Department of Planning, Housing and Infrastructure

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Research strategy for the Cumberland Plain Conservation Plan

What we heard

May 2025

Acknowledgement of Country

This report acknowledges more than 60,000 years of continuous Aboriginal[1] connections to the land that makes up NSW. We acknowledge and pay our respects to Elders past and present.

This report recognises that, as part of the world's oldest living culture, traditional Aboriginal owners and custodians share a unique bond to Country and the plants, animals, waterways and landforms it contains. This relationship has been forged through thousands of years of living with the lands and waters and engaging with them for ceremony, religion, trading and seasonal migration.

The area covered by the Cumberland Plain Conservation Plan has been traditionally cared for by 3 Aboriginal groups: the Darug, Dharawal and Gundungurra. Others, such as the Eora, Darkinjung, Wiradjuri and Yuin may also maintain trade or other obligatory care relationships with the area. The Deerubbin, Gandangara and Tharawal local Aboriginal land councils also have local land holdings and contemporary responsibilities towards all the Aboriginal peoples and communities living in the area. This report recognises that there are many Aboriginal and Torres Strait Islander peoples today who are connected to Country that is now largely known as the Cumberland Plain.

This report recognises the need to integrate Aboriginal knowledge, practices and perspectives into conservation approaches, and seeks the active leadership, participation and engagement of Aboriginal groups and practitioners.

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First published: May 2025

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[1] The term 'Aboriginal' is used in this report to recognise those who identify as Aboriginal Australian peoples (and are recognised by their communities as such) with traditional and/or contemporary connections to the lands now known as the Cumberland Plain. We recognise that labels such as Aboriginal fail to recognise the vast diversity of nation, language, clan and tribal groups now understood to be Aboriginal and/or Torres Strait Islander peoples. See Practice resource – Working with Aboriginal people and communities for more detail.

Contents

About this report

The CPCP identifies important biodiversity areas in the Cumberland Plain so they can be protected from the impacts of Western Sydney's urban development. The CPCP will ensure the areas that are home to many unique animals and plants of the Cumberland Plain are protected to 2056.

A key action in the CPCP is the creation of an ongoing research program to support the CPCP's main commitments. The Research strategy for the Cumberland Plain Conservation Plan (the strategy) was prepared to guide the research needed to carry out the CPCP. The research program guided by this strategy will provide the new information needed by those working to conserve and restore the plants and animals of the Cumberland Plain. The strategy also recognises that Aboriginal knowledge and collaboration must be an integral part of the research program.

In October 2021, the Department of Planning, Housing and Infrastructure (the department) and Western Sydney University (WSU) engaged with subject matter experts and stakeholders to help develop the draft strategy. The department then opened the draft strategy for targeted public feedback from November 2022 to February 2023.

This report outlines what we heard from engagement with subject matter experts and stakeholders and targeted public consultation.

Figure 1. Picnickers enjoying a natural area in Western Sydney

1 How the strategy was developed

The development of the strategy focused on identifying what new knowledge was needed to take effective conservation action to carry out the CPCP.

The process was built on existing knowledge and extensive consultation with stakeholders and research partners (Figure 3). This ensured the research done will provide the greatest benefit in the delivery of the CPCP.

The development of the draft strategy focused on:

- reviews of existing research and consultation with stakeholders
- identifying knowledge gaps that stop effective conservation action
- working out which knowledge gaps were of greatest importance to stakeholders
- identifying research options that could address the most important knowledge gaps
- evaluating and prioritising which research options represent the best use of research investment, considering resources, time and expected benefits.

Figure 2. Strategy preparation timeline

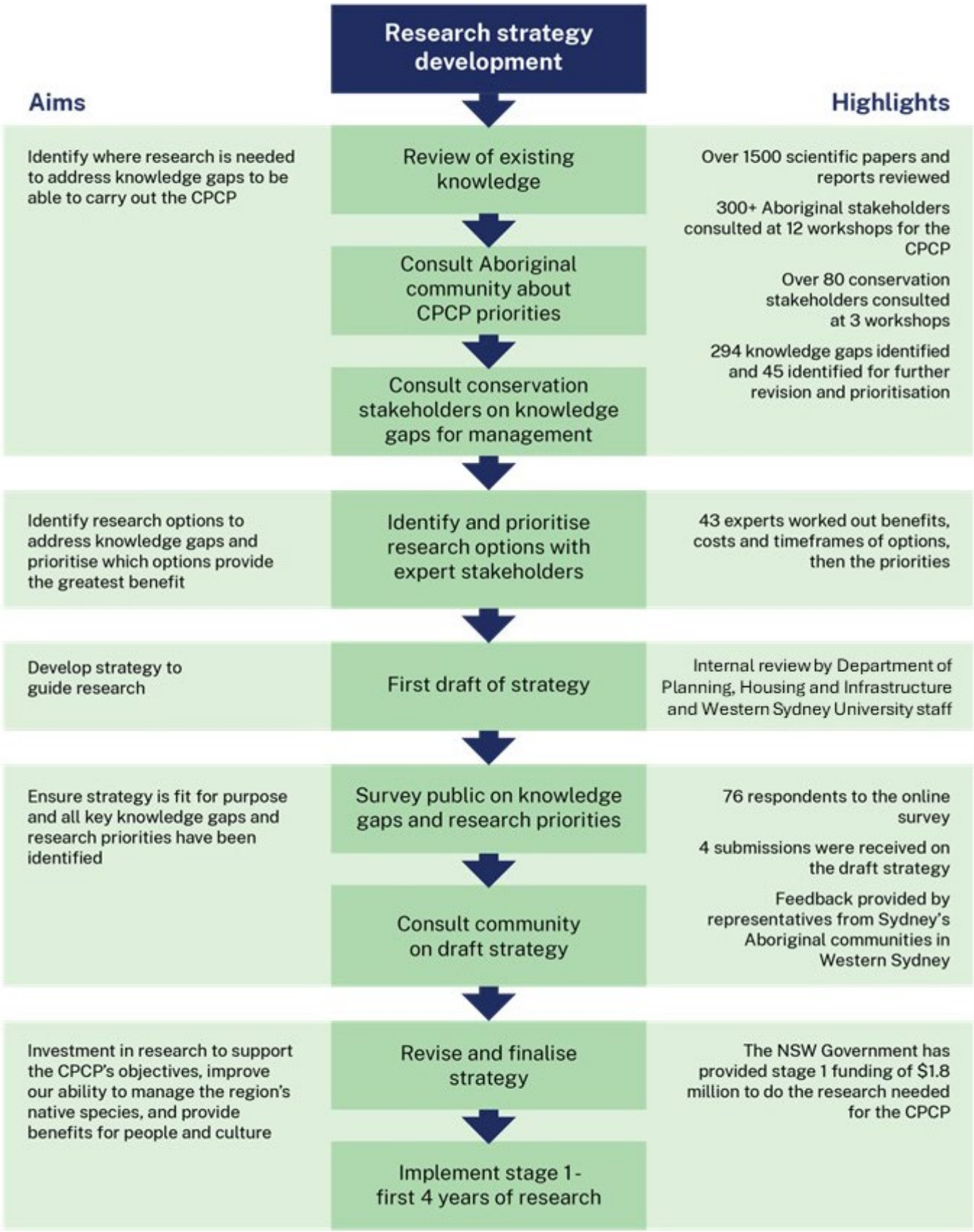

Figure 3. How the strategy was developed. Key steps in the process of developing the research strategy are shown in darker green boxes while aims and highlights are shown either side

1.1 Talking with stakeholders to develop a draft strategy

There are many groups with knowledge of the Cumberland Plain's unique ecosystems and species and peoples' connections with the area. We consulted closely with these groups to ensure the strategy uses existing knowledge and that resulting research provides the new knowledge needed. This will avoid duplication by the different stakeholders working to conserve and restore the plants and animals of the Cumberland Plain.

Stakeholders consulted were from government and non-government institutions, universities, industry, conservation groups, local community and Aboriginal groups (see Appendix 1 for a full list of organisations consulted). Stakeholders were consulted through workshops, individual emails, phone calls, video conferences and face-to-face meetings.

The key objectives were to identify:

- knowledge gaps that stop effective management
- research options that could provide the information needed
- time, cost, benefit and importance of the research options for carrying out the CPCP.

Three online workshops were hosted by WSU in October and November 2021. A total of 79 participants attended.

Participants were given an overview of existing knowledge from over 1500 scientific papers, reports from government agencies and programs and industry and community groups, and asked to identify what knowledge was needed to carry out the CPCP. They were also asked what research they felt was needed to address these gaps and comment on any possible challenges and opportunities.

There were 294 unique knowledge gaps identified and more than 900 potential activities to address them (see Appendix 4 for a complete list of knowledge gaps). Many of the knowledge gaps apply to the themes outlined in section 1.4 of the strategy.

Participants voted for the knowledge gaps they believed were the most important to support the CPCP. This resulted in a shortlist of 45.

1.2 Identifying and prioritising research to be done

An extra workshop was held with 43 expert stakeholders to further prioritise potential research options to address the 45 high-priority knowledge gaps.

For each research method, the experts estimated:

- timeframe – how long it would take to complete the research
- cost – how much the research would cost

- benefit – what benefit they estimated there would be.

The experts then voted to confirm which research options they considered most important. Experts also highlighted opportunities to collaborate with others and link with other research programs.

Appendix 3 gives a list of all research options that were developed for the 45 highest-priority knowledge gaps, their estimated timeframes, costs, potential benefits and priority, along with comments for implementation.

1.3 Developing the draft strategy for public feedback

Research that was assessed as of 'very high' or 'high' importance by stakeholders was used in the strategy and organised into key themes. As a wide variety of research was identified by stakeholders within each theme, knowledge gaps were further grouped into subthemes.

'Theme 1: Supporting Aboriginal connections' knowledge gaps for research were developed in response to the comments and views from the Aboriginal community and stakeholder consultation previously run by the department for the CPCP.

The draft strategy was prepared by a team at WSU in collaboration with the department for public feedback. Section 2 of this report provides details about the targeted consultation undertaken for the final strategy.

2 Targeted consultation on the draft strategy

2.1 Consultation snapshot

The department released the draft strategy for public feedback from 11 November 2022 to 24 February 2023. The aim of targeted consultation was to seek feedback from conservation and restoration experts or knowledge holders from research bodies, government, industry, and the community to help inform the final strategy. The documents that were put online were:

- the draft research strategy
- the draft research strategy appendices.

