiversity			
2.	How can we effectively provide, use and situate public open space to maximise value for biodiversity enhancement			

#### **Q10.** Focus area 2 – Green infrastructure and urban forests

#### Research topic 4: Non-conservation values of urban biodiversity

1.	Social research on the health, economic, social and cultural values of retaining urban biodiversity (trees, native flora and fauna species) and waterways and
	wetlands

- 2. How do we establish greater community connection to and care for ecosystems (research linking species composition and structural diversity in vegetation with particular ecosystem service outcomes
- How do we increase understanding of traditional ecological knowledge and Aboriginal values associated with environmental management

·y		
High (1)	Medium (2)	Low (3)

. . . . .

## Focus area 3 — Climate change resilience

### Q11. Please rank the urgency for each of the research questions below

#### Research topic 1: Climate change resilient native species (animals, plants and trees)

	High (1)	Medium (2)	Low (3)	
How and where to source individual plants, trees and animals for restoration (local/mixture, similar environment, climate resilient)				
Consideration of future climate when planting — considering Perth's climate in 2050				

#### Q12. Focus area 3 — Climate change resilience

1.

2.

#### Research topic 2: Threat mitigation and adaptation

- How to raise awareness of biodiversity resilience when it comes to climate change adaptation — it is often forgotten
- How do we adapt to changing infrastructure requirements and protect biodiversity during extreme weather events (water security, urban heat island, storms, floods)
- 3. To what degree should we accept the novel ecosystems — risk assessment
- 4. Develop a triage process to inform decision-making on which biodiversity elements to protect
- 5. How to reduce loss of important conservation values due to shrinking coastal reserves (sea water level rises)
- How do we set water quality/quantity targets dropping groundwater levels and reduced streamflow are a threat to the health of aquatic and groundwater dependent ecosystems

	High (1)	Medium (2)	Low (3)
ce when ften			
xtreme nd,			
cosystems			
aking on			
values vel rises)			
dropping e a threat endent			



## Focus area 4 — Fire mitigation

#### Q13. Please rank the urgency for each of the research questions below

#### **Research topic 1: Fire for regeneration**

High (1)	Medium (2)	Low (3)
	High (1)	High (1) Medium (2)

### Q14. Focus area 4 — Fire mitigation

#### Research topic 2: Fire for risk mitigation

		High (1)	Medium (2)	Low (3)
1.	What is the optimal fire risk mitigation regime for urban bushland			
2.	What is the impact of fire regimes on urban biodiversity			
3.	What is the impact of fire regimes on the urban environment (erosion, weeds, water quality, wetlands)			
4.	What is the impact of fire regimes on the urban bushland value			

## Potential focus area 5 — Biodiversity in peri-urban and regional urban areas

Q15. Do you think a fifth focus area (Biodiversity in peri-urban and regional urban areas) should be added?



Q16. If you see value in a fifth focus area (Biodiversity in peri-urban and regional urban areas), what kind of research questions would you like to see answered?



Yes

## **Overall top three research questions**

Q17. Please review all focus areas, research topics and their questions again and rank your overall top three. Which research questions are the most urgent to be answered? Please drag and drop your top three to the top of the list below.

### 1. Ecosystem restoration

- 1.1 Connectivity and restoration
- 1.2 Control of invasive pests and weeds
- 1.3 Vertebrates in urban landscapes

### 2. Green infrastructure and urban forests

- 2.1 Trees in urban environments
- 2.2 Carbon capture and storage / carbon sequestration
- 2.3 Expansion of green infrastructure
- 2.4 Non-conservation values of urban biodiversity

#### 3. Climate change resilience

- 3.1 Climate change resilient native species (animals, plants and trees)
- 3.2 Threat mitigation and adaptation