Engagement activities during the consultation period included:

- an online survey conducted by Western Sydney University (with ethics approval - HREC Approval Number: H14634) to better understand community values and opinions relevant to the strategy. The online survey was live for 5 weeks between 14 November and 19 December 2022
- contacting relevant subject matter experts and knowledge holders in research, government, industry and the community by email, providing dedicated webpages and holding science stalls to promote participation in the online survey and encourage feedback on the draft strategy
- a webinar and 12 meetings with representatives from Sydney's Aboriginal communities in Western Sydney as part of engagement for the draft Caring for Country Aboriginal Outcomes Strategy 2023–2033 (the Caring for Country strategy) from 11 November 2022 to 21 April 2023 to gather comments on both strategies. See Appendix 2 for comments received during targeted consultation.

2.2 What we heard

Key theme	
Research for the CPCP	**Key knowledge gaps and research objectives** There was general support for the research priorities across themes 1, 2, 3 and 4 and stage 1 objectives for the research program. Some

Key theme	
	suggested more research topics and ideas to help conserve and restore the Cumberland Plain. **Monitor and deliver results** There were suggestions to ensure monitoring genuinely measured the success of actions and focused on practical outcomes for carrying out the CPCP. Many comments were about the value of the Cumberland Plain and called for more research into restoration methods. There were some suggestions to find better ways to evaluate and monitor projects. This was to either understand the causes of successes and failures or to address concerns about how conservation and research goals will be met.
Supporting connection to Country through research	**Research opportunities** Comments suggested the strategy can play a role in supporting Sydney's Aboriginal communities in Western Sydney by reviving cultural knowledge and practices that have been lost over generations. **How research can be designed to enable Aboriginal people's involvement** There were some questions about Indigenous Cultural and Intellectual Property (ICIP) with some people expressing concerns about the perception of taking Indigenous knowledge, and whether Aboriginal research would be considered valid in the research community due to lack of qualifications.

2.3 How we are responding

Research for the CPCP

- Research priorities and sections throughout the strategy remained largely unchanged as feedback confirmed general support for them. In some cases, there were new suggestions for research topics which were generally covered by the existing higher level knowledge gaps and research options in the strategy.
- There will be opportunities for knowledge gaps, research activities and project ideas suggested during the targeted consultation period to be part of stage 1 (first 4 years) of the research program. This will include partnership opportunities and small grants open to a range of

interested project partners. Any approved projects will need to comply with 'section 4.6: Delivery of stage 1 projects' of the strategy.

- Carrying out the strategy will involve monitoring, reporting and evaluation to ensure the research program provides the information needed to effectively deliver the CPCP (see 'section 6' of the strategy).

Supporting connection to Country through research

- The department will provide opportunities and support for Aboriginal-led research in addition to co-creating and co-leading research as part of stage 1 of the research program, as detailed in the strategy's 'sections 2.2: Commitments to carrying out the strategy' and '4.6: Delivery of stage 1 projects'.
- Following the engagement principles outlined in section 2 of the strategy, the department will continue to work with Sydney's Aboriginal communities within Western Sydney to protect and recognise ICIP while research projects are being developed, delivered and shared.
- Through the Caring for Country Strategy the department aims to support Aboriginal people's connection to Country with application of Aboriginal traditional knowledges and practices. In doing so it will ensure that traditional knowledge and practices will be used ethically and remain the ICIP of the Aboriginal representatives who shared information (see section 2 of the strategy).
- Ensure that findings which strengthen the connections between Aboriginal knowledge and practices be returned to the Traditional Custodians and Aboriginal communities they came from. We would do this by means such as workshops or community grants to ensure the benefits of the connections are available to future generations of Aboriginal communities.

3 Next steps

The department approved the final research strategy for the CPCP in August 2023. The research program of stage 1 has now begun.

Over 4 years the department and WSU will undertake research in line with the 4 themes of the strategy:

- supporting Aboriginal connections
- engaging with peoples and cultures
- conserving threatened species and ecosystems
- restoring and reconstructing ecosystems.

A priority of the research program is to establish projects that will allow researchers and other stakeholders to work with each other on specific research projects. WSU will prepare information on its website that will identify ways that potential research partners can get involved and contribute to the research program.

By partnering with WSU through the research program we will begin to tackle barriers and knowledge gaps that arise during the delivery of the CPCP. Research will support efforts to conserve and restore threatened species and ecosystems, connect communities with the natural environment, and ensure a sustainable future for Western Sydney.

Figure 4. Aerial photo of a water body located in Western Sydney

Appendices

Appendix 1: Organisations consulted for the draft strategy

Biodiversity Conservation Trust

Blacktown City Council

Blue Mountains City Council

Botanic Gardens & Domain Trust

CSIRO

Cumberland Bird Observers Club

Australian Bird Study Association

Deloitte

Ecolearn

Ecological Consulting

Ecological Society of Australia

Environmental Defenders Office NSW

Fire Sticks

Greater Sydney Commission

Greater Sydney Landcare

Greening Australia

Hawkesbury City Council

Hawkesbury River County Council

Kalbar Operations

Landcare

Liverpool City Council

Local Land Services

Macquarie University

NSW TAFE

Penrith City Council

Pollination Group

Southern Cross University

Thismia Consulting

Toolijooa

Total Earth Care

University of NSW

University of Technology Sydney

University of Wollongong

Western Sydney Aboriginal Landcare Group

Western Sydney Parklands

Western Sydney University

Western Sydney Regional Organisation of Councils

Yarrabin

Youth Action NSW

Appendix 2: Summary of comments and views received during targeted consultation

Online submissions for the draft research strategy

Stakeholders and the public were encouraged to provide feedback on the draft strategy through an online form posted on the CPCP's dedicated 'current projects' webpage. A distribution list of 114 individuals received emails inviting comment on the draft strategy.

The department received a total of 4 comments on the draft strategy by the closing date of 24 February 2023. The online comments received on the strategy are summarised in Table 1.

Table 1. Summary of online comment on the draft research strategy

Key theme	Comment provided
Research to support the CPCP	Research how governments and the community can integrate and embed the Sydney Green Grid and green infrastructure solutions into new and existing development in the Cumberland Plain areas of the CPCP Use ecosystem services as a tool to measure the success of restoration efforts
Other comments	Interest was expressed in discussing collaborating with the CPCP research program to carry out cultural burns to help koala habitat in south-west Sydney Apply the Sydney Green Grid and Green Infrastructure Design to all new and, where possible, existing development on the Cumberland Plain due to the significant areas of housing proposed for there Remove the term 'succession' in the draft strategy and its appendices as this terminology and way of thinking may become outdated over time

Targeted engagement with representatives of Western Sydney's Aboriginal community

The department arranged for the public exhibition of the draft Caring for Country strategy and the draft research strategy to be released at the same time, to coincide with engagement activities for Aboriginal community members.

The department's engagement activities during the public release of the two strategies involved:

- a webinar to introduce the draft strategies and encourage feedback on their contents. The webinar was attended by 15 individuals and the recording of it viewed 11 times
- emails to 149 recipients previously engaged in developing the draft Caring for Country strategy that included a link to the draft research strategy seeking public feedback on the document
- meetings with representatives from Sydney's Aboriginal communities in Western Sydney and knowledge holders to seek comment on the draft Caring for Country strategy, including the draft research strategy. Meetings varied in location depending on participant interest and availability. There were four in-person meetings and eight virtual meetings with a total of 20 attendees.

The feedback from the engagement activities highlighted several important comments and views relating to research, that included:

- involve Aboriginal peoples to co-lead research to understand how Aboriginal land management practices can support conservation in Western Sydney
- explore and reclaim cultural knowledge while acknowledging Aboriginal cultural heritage associated with the land. Information should be owned by the knowledge holders, ensuring benefits for the community as it is the intellectual and cultural property of the Aboriginal peoples involved
- research may build Aboriginal communities capacity to re-establish knowledge and practices contributing to the development of Aboriginal rangers
- explore ways to reconnect Aboriginal peoples to Country and through research understand the process and implications of such reconnections
- re-imagining pre-colonisation and envisioning its significance in the contemporary world
- the Cumberland Plain is a potential food bowl, and there is a need to study its importance as a green space and cultural site
- research design should better include Aboriginal communities, considering the challenges of connecting academia and Indigenous perspectives. Language and approaches that emphasise the benefits of research for future generations and the community's well-being are crucial to engaging Aboriginal communities. Visuals and videography were identified as effective ways to share research findings

- Research should aim to honour Indigenous knowledge, address historical trauma, and foster community engagement.

Western Sydney University's online survey

The online survey asked targeted stakeholders and community members to provide input into the draft research strategy. An email distribution list of 280 people was used to encourage participation in the survey. This included stakeholders previously engaged in the development of the strategy and people who had expressed interest in research on the Cumberland Plain.

Results from the survey were used to determine the importance of knowledge gaps and prioritise research to conserve and restore the biodiversity (plants, animals and ecosystems) in Western Sydney's Cumberland Plain.

Responses to the survey have been summarised in 'Importance of key knowledge gaps for research supporting the CPCP' and 'Prioritisation of research activities for stage 1 of the research program' of appendix 2.

What the survey results told us

The survey provided overall support for the research priorities. Only two out of the 25 knowledge gaps and 33 research activities were not seen as important. We intend to keep all gaps and activities in the strategy given previous support from expert stakeholders, the relatively small sample size and lack of demographic representation across residents, landowners and Aboriginal peoples. Stakeholders and community groups will continue to be consulted about priority of research projects during stage 1 of the research strategy.

Out of 76 survey participants:

- 44% lived or worked in the Cumberland Plain
- 7% identified as Aboriginal or Torres Strait Islander
- 51% were researchers or scientists, 22% land managers or restoration practitioners, 11% policy makers, urban planners or government workers, 7% environmental advocates or volunteers, 3% Local Aboriginal Land Council or Traditional Custodians, and 6% other.

The top voted knowledge gaps across the themes were:

- how do we embed Aboriginal Knowledge and practices into conservation policy and land management?
- how can community values be shaped over time to appreciate native plants, animals and ecological communities?
- how can connectivity between habitats and habitat suitability be improved?

- what are the main physical, chemical and biological problems with soils in the Cumberland Plain that limit restoration success?

The top-voted research activities across the objectives were:

- monitored Aboriginal-led cultural burns for cultural, social and environmental benefits
- development of guidelines to prioritise sites and species that consider ecological, social, cultural, and economic values
- establishing a monitoring network to benchmark, measure change, assess impacts, and evaluate management practices
- monitoring of natural populations to assess climate sensitivity over the landscape and over time
- field trials to assess current and novel management practices to identify cost-effective ways to manage weeds and pests.

Importance of key knowledge gaps for research supporting the CPCP

We asked participants to choose the research themes they wanted to respond to and then asked them what they thought were the highest priority knowledge gaps within each theme that appeared within the draft research strategy. Participants could select up to three knowledge gaps for each theme. Results from the prioritisation of knowledge gaps for each theme are summarised in Table 2.

We then asked survey participants if there were any other knowledge gaps that the draft strategy should prioritise for each theme, and if there were any other suggestions for future research to support the CPCP. Responses were optional, with all comments summarised in Table 3.

The total number of respondents for each theme were:

- 24 respondents for Theme 1. Supporting Aboriginal connections
- 29 respondents for Theme 2. Engaging with peoples and cultures
- 43 respondents for Theme 3. Conserving threatened species and ecosystems
- 50 respondents for Theme 4. Restoring and reconstructing ecosystems.

Table 2. Participant voting totals (in percentage) for highest priority knowledge gaps within each theme

Knowledge gaps	Percentage (%)
Theme 1. Supporting Aboriginal connections **(24 respondents with 62 votes counted)**	
How do we embed Aboriginal Knowledges and practices into conservation policy and land management?	24

Knowledge gaps	Percentage (%)
How do traditional fire management practices enhance and protect biodiversity and minimise risk?	21
What sites, places and species are culturally important to Aboriginal peoples?	16
What role can Aboriginal peoples play in managing cultural resources?	13
How can caring for Country enhance mental health and physical health?	8
How do Aboriginal stories and trade-trails inform connections in the landscape and natural ecosystem?	8
What are the barriers for Aboriginal peoples in accessing employment and training in the environmental sector?	6
How can Aboriginal-led tourism support conservation and economic outcomes in the Cumberland Plain?	3
How can languages be revived and supported?	0
Theme 2. Engaging with peoples and cultures **(29 respondents with 71 votes counted)**	
How can community values be shaped over time to appreciate native plants, animals and ecological communities?	25
How can landowners be encouraged to participate in conservation, restoration and caring for Country?	20
What are the alternative approaches to optimise conservation with urban growth needs?	18
How and why do different community members value biodiversity and conservation?	10
What is the role of storytelling in the media in changing community values?	10
What are the key areas of conflict between community access and public use of natural areas for conservation and restoration?	10
How can the community be involved in monitoring conservation outcomes?	6
How does the community value conservation agreements on private land compared to publicly accessible conservation areas?	1

Knowledge gaps	Percentage (%)
Theme 3. Conserving threatened species and ecosystems (43 respondents with 111 votes counted)	
How can connectivity and habitat suitability be enhanced?	23
What natural areas have high diversity for conservation or sources for restoration?	16
How do you effectively manage fire to enhance conservation outcomes and minimise risk to assets and lives in peri-urban environments?	14
What is the importance of species and functional diversity for ecosystem resilience?	14
What will the impacts of climate change be on ecosystem function?	12
What locations and habitat features act as climate refugia?	10
What is the sensitivity of native species to extreme weather events?	6
How do existing threats of weeds and pests interact with climate change?	5
Theme 4. Restoring and reconstructing ecosystems (50 respondents with 124 votes counted)	
What are the main soil physical, chemical and biological barriers that limit restoration success?	20
How do we prioritise where restoration is undertaken?	19
What level of diversity is required to enhance capacity to adapt to future conditions?	14
What management actions can cost-effectively reduce invasive or pest species?	13
What is the role of natural succession in restoration projects?	11
How do we develop and secure the capacity of the restoration sector?	10
How can soil microbes be used to enhance restoration?	8
How to determine the role and value of remnant native seedbanks?	5

Table 3. Summary of comments suggesting extra knowledge gaps for each of the 4 themes

Theme	Feedback provided
Theme 1. Supporting Aboriginal connections	Explore how Aboriginal people can return to Country Rebuild and regrow local traditional knowledge in the community to help re-establish a connection to Country Look at how to translate recognition of Indigenous Intellectual Cultural Property into research practice How indigenous management of the Cumberland Plain could be revived and supported
Theme 2. Engaging with peoples and cultures	Look at alternative ways to maximise housing for people while catering for the needs of the natural environment Identify barriers to engaging culturally and linguistically diverse (CALD) communities in biodiversity conservation and to overcome current misconceptions in those communities about the Australian natural environment, which could benefit emergency management such as bushfires and floods Involve grassroots community members with conservation and volunteering who would then help educate others in the community and encourage their participation Educate people, politicians and developers to respect the value of floodplains Identify a range of measures that can change behaviours of various stakeholders impacting on the Cumberland Plain and how to implement these measures
Theme 3. Conserving threatened species and ecosystems	Understand what policy and legislative guidelines are needed to stop clearing of critically endangered ecological communities Investigate the effectiveness of offsetting and its relationship with any net loss of biodiversity on the Cumberland Plain How will successes and failures be monitored and measured for restoration works and individual species Understand the causes for species becoming threatened to help inform future decision-making What cost and capacity requirements are needed to manage and conserve native ecosystems to their desired states Understanding the habitat value of modified areas in the Cumberland Plain such as private gardens, walkways and parks, and how these areas can be improved to maximise their value for species conservation Take away the emphasis on climate-change threats and focus instead on measures that will ensure Cumberland Plain ecosystems remain

Theme	Feedback provided
	healthy by tackling weeds, appropriate use of fire management and ensuring no further losses to remaining natural vegetation Active management of the Cumberland Plain in response to climate change and urban impacts including what best practice approaches are needed to re-establish vegetation communities with minimal intervention and resources, and identifying and maximising areas for reconstruction to rebuild connectivity across the landscape
Theme 4. Restoring and reconstructing ecosystems	Find out how to better evaluate, establish and appreciate pre-colonisation ecosystems of the Cumberland Plain to understand what reconstruction and restoration should look like, including with a cultural perspective, today Research what would be the most effective ecosystem reconstruction and restoration benchmarks, design typologies and techniques to maximise ecosystem function and structure and benefits for people and nature in the Cumberland Plain Identify fit for purpose and achievable restoration strategies to help restore ecosystems First focus on protecting, maintaining and enhancing existing natural areas Determine the role and value of native plant bud and tuber banks versus seed banks Define restoration to resolve future problems in determining what is the end goal and how to know if you've got there Research what management actions can assist with returning the Cumberland Plain to its former vegetation structures Research the value of modified and degraded landscapes to maximise their potential Research the value of introduced weeds for some native species to ensure their removal does not cause harm Research fire
Further research areas	The role of politicians in the ability to deliver conservation outcomes Conserve threatened species by providing care and reducing development impacts around more intact Country Historical research to understand what the Cumberland Plain biota was like before European colonisation Create awareness and promote the area as the Cumberland Plain to encourage people to be more interested in caring for it and sharing their knowledge with others

Theme	Feedback provided
	Focus research on ground layer restoration and enhancement and understanding appropriate carrying capacity and species ratios
	Generate and use findings from establishing large scale and commercially viable native plant seed for the Cumberland Plain Woodland flora and propagule industry to help with success of research outcomes
	Ensure monitoring is useful and helps to close the loop for required outcomes
	Identify what an effective seed supply chain would look like for at-scale Cumberland Plain restoration
	A potential research project collaboration that would involve monitoring fauna of the Cumberland Plain
	Identify the need for introducing artificial habitat features such as constructed ponds and tree hollows into degraded areas
	Assess the impact of future introduced threat species such as the cane toad
	Research into how modified landscapes can retain some ecosystem function
	Research into how the local community can get involved in providing quality habitat on private property

Prioritisation of research activities for stage 1 of the research program

Respondents were asked to select the objectives they wanted to respond to and asked them what they thought were the highest priority research activities within each objective for starting stage 1 of the research program. Respondents could select up to three research activities per objective. These results are summarised in Table 4.

The total number of respondents for each objective were:

- 14 respondents for Objective I. Strengthening Aboriginal knowledge and practices
- 26 respondents for Objective II. Prioritising sites for shared cultural, conservation and restoration values
- 42 respondents for Objective III. Improving the health and resilience of ecosystems
- 23 respondents for Objective IV. Improving management of climate change risks
- 32 respondents for Objective V. Identifying cost-effective management practices.

Table 4. Participant prioritisation results in percentages (%) for stage 1 research activities listed under objectives I, II, III, IV and V

Research activities	Percentage (%)
Objective I. Strengthening Aboriginal Knowledge and practices **(14 respondents with 37 votes counted)**	
Monitored Aboriginal-led cultural burns for cultural, social and environmental benefits	29.7
Trials of Aboriginal natural harvesting for cultural, social and environmental benefits	24.3
Interviews with Aboriginal peoples on knowledge systems, language and songlines	21.6
Yarning and storytelling on relatedness to species, places and Country	16.2
Examination of archival materials	8.1
Genetic analysis of plants and animals, and analysis of charcoal deposits	0.0
Development of guidelines to prioritise sites and species that consider ecological, social, cultural, and economic values	33.9
Ecological surveys, including standard and novel properties, to determine ecosystem function and health	23.7
Surveys and focus groups with local community groups to understand their relationship with the environment, plants and animals	20.3
Citizen science approaches to explore shared values for conservation and restoration	15.3
Genetic analysis of native species to assess levels of genetic diversity and connectivity	6.8
Objective III. Improving the health and resilience of ecosystems **(42 respondents with 104 votes counted)**	
Establishing a monitoring network to benchmark, measure change, assess impacts, and evaluate management practices	33.7
Experimental plots to test diversity-function relationships and determine thresholds for resilient natural ecosystems	19.2
Defining and quantifying factors for healthy and self-sustaining restoration sites	17.3
Engaging the community and raising awareness of ecosystem diversity, function and resilience	16.4
Modelling and simulation studies to predict ecosystem functions and resilience to disturbance	13.5
Objective IV. Improving management of climate change risks **(23 respondents with 62 votes counted)**	
Monitoring of natural populations to assess climate sensitivity over the landscape and over time	30.7

Research activities	Percentage (%)
Field and laboratory studies of the tolerance in native species to extreme weather events	27.4
Modelling to predict species and areas of greatest vulnerability to climate change	22.6
Genetic analyses of animal and plant populations to predict adaptive capacity	12.9
Identify social and cultural impacts from climate change and how Aboriginal practices may improve climate change resilience	6.5
Objective V. Identifying cost-effective management practices **(32 respondents with 86 votes counted)**	
Field trials to assess current and novel management practices to identify cost-effective approaches to manage weeds and pests	23.3
Collect field survey data to assess outcomes of current management practices	19.8
Field and laboratory-based experiments to identify barriers to successful restoration	18.6
Evaluate the role of succession in conservation and restoration programs	16.3
Develop sector-wide guidelines for conservation and restoration	11.6
Assess capacity to implement management at appropriate scales (spatial and temporal) and at reasonable costs (financial and social)	10.5

Appendix 3: Prioritisation process information

A. Engaging with peoples and cultures

Table 5 identifies the knowledge gaps and desired outcomes from research. Table 6 details the research needed to fill the knowledge gaps listed in Table 5.