### 4. Fire mitigation

- 4.1 Fire for regeneration
- 4.2 Fire for risk mitigation

### 5. Biodiversity in peri-urban and regional urban areas)

1.1.1	How connected can the landscape be made — what are the optimal minimal linkages that can be provided
1.1.2. (	Connecting the landscape — remnant vegetation versus the matrix
1.1.3.	What are the best practice novel nature habitat infrastructure designs
1.1.4.	How to quantify the value/resilience/viability of very small remnants of urban bushland
1.1.5.	Are there 'supercharger' species that provide the greatest habitat value
1.1.6.	What parts of the urban landscape/remnant habitats will benefit most from targeted urban biodiversity enhancement



1.2.1	How to manage highly problematic invasive species e.g. weeds escaping from gardens, feral cats
1.2.2.	Risks, resource requirements and effectiveness of different herbicides
1.2.3.	What are optimal methods of control — research into less toxic and more targeted pest control alternatives and its correct use
1.2.4.	How do we determine the urgency/prioritisation of weeds and pest control (immediate/urgent/non-urgent)
1.2.5.	How to manage the spread of weeds when connectivity is improved
1.3.1.	How do we manage herbivore density (including reintroduction and culling) in urban remnants to optimise fuel reduction benefits
1.3.2.	How do we appropriately manage large vertebrates
1.3.3.	How do we manage people versus animal conflicts
2.1.1.	How can we prevent loss of canopy cover on private property
2.1.2.	How can we align urban canopy targets for different organisations involved
2.1.3.	How to address the lack of information on co-benefits of trees in urban areas (biodiversity, health and well-being, heat island effect, carbon sequestration)
2.1.4.	Research on height and root depth and spread to enable informed decision-making for tree asset management
2.1.5.	Develop a generalist species list which species provide optimal infrastructure compatibility/carbon value/biodiversity value
2.1.6.	How to manage the understory in urban forests
2.2.1.	How to quantify carbon capture of different tree species to achieve net zero
2.2.2.	Biodiversity and carbon offsets serve different purposes — how to optimise biodiversity and carbon capture through quantitative benefits of offsets
2.2.3.	Optimal grow area to grow carbon sequestration plantings
2.3.1.	What is the optimal design of service/infrastructure corridors and assets to support green corridors for biodiversity
2.3.2.	How can we effectively provide, use and situate public open space to maximise value for biodiversity enhancement
2.4.1.	Social research on the health, economic, social and cultural values of retaining urban biodiversity (trees, native flora and fauna species) and waterways and wetlands
2.4.2.	How do we establish greater community connection to and care for ecosystems (research linking species composition and structural diversity in vegetation with particular ecosystem service outcomes)
2.4.3.	How do we increase understanding of traditional ecological knowledge and Aboriginal values associated with environmental management



3.1.1. How and where to source individual plants, trees and animals for restoration (local/mixture, similar environment, climate resilient)
3.1.2. Consideration of future climate when planting – considering Perth's climate in 2050
3.2.1. How to raise awareness of biodiversity resilience when it comes to climate change adaptation — it is often forgotten
3.2.2. How do we adapt to changing infrastructure requirements and protect biodiversity during extreme weather events (water security, urban heat island, storms, floods)
3.2.3. To what degree should we accept the novel ecosystems — risk assessment
3.2.4. Develop a triage process to inform decision-making on which biodiversity elements to protect
3.2.5. How to reduce loss of important conservation values due to shrinking coastal reserves (sea water level rises)
3.2.6. How do we set water quality/quantity targets — dropping groundwater levels and reduced streamflow are a threat to the health of aquatic and groundwater dependent ecosystems
4.1.1. What is the optimal use of fire to regenerate and maintain high quality landscapes
4.1.2. How do we introduce cultural burning practices in urban areas
4.2.1. What is the optimal fire risk mitigation regime for urban bushland
4.2.2. What is the impact of fire regimes on urban biodiversity
4.2.3. What is the impact of fire regimes on the urban environment (erosion, weeds, water quality, wetlands)
4.2.4. What is the impact of fire regimes on the urban bushland value

Q18. If you think any issue or challenge with regards to urban biodiversity resilience is missing from this exercise, please provide feedback below.