Table 5. Knowledge gaps and desired outcomes – Engaging with peoples and cultures

Gap no.	Knowledge gap	Desired outcome
A1	Who has a cultural investment in the Country? (Move beyond land council to community groups etc) If the research has some element of being indigenous-led it needs a veto body. Each project that is proposed has to come before an independent review body.	Know who has knowledge of Country. And know how to approach them (reciprocity comes into play – trust-building exercise - protect their rights).
A2	We lack an understanding of how the community (residents, landowners, Aboriginal groups, conservation practitioners) value biodiversity and conservation.	Achieve a benchmark for community values to build from. Positive values can be built upon; negative values can be changed.
A3	How do songlines and Aboriginal trails relate to important connectivity values in the CP and how can ecosystems be connected via existing songlines, waterways and Aboriginal trails?	Create more biodiversity corridors from traditional songlines and their connections to waters.
A4	How can landowners be encouraged to participate in conservation on their land within and outside of the biodiversity offset market? How can landowners participate in the conservation of Country?	More landowners participate in conservation and restoration.
A5	How can values from a diversity of communities in Western Sydney be shaped over time to respect and appreciate nature and native assemblages rather than simply greenspace?	More appreciation of native plants, animals and communities and thereby improved biodiversity outcomes. More native plants in green areas and gardens to attract insects and pollinators and conserve genetic resources.

Gap no.	Knowledge gap	Desired outcome
A6	What are the key areas of conflict between public use of the conservation areas and managing these areas for restoration and threatened species? Public use can be positive in the sense that it increases appreciation, such as hiking, and negative in that it results from a lack of appreciation (dumping). It can also be in the middle such as BMX biking.	Less damaging behaviour such as dumping; more respectful behaviour from non-passive use of conservation areas.
A7	How can we protect spiritually significant sites while protecting Country? What are the culturally significant species and places in the CP (is everything significant)?	Improved management of culturally significant species and places. Monitor advertising of CPCP work.
A8	Does management by Aboriginal Custodians enhance the broader sense of connectedness with implications for value of species and places?	Improved management of culturally significant species and places.
A9	How does cultural burning compare with ecological and hazard-reduction burning practices in terms of biodiversity and conservation gains and the community's connection to Country?	Both cultural and ecological outcomes. Cultural burning has its own aims and objectives. Improved biodiversity is a secondary desirable outcome.
A10	How can we value and cost restoration and conservation actions and therefore prioritise actions efficiently?	Prioritised conservation and restoration actions are more 'efficient'; that is, actions get more bang for their buck (are more cost-effective). Where valuation is possible, conservation and restoration actions can be justified on the basis of benefits exceeding costs, which improves the allocation of government funds.
A11	How does the community value offset sites relative to in-situ ecosystems/species and publicly accessible conservation reserves?	Understand how offset sites (biodiversity stewardship agreements on private land and planned conservation reserves) are valued relative to in situ biodiversity. This would improve prioritisation of project sites and provide evidence for policy initiatives on the amount of offsetting to be done and accessibility to offset sites.

Gap no.	Knowledge gap	Desired outcome
A12	How can the community be involved in monitoring conservation and restoration actions, both to enhance community appreciation and ensure long-term adaptive management and conservation success?	Improved monitoring of restoration outcomes; greater appreciation of biodiversity values.
A13	What is the role of narrative, storytelling and the media in changing community values over time and how can this be built on and improved upon?	Greater appreciation of a range of biodiversity values. Cultural appreciation.
A14	How do different cultural groups value biodiversity and conservation in the CP and how can values be changed to engage with and appreciate biodiversity?	Achieve a benchmark of community values to build from with specific reference to CALD communities. Positive values can be built upon; negative values can be changed.
A15	What are the best ways to engage the community to participate in conservation activities?	Greater participation in conservation and restoration activities; improved appreciation of biodiversity values.
A16	How can Aboriginal methodologies be best incorporated into the CPCP research strategy?	Improved conservation and restoration outcomes; knowledge of Aboriginal practices used in science and social science research.
A17	Is the governance model right for delivering the CPCP in terms of responsibilities of State and Local governments and community groups? What are the possible governance approaches and how does the current model compare?	Improved governance arrangements and conservation/restoration outcomes.
A18	What condition/ species/ecosystem structure are we restoring to?	Improved conservation and restoration outcomes through understanding the desired future state.
A19	How do we rebuild songlines etc severely impacted by Sydney colonisation?	Rebuilt songlines
A20	How do we build a new cultural understanding of Country?	Improved cultural understanding of Country
A21	How do we restore the cultural relationship to Country, rather than just wildlife?	Improved cultural relationship to Country

Table 6. Research types and approaches for each knowledge gap – Engaging with peoples and cultures. See Table 5 for explanation of Gap no.

Gap no.	Research type	Approach	Timeframe	Potential	Likely cost	Priority	Comment
A1	Aboriginal-led methodologies	Aboriginal ethics and protocol (AIATSIS, NHMRC) - trust building	0-5 years	Very high	<$10K	High	Interactive research options. Bring Aboriginal groups together first to get everyone on the same page and build an understanding of cultural values of Country and then aspirations for active management of Country towards a healthy balance. Start with conversation about what we know a healthy balance looks like
A1	Aboriginal-led methodologies	Local community preferences in terms of communication and methods such as storytelling, yarning, participatory values.	0-5 years	Very high	$100-1000K	High	Very high impact. Resisting development to preserve Country. If we can get Aboriginal groups on board, it would have ground-up support
A1	Aboriginal-led methodologies	Exploring maps (varying opinions on worth). Participatory mapping. Identifying areas of significance.	0-5 years	Very high	$10-100K	Moderate	Question about importing knowledge. Depends on local community groups

Gap no.	Research type	Approach	Timeframe	Potential	Likely cost	Priority	Comment
A2	Community activity / engagement	Community group meetings and elect reps to attend Community Hub meetings	16-35 years	Very high	>$1000K	High	No comment
A2	Online survey / interviews	Large scale survey of community values	0-5 years	Very high	Not identified	Low	No comment
A3	Aboriginal-led methodologies	Not identified	Not identified	Not identified	Not identified	Low	Question mark - sovereignties. The community can decide how these relate to the project
A4	Online survey / interviews	Semi-structured interviews with landowners	Not identified	Not identified	Not identified	Moderate	No comment
A4	Online survey / interviews	Focal groups	Not identified	Not identified	Not identified	Low	No comment
A4	Policy / literature review	Not identified	Not identified	Not identified	Not identified	Low	No comment
A5	Community activity / engagement	Shared values workshop - shared learning	0-5 years	Very high	$10-100K	High	No comment
A5	Community activity / engagement	Sharing stories - with permission, greater awareness of the significance of native plants	Not identified	Not identified	Not identified	Moderate	No comment
A5	Community activity / engagement	Participatory action research	Not identified	Not identified	Not identified	Low	No comment

Gap no.	Research type	Approach	Timeframe	Potential	Likely cost	Priority	Comment
A6	Policy / literature review	Build off existing knowledge such as the NPWS behavioural change campaign	0-5 years	Low	Not identified	Low	No comment
A6	Field surveys	To understand where impacts occur	0-5 years	Medium	Not identified	Low	No comment
A6	Citizen science	To understand impacts and monitor behaviour	6-15 years	Medium	Not identified	Low	No comment
A6	Policy / literature review	Policy evaluation at the Local Government level focused on monitoring and preventing damaging behaviour. (Social change via banning practices that impinge on nature - rights of nature approach).	0-5 years	High	Not identified	Low	No comment
A7	Policy / literature review	Approaches to Aboriginal understandings of entities and Country (their interrelatedness). Beyond their individual value. Understanding Aboriginal standpoints	0-5 years	High	$10-100K	Very High	No comment
A8	Aboriginal-led methodologies	Aboriginal-led and methodological approach to understand interrelated species and places and Country (yarning, storytelling, how they are told on Country) known as Indigenous research methodologies (IRM).	0-5 years	Very high	$100-1000K	High	Relevant throughout the CPCP lifespan and beyond

Gap no.	Research type	Approach	Timeframe	Potential	Likely cost	Priority	Comment
A9	Policy / literature review	Comparative research	Not identified	Not identified	Not identified	Not identified	Knowledge gap aligned with priorities elsewhere and not detailed here
A9	Community activity / engagement	Participatory action research - experience	Not identified	Not identified	Not identified	Not identified	No comment
A10	Policy / literature review	Build off existing department methods of valuing green space. Combine with the biodiversity assessment method (BAM). Analyse existing Biodiversity Conservation Trust (BCT) and department databases for costs and the determinants of conservation success	Not identified	Not identified	Not identified	Moderate	No comment
A10	Online survey / interviews	Not identified	Not identified	Not identified	Not identified	Low	No comment
A11	Online survey / interviews	Non-market valuation (contingent choice) approaches to compare (1) offset site to (2) public reserve to (3) in situ	Not identified	Not identified	Not identified	Low	No comment
A12	Policy / literature review	Not identified	Not identified	Not identified	Not identified	Moderate	No comment
A12	Citizen science	Not identified	Not identified	Not identified	Not identified	Low	No comment
A12	Community activity / engagement	Not identified	Not identified	Not identified	Not identified	Low	No comment

Gap no.	Research type	Approach	Timeframe	Potential	Likely cost	Priority	Comment
A13	Policy / literature review	Sand talk? The department's behavioural insights team	Not identified	Not identified	Not identified	High	No comment
A13	Aboriginal-led methodologies	Intergenerational Aboriginal knowledge sharing	Not identified	Not identified	Not identified	Low	No comment
A13	Aboriginal-led methodologies	Culture camps	Not identified	Not identified	Not identified	Moderate	No comment
A14	Online survey / interviews	Large scale survey of community values	Not identified	Not identified	Not identified	Moderate	No comment
A15	Policy / literature review	Not identified	Not identified	Not identified	Not identified	Low	No comment
A15	Online survey / interviews	Not identified	Not identified	Not identified	Not identified	Low	No comment
A16	Aboriginal-led methodologies	Has to be Aboriginal led	Not identified	Not identified	Not identified	Moderate	No comment
A17	Policy / literature review	Not identified	Not identified	Not identified	Not identified	Moderate	Multifunctionality; need for co-design
A18	Community activity / engagement	Not identified	Not identified	Not identified	Not identified	High	Need to distinguish restoration from regeneration
A19	Aboriginal-led methodologies	Walking contemporary Aboriginal songlines as a way to teach the public about Country	Not identified	Not identified	Not identified	Very high	No comment
A20	Aboriginal-led methodologies	Not identified	Not identified	Not identified	Not identified	Very high	No comment

Gap no.	Research type	Approach	Timeframe	Potential	Likely cost	Priority	Comment
A21	Aboriginal-led methodologies	Not identified	Not identified	Not identified	Not identified	High	No comment

B. Conserving threatened species and ecosystems

Table 7 identifies the knowledge gaps and desired outcomes from research. Table 8 details the research needed to fill the knowledge gaps listed in Table 7.

Table 7. Knowledge gaps and desired outcomes – Conserving threatened species and ecosystems

Gap no.	Knowledge gap	Desired outcome
B1	What locations within the Cumberland Plain have high diversity (community, species, genetic endemic / unique) for conservation or sources for restoration? [Sub knowledge-gap] How to determine high value and assess state for different vegetation types?	Identify areas for priority conservation and / or high-quality sources for regeneration / restoration. List of locations of significant value. High diversity / low degradation sites
B2	What are the best indicators of biodiversity and conservation values at local and regional scales? [Sub knowledge-gap] What are the indicators that best describe the value of assets and can be put on an asset register?	Use cost-effective methods that provide improved indicators of biodiversity and conservation values
B3	What locations and habitat features within the Cumberland Plain may act as climate / habitat refugia (or areas of high exposure)?	Identify landscape and habitat features for priority conservation and / or restoration
B4	What is the minimum viable population size able to persist into the future within the Cumberland Plain?	Target active management on patches to enhance holding capacity / connectivity

Gap no.	Knowledge gap	Desired outcome
B5	How to enhance connectivity between habitats and population holding capacity in the Cumberland Plain? [Sub knowledge-gap] What are the current / future ways to measure connectivity for the region and different plant and animal populations? What are the dispersal mechanisms, pathways and barriers for key animal and plant populations across the landscape and through time? How well do corridors or other dispersal aids improve connectivity for key animal and plant populations?	Inform active management through knowledge of landscape features that act as barriers, and corridor attributes that help movement and persistence, along with patch size and features that support greater population size and health in the future. Finding out how and where landscape features create variation in connectivity for different animal and plant populations under a range of future scenarios. Better explanation of the assumptions underpinning connectivity analyses, and validation of those analyses
B6	How to monitor effectively to detect long-term changes in populations, species and community diversity and function? [Sub knowledge-gap] What to monitor (e.g. threatened vs common species? Species vs communities? Psyllids? Healthy vs impacted communities?	Inform monitoring programs to be able to detect change in the status of species and ecosystems associated with land use, management and climate change. Carry out monitoring program to inform management
B7	What are the key threats facing target threatened species and TECs in the Cumberland (at a scale appropriate for on-ground management, e.g. which invasives, which fire regimes)?	Objective prioritisation of key threats for the persistence of threatened species and TECs in the CPCP. Prioritise the assets (population, species, TEC) for conservation
B8	Interactions between threats: fragmentation, habitat degradation, fire and climate change	Inform and prioritise management of threats with greater certainty into the future
B9	What is the sensitivity to heat and drought of threatened species and dominant species in TECs within the CP?	Determine species sensitivity to extremes to inform decision making for the prioritisation of conservation efforts
B10	What is the capacity of threatened species and ecosystems to adapt to climate change?	Capacity to adapt to climate change through genetic and environmental mechanisms to inform vulnerability and active management strategies (e.g. translocation, assisted gene migration)
B11	Importance of species and / or functional diversity for ecosystem resilience	Determine thresholds of diversity required for ecosystem function and resilience into the future

Gap no.	Knowledge gap	Desired outcome
B12	What are the current states and transition zone of CP ecosystems with different land use histories, disturbance regimes and current management?	Inform and prioritise active management actions with greater confidence in the ecosystem state and trajectory in the future
B13	Determinants of successful adaptive management strategies, including translocation and assisted migration for threatened species	Inform and prioritise active management of threatened species with greater confidence in the most likely outcomes
B14	How do you effectively manage fire in the Cumberland Plain to minimise risk to biodiversity (in the context of constraints on protecting life and property)? [Sub knowledge-gap] Does fire need to be introduced to long-unburnt areas in this transition zone between rural and urban environments, and if so, what type of fire regime?	Inform fire management and enable burns to improve biodiversity and conservation values. Minimise risk of loss to biodiversity
B15	How do cultural burns and Aboriginal practices contribute to biodiversity and conservation?	Provide mechanism for caring for Country, community engagement and Aboriginal-led cultural practices to be supported in the CPCP

Table 8. Research types and approaches for each knowledge gap – Conserving threatened species and ecosystems. See Table 7 for explanation of Gap no.

Gap no.	Research type	Approach	Timeframe	Potential	Likely cost	Priority	Comment
B1	Analyse existing data	Compile existing plot-based data	0-5 years	Medium	$10K-100K	Very high	Work done by CPCP mapping conservation layer - check inputs and develop models
B1	Field surveys	Conduct new field surveys including Structured Regional Fauna Surveys	0-5 years	High	$100-1000K	Very high	Attributes vary by vegetation type

Gap no.	Research type	Approach	Timeframe	Potential	Likely cost	Priority	Comment
B1	Genetic analyses	Estimate genetic diversity, species diversity, functional diversity and uniqueness across the greater Sydney region	0-5 years	High	$100-1000K	Moderate	No comment
B1	Aboriginal practice	Incorporate Aboriginal Cultural Heritage with work led by appropriate Aboriginal knowledge holders	6-15 years	Medium	$100-1000K	Low	Local Aboriginal leadership essential
B2	Policy / literature review	Current approaches for valuing natural assets (standardised priority matrix for biodiversity assets). How objective / repeatable are these?	0-5 years	Not identified	Not identified	Low	How can a land manager be sure that a biodiversity priority matrix is effectively identifying the most important assets for management?
B2	Online survey / interviews	How do we get the whole community to value biodiversity outcomes relative to other land use options?	0-5 years	Not identified	Not identified	Low	Value should be based also on investment required to manage
B2	Aboriginal practice	Not identified	Not identified	Not identified	Not identified	Low	No comment
B2	Field surveys	Ground truthing valuation matrix effectiveness	Not identified	Not identified	Not identified	Low	No comment
B3	Modelling / simulation	Not identified	Not identified	Not identified	Not identified	High	No comment
B3	Mapping / remote sensing	Not identified	Not identified	Not identified	Not identified	Low	No comment

Gap no.	Research type	Approach	Timeframe	Potential	Likely cost	Priority	Comment
B3	Implement sensors / imaging	Not identified	Not identified	Not identified	Not identified	Low	No comment
B3	Field surveys	Not identified	Not identified	Not identified	Not identified	Low	No comment
B4	Field surveys	Demographic data (of flora and fauna), including reproduction and recruitment	6-15 years	High	$100-1000K	Low	Long-term study minimum 3-years, best 20+ years. Combined with modelling
B4	Modelling / simulation	Flora and fauna population viability analysis, transition models including disturbance and threats	6-15 years	High	$100-1000K	Low	Some immediate outputs but limited by data inputs. Maybe combined with field surveys to share costs and outputs
B4	Genetic analyses	Determine effective population size, diversity / structure.	0-5 years	High	$100-1000K	Low	No comment
B4	Field experiments	Adding new material to test improved viability, habitat / resource/ pollinator	6-15 years	Medium	$100-1000K	Low	Application to target species with development of methods for other species' TECs
B5	Analyse existing data	Not identified	Not identified	Not identified	Not identified	Low	No comment

Gap no.	Research type	Approach	Timeframe	Potential	Likely cost	Priority	Comment
B5	Mapping / remote sensing	Classic landscape ecology patch metric analysis and mapping, using existing data such as aerial photos, digital elevation models, and other geographic information system layers; analyse where new connectivity measures make biggest impact in overall connectivity for all components of biodiversity; need to objectively identify which animal and plant groups are crucial? Identify dispersal barriers as well as potential perverse outcomes (e.g. predation, invasive species)	0-5 years	Very high	$100-1000K	Low	No comment
B5	Field surveys	Field surveys to assess and refine predictive models of the habitat corridors of key animal and plant populations (biota), the habitat and barriers influencing movement of these biota and identification of priority corridors for conservation and restoration investment	6-15 years	High	$100-1000K	Low	No comment
B5	Field experiments	Introduce novel techniques to improve connectivity. Compare to existing links using comparative experiments on key biota	6-15 years	High	$100-1000K	Low	No comment
B6	Analyse existing data	Not identified	Not identified	Not identified	Not identified	Moderate	No comment

Gap no.	Research type	Approach	Timeframe	Potential	Likely cost	Priority	Comment
B6	Mapping / remote sensing	Remote sensing useful for psyllid dieback (in combination with ground surveys) and land use change / what patches most vulnerable to clearing	0-5 years	Not identified	Not identified	Moderate	No comment
B6	Field surveys	Build on existing studies, e.g. Mt Annan, Hoxton Park, Scheyville and probably others. Existing BioNet survey sites from late 90s / early 2000s could be re-surveyed. Use recent field plots established under Commonwealth research funding for fire recovery. Key questions: how well do sites retain their biota? How do individual species vary from year to year (probably related to rainfall)? Which introduced species are increasing? Bird and invertebrate component important for fauna	Not identified	Not identified	Not identified	High	No comment
B6	Citizen science	Analyse citizen science platforms if enough people are engaged. To be successful, need group of engaged people. Strategic workshops could be helpful to build local ownership (e.g. Agnes Banks)	0-5 years	Not identified	$10K-100K	Low	No comment
B6	Genetic analyses	Not identified	Not identified	Not identified	Not identified	Low	No comment

Gap no.	Research type	Approach	Timeframe	Potential	Likely cost	Priority	Comment
B7	Analyse existing data	CPCP, Saving Our Species (SOS), Biodiversity Conservation Trust, Botanic Gardens of Sydney existing work	0-5 years	Very high	$10K-100K	Low	Collated at generic level in SOS program
B7	Mapping / remote sensing	CPCP maps (BIOSIS)	0-5 years	High	$10K-100K	Low	Climate change and land clearing are not addressed
B7	Modelling / simulation	Based on field validation	0-5 years	Medium	$10K-100K	Low	No comment
B7	Field surveys	Field validation across seasons / conditions. Confirm population data	0-5 years	Very high	$100-1000K	Low	Survey of private land is a key outcome required
B8	Analyse existing data	Not identified	Not identified	Not identified	Not identified	Moderate	No comment
B8	Aboriginal practice	Not identified	Not identified	Not identified	Not identified	Low	No comment
B8	Field surveys	Not identified	Not identified	Not identified	Not identified	Low	No comment
B8	Field experiments	Not identified	Not identified	Not identified	Not identified	Moderate	No comment
B9	Modelling / simulation	Climate niche / species distribution modelling (SDM). Application of mechanistic models with physiological tolerance	0-5 years	High	$10K-100K	Low	Macquarie University existing SDM work. Greater time/costs required for mechanistic models