• •



## **OUTCOMES ONLINE EXERCISE WORKSHOP 2**



## **Outcomes question 3**

## **Outcomes question 4**

#### Focus area 1: Ecosystem restoration Research topic 1: Connectivity and restoration

- 1. How connected can the landscape be made what are the optimal minimal linkages that can be provided
- 2. Connecting the landscape remnant vegetation versus the matrix
- 3. What are the best practice novel nature habitat infrastructure designs
- 4. How to quantify the value/resilience/viability of very small remnants of urban bushland
- 5. Are there 'supercharger' species that provide the greatest habitat value
- 6. What parts of the urban landscape/remnant habitats will benefit most from targeted urban biodiversity enhancement



## **Outcomes question 5**

#### Focus area 1: Ecosystem restoration Research topic 2: Control of invasive pests and weeds

- 1. How to manage highly problematic invasive species e.g. weeds escaping from gardens, feral cats
- 2. Risks, resource requirements and effectiveness of different herbicides
- 3. What are optimal methods of control research into less toxic and more targeted pest control alternatives and its correct use
- How do we determine the urgency/prioritisation of weeds and pest control (immediate/urgent/non-urgent)
- 5. How to manage the spread of weeds when connectivity is improved



## **Outcomes question 6**

#### Focus area 1: Ecosystem restoration Research topic 3: Vertebrates in urban landscapes

- How do we manage herbivore density (including reintroduction and culling) in urban remnants to optimise fuel reduction benefits
- 2. How do we appropriately manage large vertebrates
- 3. How do we manage people versus animal conflicts





## **Outcomes question 7**

#### Focus area 2: Green infrastructure and urban forests Research topic 1: Trees in urban environments

- 1. How can we prevent loss of canopy cover on private property
- How can we align urban canopy targets for different organisations involved
- 3. How to address the lack of information on co-benefits of trees in urban areas (biodiversity, health and well-being, heat island effect, carbon sequestration)
- 4. Research on height and root depth and spread to enable informed decision-making for tree asset management
- Develop a generalist species list which species provide optimal infrastructure compatibility/carbon value/biodiversity value
- 6. How to manage the understory in urban forests



## **Outcomes question 8**

#### Focus area 2: Green infrastructure and urban forests Research topic 2: Carbon capture and storage/carbon sequestration

- 1. How to quantify carbon capture of different tree species to achieve net zero
- Biodiversity and carbon offsets serve different purposes how to optimise biodiversity and carbon capture through quantitative benefits of offsets
- 3. Optimal grow area to grow carbon sequestration plantings



## **Outcomes question 9**

#### Focus area 2: Green infrastructure and urban forests Research topic 3: Expension of green infrastructure

- 1. What is the optimal design of service/infrastructure corridors and assets to support green corridors for biodiversity
- 2. How can we effectively provide, use and situate public open space to maximise value for biodiversity enhancement



## **Outcomes question 10**



#### Focus area 2: Green infrastructure and urban forests Research topic 4: Non-conservation values of urban biodiversity

- 1. Social research on the health, economic, social and cultural values of retaining urban biodiversity (trees, native flora and fauna species) and waterways and wetlands
- 2. How do we establish greater community connection to and care for ecosystems (research linking species composition and structural diversity in vegetation with particular ecosystem service outcomes)
- 3. How do we increase understanding of traditional ecological knowledge and Aboriginal values associated with environmental management



## **Outcomes question 11**

#### Focus area 3: Climate change resilience Research topic 1: Climate change resilient native species

- 1. How and where to source individual plants, trees and animals for restoration (local/mixture, similar environment, climate resilient)
- 2. Consideration of future climate when planting considering  $\ensuremath{\mathsf{Perth's}}$  climate in 2050