Gap no.	Research type	Approach	Timeframe	Potential	Likely cost	Priority	Comment
B9	Mapping / remote sensing	GIS + flow accumulation models combined with satellite imaging and flight data	0-5 years	Medium	$10K-100K	Moderate	No comment
B9	Field surveys	Observe dieback / failures. Incorporate sensors. Consider exposure and microhabitat	6-15 years	High	$100-1000K	Moderate	No comment
B9	Controlled growth / laboratory experiments	Determination of physiological tolerance to heat and drought to estimate threshold traits (e.g. Tmax, P50)	0-5 years	Very high	$100-1000K	Moderate	All species possible. Reduced costs for target species
B10	Field surveys	Not identified	Not identified	Not identified	Not identified	Low	No comment
B10	Genetic analyses	Not identified	Not identified	Not identified	Not identified	Low	No comment
B10	Field experiments	Not identified	Not identified	Not identified	Not identified	Low	No comment
B10	Controlled growth / laboratory experiments	Not identified	Not identified	Not identified	Not identified	Low	No comment
B11	Modelling / simulation	Not identified	Not identified	Not identified	Not identified	High	No comment
B11	Field surveys	Not identified	Not identified	Not identified	Not identified	Low	No comment

Gap no.	Research type	Approach	Timeframe	Potential	Likely cost	Priority	Comment
B11	Field experiments	Not identified	Not identified	Not identified	Not identified	High	No comment
B12	Online survey / interviews	Not identified	Not identified	Not identified	Not identified	Low	Consider use of superphosphates, fire, flood
B12	Aboriginal practice	Recognise and respect different objectives	Not identified	Not identified	Not identified	Low	No comment
B12	Field surveys	Define and characterise reference states	Not identified	Not identified	Not identified	Low	No comment
B12	Mapping / remote sensing	Detect transitions (regrowth, dieback, clearing, olive invasion etc.)	Not identified	Not identified	Not identified	Low	No comment
B12	Modelling / simulation	Development of conceptual models with drivers to predict. Data required from field surveys and experiments	Not identified	Not identified	Not identified	Low	No comment
B12	Field experiments	Use experimental manipulations for model validation	Not identified	Not identified	Not identified	Low	No comment
B13	Analyse existing data	Not identified	Not identified	Not identified	Not identified	Low	No comment
B13	Field surveys	Not identified	Not identified	Not identified	Not identified	Low	No comment
B13	Other approach	Not identified	Not identified	Not identified	Not identified	Low	No comment

Gap no.	Research type	Approach	Timeframe	Potential	Likely cost	Priority	Comment
B13	Genetic analyses	Not identified	Not identified	Not identified	Not identified	Low	No comment
B14	Analyse existing data	What land management including fires has been undertaken recently?	Not identified	Not identified	Not identified	Low	No comment
B14	Field surveys	Not identified	Not identified	Not identified	Not identified	Low	No comment
B14	Field experiments	Alternative fire management options, e.g. fire seasonality? Bursaria management? Other types of disturbance?	0-5 years	Very high	$100-1000K	Very high	0-5 years to establish, but longer-term monitoring will yield greater value. Establishment phase costing ~$100k / year, but longer-term funding / monitoring highly desirable
B15	Aboriginal practice	Not identified	Not identified	Not identified	Not identified	Low	No comment
B15	Community activity / engagement	Not identified	Not identified	Not identified	Not identified	Low	No comment
B15	Field surveys	Not identified	Not identified	Not identified	Not identified	Low	No comment

C. Restoring and reconstructing ecosystems

Table 9 identifies the knowledge gaps and desired outcomes from research. Table 10 details the research needed to fill the knowledge gaps listed in Table 9.

Table 9. Knowledge gaps and desired outcomes – restoring and reconstructing ecosystems

Gap no.	Knowledge gap	Desired outcome
C1	What physical-chemical and biological barriers to successful soil restoration are associated with past management or site conditions??	Knowledge of how to improve site preparation that takes into account past land use
C2	What management actions most effectively overcome soil physical-chemical and biological barriers to restoration success?	An assessment of management outcomes relative to initial site conditions and management actions including cost-benefit trade-offs and long-term restoration outcome
C3	How does soil biodiversity influence ecosystem function and resilience under current and future conditions?	Ecological knowledge of species interactions that can improve restoration outcomes, including improved resistance and resilience to current and future threats
C4	How can restoration projects be managed to reduce the threats associated with fire, climate change, fragmentation and habitat degradation and their interactions?	Knowledge that allows adaptive management that considers primary management needs (reconstruct / rehabilitate), secondary fire / vandalism, and finally extremes and climate change
C5	How do native and exotic vertebrate herbivores influence biodiversity, ecosystem structure and function? How can these effects be taken into account in restoration projects to enhance outcomes?	Total grazing pressure is managed to maximise restoration outcomes (What are the optimal grazing regimes for CP ecosystems in the cycle of restoration?)
C6	Can we identify microbes that improve the performance and resilience of key plant species used in restoration?	Identify individual microbes or groups of microbes that act together (consortia), which improve ecosystem function, including resistance and resilience of plant species to disturbance

Gap no.	Knowledge gap	Desired outcome
C7	Can microbial symbionts be used to improve the production, establishment and growth of key plant species used in restoration?	Knowledge of microbial symbionts associated with key species used in restoration which will improve its success. Similar principles can be applied for priority conservation species
C8	What diversity from genetic to species, aboveground and belowground, is required to improve adaptive capacity in restoration projects given likely future climate scenarios?	Guidelines for biodiversity targets to improve long-term restoration outcomes
C9	What is the role of succession in restoration projects and how can we use this as a tool to promote desired restoration outcomes?	Evaluate successional patterns on degraded land, and in restoration programs, to identify opportunities to allow 'natural' or improved (through management) successional trajectories
C10	What are the thresholds for ecological communities to transition to desired states naturally, with minimal inputs or active management?	Better knowledge of potential tipping points beyond which existing management practices are unable to support certain outcomes
C11	How can we manage plant-soil microbial interactions to improve restoration success under current and future conditions?	Ecological knowledge of species interactions that can improve restoration outcomes, including improved resistance and resilience to current and future threats
C12	What is the most cost-effective way to manage invasive or pest species?	Knowing how effective management actions are at controlling exotic species in the longer term, which will provide guidelines for when to carry out certain actions. Recognising that control requires up-front costs as well as ongoing maintenance to ensure desired long-term outcomes
C13	What is the desired trajectory or outcome of restoration projects for the Cumberland Plain?	Better knowledge of what the broader range of stakeholders desire in terms of green space throughout the CP in the long term (clear link with the community theme)
C14	What skills, capacity or access to material is required to maintain genetic diversity of seed production areas relevant to the CPCP?	Identify industry needs critical to ensuring that restoration practices can be carried out

Gap no.	Knowledge gap	Desired outcome
C15	What are the effective timeframes for restoration success?	Better guidelines for monitoring, evaluating and managing restoration programs that take into account the long-term nature of restoration
C16	How do we develop and secure the capacity of the restoration sector to undertake the projected levels of reconstruction and restoration needed to support the CPCP outcomes, including access to seed/propagule sources, facilities to grow material, and the know-how and capacity to implement in practice?	Identify industry needs critical to ensuring that restoration practices can be implemented
C17	What is the role of fire in population dynamics of species relevant to desired restoration outcomes?	Knowing how to use fire to manage restoration outcomes
C18	What is the potential role of existing seed banks in bush regeneration and how do we assess when it is valuable to maintain this resource?	Knowing how to establish industry-wide guidelines for site preparation that can reduce costs of sourcing plant material while maintaining local populations
C19	Where should restoration be prioritised given conservation needs, ecological processes and constraints, social and cultural values that might limit / enhance outcomes	Framework to prioritise areas for restoration and desired restoration outcomes, including ecological and social / cultural; decision tree based on quality, past experience, needs / values

Table 10. Research types and approaches for each knowledge gap – restoring and reconstructing ecosystems. See Table 9 for explanation of Gap no.

Gap no.	Research type	Approach	Timeframe	Potential	Likely cost	Priority	Comment
C1	Field surveys	Establish benchmarks for physical-chemical and biological properties of soil for target species and TECs, including existing restoration	0-5 years	High	$100-1000K	Very high	This knowledge can also be used to determine (prioritise) if a site is even worth it (cost wise) to restore, i.e. perhaps not a target for restoration if the conditions are too poor

Gap no.	Research type	Approach	Timeframe	Potential	Likely cost	Priority	Comment
C1	Field experiments	Evaluate restoration outcomes associated with individual management actions given contrasting site conditions	6-15 years	High	$100-1000K	Very high	No comment
C1	Controlled growth / laboratory experiments	Pot experiments to evaluate establishment, growth, performance etc in soils with different conditions	0-5 years	Medium	$100-1000K	Low	Field surveys can inform experiments in the field and lab
C1	Analyse existing data	Draw on previous work in field, combined with field surveys	0-5 years	High	$10-100K	High	No comment
C2	Field experiments	Experimental (both field and lab) approaches taking advantage of the existing range of soils, health conditions and existing vegetation to test what suite of conditions are more or less conducive to a response to particular restoration efforts	Not identified	Not identified	Not identified	Not identified	No comment
C2	Other approach	Need a feasibility study - both in terms of implementation (i.e. large areas) and cost / socio-economic study (inputs v outputs)	0-5 years	High	$10-100K	High	Ongoing - need the data first so probably a longer-term outcome
C2	Controlled growth / laboratory experiments	Test effects of specific actions - resistance and resilience to disturbance / stress	0-5 years	High	$100-1000K	Low	No comment

Gap no.	Research type	Approach	Timeframe	Potential	Likely cost	Priority	Comment
C3	Field surveys	Develop benchmarks for soil biodiversity for i) individual species, ii) TECs - to develop understanding of relationships of soil biodiversity with "healthy" and "unhealthy" ecosystems including spatial and temporal heterogeneity	0-5 years	Medium	$100-1000K	Moderate	No comment
C3	Field experiments	Assess linkages between soil biodiversity / belowground community composition and functioning - community/ecosystem scale. (1) Is our understanding of "healthy/unhealthy" correct, and (2) can we shift unhealthy -> healthy	6-15 years	Medium	$100-1000K	Moderate	No comment
C4	Mapping / remote sensing	Establish (semi) permanent monitoring within, and targeted observational studies of, sites with different management	16-35 years	Low	>$1000K	Low	Very different threats that need different management and solutions (i.e. may need knowledge-based, political/ social / governance or on-ground action). They also operate at different spatial and temporal scales

Gap no.	Research type	Approach	Timeframe	Potential	Likely cost	Priority	Comment
C4	Field experiments	Embed experimental manipulation within existing and planned restoration projects with different management practices	6-15 years	Low	$100-1000K	Moderate	Knowledge framework / infrastructure that draws together and integrates research, data, policies etc from all other research themes and programs
C4	Online survey / interviews	Consultation with practitioners and land managers	0-5 years	High	$10-100K	Low	No comment
C5	Field surveys	Assess the effects of native and exotic herbivores on ecosystem structure and function in TECs	6-15 years	Medium	$10-100K	Low	No comment
C5	Field experiments	Assess the effects of native and exotic herbivores on ecosystem structure and function in TECs	6-15 years	Medium	$10-100K	Low	No comment
C6	Field surveys	Surveys of soil surrounding plant roots (rhizosphere soil) associated with species commonly used in restoration programs, including species targeted in conservation projects, to identify microbes associated with healthy populations	0-5 years	High	$100-1000K	High	No comment
C6	Controlled growth / laboratory experiments	Isolation and cultivation of microbes associated with Cumberland Plain plant species and follow up experiments to test their potential benefit to plant establishment and growth	0-5 years	High	$100-1000K	Moderate	Need information from field surveys to identify target species

Gap no.	Research type	Approach	Timeframe	Potential	Likely cost	Priority	Comment
C6	Field experiments	Can we change conditions to manage soil microbes?	6-15 years	Medium	$100-1000K	Low	Opportunity to build on information from the field survey (if those surveys assess microbial communities at a relevant scale)
C7	Field experiments	Combination of lab and field studies to assess the potential to incorporate symbiont with other seed treatments, e.g. pellets using direct seeding. Need to keep cost-effectiveness in mind, not just ecological / biological feasibility	0-5 years	High	$100-1000K	Low	No comment
C7	Field surveys	Approach must include assessment of microbial treatments' effects on seed germination but also long-term establishment, growth and resilience to environmental stress	6-15 years	High	$100-1000K	Low	No comment
C7	Other approach	Develop guidelines for the use of microbial inoculants in restoration programs	6-15 years	High	$100-1000K	Low	No comment
C8	Analyse existing data	Come up with a narrowed list of high priority species, and form categories for others in terms of how they compare	0-5 years	Very high	$10-100K	Low	Analyse data to determine what is happening on the ground across groups that undertake restoration
C8	Field experiments	Determining the contribution of genetic diversity to restoration outcomes	6-15 years	High	$100-1000K	High	Short to longer term with different outcomes

Gap no.	Research type	Approach	Timeframe	Potential	Likely cost	Priority	Comment
C8	Field surveys	Genomic surveys of climate adaptation	16-35 years	High	$100-1000K	Low	Ongoing - can assess outcomes relative to disturbance, extreme events, increasing pressures on ecosystems; should be informed by field survey below
C8	Field surveys	Validate / benchmark what a healthy system is to develop guidelines	0-5 years	High	>$1000K	High	Fit with outcomes knowledge gap 1 and 2 - design field survey to address extra knowledge gaps (i.e. whole of system approach)
C9	Field surveys	Compare the outputs of different trajectories of successional change of existing projects carried out over past decades (in terms of species type, diversity etc). Measure time it takes for communities to become established. Assess how established restoration projects have developed given diversity inputs	0-5 years	High	$100-1000K	Very high	Pioneer species are often planted because they perform well, but how does this influence the establishment and conditioning for later successional species? Need to develop approaches to balance the role of seeding vs natural immigration

Gap no.	Research type	Approach	Timeframe	Potential	Likely cost	Priority	Comment
C9	Field surveys	Observational studies to increase our understanding of successional patterns in target TECs	16-35 years	Medium	$10-100K	Low	How do early successional species influence the establishment of exotic species? What species could be established to suppress undesired species establishing?
C9	Field experiments	Manipulative studies to assess how interactions among species change during succession - short term could assess establishment of both native and exotic species, longer term studies could assess whole system development	0-5 years	High	$100-1000K	Low	Assess how individual species influence trajectory vs limiting the establishment of other desired species
C10	Field surveys	Community specific (prioritising the most threatened) field experiments to understand response to management. Include a range of starting conditions and different management intensities and with controls, long to medium term, spatially controlled	6-15 years	High	$100-1000K	Low	No comment

Gap no.	Research type	Approach	Timeframe	Potential	Likely cost	Priority	Comment
C11	Field experiments	Targeted experimental work to understand plant-soil interactions that support plant community and species persistence	Not evaluated	Not identified	Not identified	Low	Scenario testing - could assess how likely future conditions affect plant-soil microbial interactions, and the broader microbial assemblage, and whether this improves / impairs restoration outcomes
C11	Controlled growth / laboratory experiments	Assess how plant-soil interactions are modified by soil properties, such as high nutrient levels, and whether this limits restoration success	Not evaluated	Not identified	Not identified	Low	No comment
C11	Field experiments	Experiments that use mechanisms that improve microbial diversity / composition relative to a known target	Not evaluated	Not identified	Not identified	Low	No comment
C12	Field surveys	Establish (semi) permanent monitoring in current and planned restoration projects with different management	16-35 years	High	$100-1000K	Very high	No comment
C12	Field experiments	Embed experiments within existing and proposed restoration projects	6-15 years	High	$100-1000K	Low	No comment
C12	Field experiments	Experimentally test the effectiveness of management actions to manage exotic species	6-15 years	High	$100-1000K	High	No comment

Gap no.	Research type	Approach	Timeframe	Potential	Likely cost	Priority	Comment
C12	Other approach	Understand ecology and management of high threat invasive perennial weed species	6-15 years	Very high	$100-1000K	Low	No comment
C13	Online survey / interviews	Stakeholder surveys and expert knowledge	0-5 years	High	$10-100K	Low	No comment
C13	Analyse existing data	Cost-benefit analyses of the likely long-term feasibility of 'forcing' restoration projects to mimic specific TECs	0-5 years	Medium	$10-100K	Low	No comment
C13	Online survey / interviews	Assess what the community values	0-5 years	High	$10-100K	Low	No comment
C14	Online survey / interviews	Consult stakeholders in the sector to assess shortcomings in access to material, capacity to produce material, etc., and develop mechanisms to overcome these	0-5 years	Very High	$10-100K	Very high	No comment
C14	Policy / literature review	Establishing guidelines / mechanisms to ensure the restoration industry is supported throughout the CPCP	0-5 years	Very high	$10-100K	Low	No comment
C14	Modelling / simulation	Identify needs for which species will be required where	0-5 years	Very high	$10-100K	Very high	No comment
C15	Online survey / interviews	Develop mechanisms that better account for the long-term nature of restoration programs (e.g. longer funding cycles, clearer objectives)	16-35 years	Medium	$10-100K	Low	Needs clear statement of what success looks like and appropriate benchmarks

Gap no.	Research type	Approach	Timeframe	Potential	Likely cost	Priority	Comment
C15	Analyse existing data	Review conservation and restoration efforts to determine outcomes	0-5 years	High	$100-1000K	Low	No comment
C15	Modelling / simulation	Determining trajectory and management practices to support intended outcomes	0-5 years	High	$10-100K	Moderate	No comment
C16	Online survey / interviews	Consult stakeholders in the sector to assess constraints on restoration implementation and develop mechanisms to overcome these	0-5 years	Very high	$10-100K	Very high	Lots of knowledge but have failed to bring it all together and develop clear end goals; often failure is highlighted while success is not always measured / 'advertised'; capacity is available, but knowledge needs to be integrated with practice, research, etc; how can we use this knowledge to inform policy?
C16	Policy / literature review	Develop guidelines for best principles that establish a sector-wide approach to CP restoration including propagule collection, propagation, and access to support the proposed works	0-5 years	Very high	$10-100K	Very high	No comment
C16	Policy / literature review	Develop mechanisms that better account for the long-term nature of restoration programs	0-5 years	Very high	$10-100K	Moderate	No comment

Gap no.	Research type	Approach	Timeframe	Potential	Likely cost	Priority	Comment
C17	Policy / literature review	How, where and when can fire be used as a management tool in Western Sydney?	0-5 years	High	$10-100K	High	No comment
C17	Field surveys	Biomass / fuel load management	16-35 years	High	$100-1000K	Low	No comment
C17	Field experiments	Evaluating the effectiveness of alternative mechanisms that may / will give the same restoration outcomes	6-15 years	High	$100-1000K	Low	No comment
C17	Field experiments	Management for species - complexity of communities and target taxa / growth forms	6-15 years	High	$100-1000K	Low	No comment
C18	Controlled growth / laboratory experiments	Systematic surveys to collect soil seedbank followed by germination trials to understand exotic weed load and native species abundance and diversity	0-5 years	Very high	$100-1000K	Very high	No comment
C18	Controlled growth / laboratory experiments	Understanding germination cues of priority species. Seed burial trials to understand seed longevity in the soil	16-35 years	High	$10-100K	Low	No comment

Gap no.	Research type	Approach	Timeframe	Potential	Likely cost	Priority	Comment
C19	Policy / literature review	Analyse existing information and provide guidelines for decision making based on prioritisation. These are then adapted as new information comes in	0-5 years	Very high	$10-100K	Very high	Short to long term / ongoing - need to adapt to changing conditions, needs, other changes; hierarchy of decisions - where do you restore (prioritise relative to conditions / outcomes), what do you do, how does management change through time?
C19	Community activity / engagement	Test decision tree formally through interaction with stakeholders but validate using data	0-5 years	Very high	$100-1000K	Very high	Ongoing

Appendix 4: Knowledge gaps and supporting information

This information was provided by participants during workshops conducted to help develop the draft research strategy. Participants identified 294 unique knowledge gaps and over 900 potential activities to address them. All identified knowledge gaps from the workshops are listed below. Knowledge gaps have been edited for clarity purposes only, to ensure transparency.

Common acronyms: Cumberland Plain (CP); Cumberland Plain Woodland (CPW); Climate Change (CC); Threatened Ecological Community (TEC); Endangered Ecological Community (EEC); Biodiversity Stewardship Agreement (BSA); National Park (NP); Traditional Owners (TO).

Workshop – Engaging with peoples and cultures

- What does Country need? Aboriginal-led research to establish the needs of Country and guide conservation / restoration.
- Ontological (in)compatibility.
- How can we incorporate Traditional practice and culture into management for biodiversity?
- How can citizen science and cultural aspects of the CP be combined and what spaces could that activate to facilitate greater understanding of the Aboriginal cultural landscapes that exist in their community?
- What are the cultural connections and aspirations for places with CPW, not only framed around biodiversity and conservation but the broader spiritual connection to Country?
- How do First Nations Traditional Owners want to have a seat at the 'research' and restoration decision making, and can there be empowerment for both these areas to provide paid employment to care for Country?
- What is reciprocity versus giving back to Aboriginal communities?
- Recognising Aboriginal science in western terms.
- How to respectfully share knowledge between Aboriginal and Settler (general) community.
- Two-eye seeing approach – Cultural / Western science.
- Broader focus on education. There is a focus on birds and animals, but what about the more invisible yet intriguing like fungi, insects, lichen. You capture a new group of people here.
- What do communities value? Do these values align with biodiversity and conservation?
- How do people value green space - both in terms of what is in their region and what they have access to? Will increased access help improve public perception of green space?