## **Outcomes question 12**

#### Focus area 3: Climate change resiliences Research topic 2: Threat mitigation and adaptation

- 1. How to raise awareness of biodiversity resilience when it comes to climate change adaptation it is often forgotten
- 2. How do we adapt to changing infrastructure requirements and protect biodiversity during extreme weather events (water security, urban heat island, storms, floods)
- 3. To what degree should we accept the novel ecosystems risk assessment
- 4. Develop a triage process to inform decision-making on which biodiversity elements to protect
- 5. How to reduce loss of important conservation values due to shrinking coastal reserves (sea water level rises)
- How do we set water quality/quantity targets dropping groundwater levels and reduced streamflow are a threat to the health of aquatic and groundwater dependent ecosystems



## **Outcomes question 13**

### Focus area 4: Fire mitigation Research topic 1: Fire for regeneration

- 1. What is the optimal use of fire to regenerate and maintain high quality landscapes
- 2. How do we introduce cultural burning practices in urban areas



## **Outcomes question 14**



- 1. What is the optimal fire risk mitigation regime for urban bushland
- 2. What is the impact of fire regimes on urban biodiversity
- 3. What is the impact of fire regimes on the urban environment (erosion, weeds, water quality, wetlands)
- 4. What is the impact of fire regimes on the urban bushland value



## **Outcomes question 15**

Fifth focus area (Peri urban and regaion urban areas)





## **Outcomes question 17**

### Most urgent reseach questions



## **Outcomes question 17**

Understanding and mitigating impact of future climate on ecological heath. Science to inform development of whole-of-government indicators and targets for ecological health (and embedding in policy/legislation).

Concern that there is a great deal of information available on all of these issues. However, the participants don't seem to be aware of this body of work and are certainly not applying it to urban bushland. This highlights the need for somebody to interpret and share current research.

How do we ensure that the species planted to enhance biodiversity are suitable local endemic species that will enhance habitat value and create structural variability, but not become disturbance opportunistic invaders and increase the overall bush fire hazard risk of urban bushland areas?

## **Appendix 3** End user workshop attendees and contributors

## **INITIAL SCOPING SESSIONS 2018**

## 13 March 2018 — WABSI – SWAN NRM

NAME	ORGANISATION
Belinda Robson	Murdoch University
Craig Carpenter	Australian Institute of Landscape Architects
Emma Yuen	CRC for Water Sensitive Cities
Geoff Barret	Department of Biodiversity, Conservation and Attractions
Debbie Besch	Department of Biodiversity, Conservation and Attractions
Glen Shaw	Department of Planning, Lands and Heritage
Rod Safstrom	Department of Primary Industries and Regional Development
Paul Bodlovich	Perth NRM
Jason Pitman	Perth NRM
Mariyon Slany	Perth NRM
Karen Warner	EMRC
Nicole Matthews	WALGA
Renata Zelinova	WALGA
Jason Mackay	Water Corporation
Peter Nash	South West Group
Bruce Webber	WABSI



## 24 July 2018 — WABSI – UDIA (WA) Environment Committee

NAME	ORGANISATION
Members	UDIA (WA) Environment Committee
Bruce Webber	WABSI

## **URBAN BIODIVERSITY WORKSHOP 1**

## 30 November 2021

NAME	ORGANISATION
Nicholas Dufty	Department of Planning, Lands and Heritage
Lisa Edwards	WA Loves Nature
Mary Gray	Urban Bushland Council
Luke McMillan	Perth NRM
Garry Middle	WA Local Government Association (WALGA)
Dave Mitchell	Department of Biodiversity, Conservation and Attractions
Vern Newton	Hanson
Kim Onton	Department of Biodiversity, Conservation and Attractions
Antonietta Torre	Water Corporation
Megan Waddell	Infrastructure WA
James Widenbar	Western Power
Bruce Webber	WABSI
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## **URBAN BIODIVERSITY WORKSHOP 2**

## 5 April 2023

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