- What's the emotional relationship people who live and work in CPW have to those places e.g. what do they value, not necessarily framed around 'biodiversity'?
- How do residents evaluate the use of public funds for biodiversity offsets? Is a lack of access to restoration / biodiversity offset sites a barrier for appreciation of where the money goes?
- Community priorities and aspirations e.g. strategic plans.
- Capitalising on the desire for recreational activities to encourage low-impact experiences in natural settings.
- Link between ‘urban green infrastructure’ (in growth areas) versus ecological connectivity that CPCP will create.
- How do attitudes differ between different sectors of community?
- Attitudes and knowledge of migrants. Many share a love of land and to connect them to local environment would benefit both.
- What are people's attitudes to conservation and biodiversity in the CP?
- Forming long-term connections and networks where once engaged, people can continue to engage and welcome people.
- Incorporating cultural healing spaces within the proposed blue-green networks - new places that form songlines.
- For private landholders what are the core challenges and barriers for effective EEC conservation and what are the funding mechanisms to support this?
- What are the key areas of human-wildlife conflict and what are the options for managing this?
- What are the drivers of conflict concerning increasing green space?
- Does increasing green space result in gentrification?
- Ownership versus caretaker. Property rights versus shared resources.
- Understanding barriers and challenges for private landowners to support restoration and conservation.
- 'Plastic Panda syndrome': next generation preferring 4K high-res video of 'wild nature' vs real (uncomfortable, hot, dirty) outdoor experiences.
- Are we imposing artificial ‘western' timeframes or administrative barriers on Indigenous communities? If so, how we manage this?
- Knowledge and understanding of actions that promote / support biodiversity
- Cannot assume any interest or knowledge of the natural environment.
- How do we translate successful community engagement projects to CP? e.g. Wooli NP.
- Hegemony (dominance) of 'Western' thinking and conservation practices.
- What do landowners know about conservation and what don't they know?

- What is the value to the community of BSA or other private / government conservation land with no public access?
- What incentive / information / assistance is needed to get landholder involvement in conservation outcomes?
- Benefits for locals - health, cooling etc.
- Cost-benefit analysis of restoration from different starting levels of degradation versus conservation of pristine areas.
- Is there a conflict between public access and use, and management for conservation?
- Understanding what the barriers are to engagement and conservation.
- The dynamics of CALD attitudes, do they / have they changed over time?
- Make (better) use of narrative, storytelling (about meanings of conservation and biodiversity to people, communities), to complement quant indicators.
- How can multilevel school, council and Landcare networks be used for effective TEC conservation?
- How to better engage with migrants not familiar with the Australian bush in Western Sydney?
- How does the media affect and shape community attitudes to conservation? Which media channels are most effective?
- What are the cultural factors that influence behaviour change in Western Sydney?
- How to improve messaging to the community about what we are doing - how to get people on board or provide a forum to express their opinions.
- How do local residents perceive rewilding projects? Will access to spaces where they can (potentially) observe rare species improve perceptions?
- What's the understanding between people seeing nature and understanding, and interest in healthy ecosystems and services?
- What are community attitudes to controls on domestic animals - cats, dogs?
- What are community attitudes to critically endangered species that they will never encounter themselves?
- Engagement fatigue.
- How to re-engage disenfranchised groups e.g. koala interest groups in Wollondilly?
- Potential of financial compensation mechanisms (payment for what? Traditional Knowledge, ecosystem services, etc).
- How to best engage with stakeholders we know are impacting on biodiversity e.g. waste dumpers, BMX trail bike riders?

- How to balance the benefits of people engaging with nature through recreational use and damage to environment.
- What methods can we use to educate residents using the bush for illegal activities such as motor bikes, 4WDs, bike jumps and tracks?
- How are restoration activities perceived within local and regional contexts?
- Who are the community leaders in non-English speaking cultural groups who can engage and educate?
- How do we identify/ attract community champions who lead others to create community change?
- Are there community volunteers / groups with local knowledge / expertise / relationships that can be drawn on?
- Increase volunteering for conservation.
- Financial incentives for landowners to engage in BSAs.
- Empowering communities.
- Who are the community members already loving nature in areas with CPW? Who are the others who don't love it, and why not?
- How do diverse cultural groups receive their local news and conservation knowledge - social media, foreign language newspapers?
- How to give more social weight to conservation programs - should this be used more when determining projects?
- What are the limitations of citizen science for capturing monitoring data for restoration activities? Are there any?
- Overlaps between songlines and biodiversity corridors?
- Can we link songlines and Aboriginal trails with landscape connectivity for biodiversity and conservation?
- Songlines and Cultural protocols.
- Significance of and connection to place/Country.
- Kinship to Country.
- What are culturally significant species and places in the CP that could be better managed by Aboriginal Custodians?
- Critical assessment of the financial costs of carrying out cultural activities, and beneficiaries.
- How/ where do Aboriginal people see their role in the restoration of ecological and cultural spaces within the CP?
- How can we use caring for Country to create a sense of belonging for a diverse community?

- How can Indigenous relational knowledge genuinely lead effective CPW biodiversity conservation in an operation of neoliberal management regimes and expectations?
- How do we provide indigenous leadership for research in biodiversity and conservation?
- What assistance do Aboriginal people need to be involved in conservation on their Country?
- How does cultural burning compare with ecological and hazard reduction burning practices in terms of biodiversity and conservation gains?
- Can cultural burning be used to improve management but also community engagement?

Workshop - Conserving threatened species and ecosystems

- Identifying locations within the Cumberland Plain that are disproportionately important in terms of the species population viability or climate refugia [places supporting species that were previously more widespread]. Focusing on sites with endemism [meaning: with species found only in that area].
- What constitutes a viable patch for investment into conservation / research?
- Where are the microrefugia from climate change? For each threatened species, what microhabitat conditions buffer climate effects?
- Mapping of threatened species distributions at high resolution to make regional risk assessments, including exposure to threats.
- How can Indigenous knowledge be meaningfully grounded through the research, including participation in the research process and outcomes?
- What role did and do Aboriginal Custodians have in managing parts of the CP?
- Understanding that Country needs people, the impacts of 200-plus years on Traditional Owners' continuous in-depth knowledge systems, and the effects and contemporary barriers to caring for Country by authentic Traditional Owner leadership.
- Switching the viewpoint to Indigenous, what are the culturally significant species and places in the CP that could be better managed by Aboriginal Custodians?
- What are Indigenous approaches to fire and landscape resilience?
- How does soil biodiversity influence ecosystem functional resistance and resilience and how this is impacted by global change?
- Understanding how plant-soil microbe interactions change in response to global change drivers.
- Understudied species and understanding of lichen and fungi. Which species are necessary for healthy ecosystems and how will they be affected by climate change?
- Enhanced plant performance through management of soil biotic and abiotic properties.

- Relationship between belowground biodiversity and function, and aboveground community and function. This would guide management of belowground that can support whole ecosystem health.
- Disease - phytophthora etc. invasion, alternative hosts.
- Invertebrate richness and abundance.
- Understanding the interaction of soil biota with plant community types.
- Mycorrhiza susceptibility to heat, *Pterostylis saxicola*.
- Do we have any knowledge of soil seed bank dynamics for threatened species and how can we effectively test for resilience of this important resource?
- How to optimise fire management, such that conservation outcomes are maximised and risk to local / regional communities is minimised.
- There is a knowledge gap around seasonality of fire. Prescriptions for more southern grasslands and grassy woodlands favour spring as the 'best' season to burn. This may not apply on the Cumberland Plain, which is further north, and with less seasonality in rainfall. Linked to this is fire intensity, which can have major effects on eucalypt populations via mortality of the sapling and young tree stages. We know that lack of fire in CPW can lead to encroachment of the shrub *Bursaria*; if fire intensity increases with climate change, this may favour the open woodland state, mediated by the mortality of the eucalypt sapling stage.
- What is the best fire regime for CP communities to support their resilience?
- Effect of hazard reduction burning on homogenisation of the landscape/ managing time since fire.
- Understanding interactions between fire and other ecosystem processes (e.g. seed dispersal, seed predation and pollination).
- Understanding how fire influences species and TECs and how we can use fire to manage threatened species as well as invasive species.
- Long-term multiscale monitoring of species, populations, ecosystem function using standardised protocols and central database.
- How do organisms move through the landscape? What are the barriers? Which components of the landscape are harder/ softer barriers?
- Minimum population size and dispersal requirements for threatened species identified in the CPCP.
- How does fauna move across the Cumberland Plain - corridors for residents and seasonal altitudinal migrants?
- Connectivity needs to be considered for mobile species e.g. birds, not just for terrestrial species, and the movement cost of moving through non-reserved parts of the matrix.

- Fragmentation effects on fauna, how to maintain connected, sustainable populations.
- Explore the possible corridor links across various community types for passage of fauna and plant movement, plus fire management strategies across the broader CP communities.
- Investigating the value of railway corridors as connective corridors for biodiversity.
- What kind of landscape connectivity works to assist with migration of species?
- How are invertebrate communities affected by habitat area and connectivity?
- Does habitat connectivity enhance adaptive capacity within the CP for threatened species and those in TECs?
- Mammal habitat augmentation to permit dispersal.
- Connective patch gap distance for dispersal barriers for various mammal species.
- How do corridors affect connectivity and habitats?
- Pollinator needs of *Pterostylis saxicola* [an endangered orchid].
- Understanding the relationship between site quality and structure / composition of tree stands.
- What do we want to achieve in terms of biodiversity, authenticity, threatened biota, cultural heritage?
- Defining what we're aiming for - conservation of what's there now or what the future climate may support, or what was once there.
- What are the vegetation structure requirements of threatened flora species (e.g. canopy benchmarks)?
- Understanding barriers for private landholders to support threatened species and ecosystem resilience.
- The impact that small landholders have on biodiversity.
- Getting all levels of government, community and other groups involved and on the same page - and how this can be done.
- How to deal with the difference between Traditional Owners and Local Aboriginal Land Councils (these parties have different ideas and agendas).
- Quantifying threatened species assets on private curtilage.
- How are restoration activities perceived within the local / regional and national context?
- Interactions/ partnerships between adjacent local government areas.
- The current state and future trajectories of remnants is affected by legacies (e.g. fertiliser application, grazing, fire history). How can we quantify these such that appropriate management can be planned?

- Remnant size may be poor indicator of conservation value and future viability because the degree to which biodiversity and conservation values are represented is context-dependant. How can we devise better metrics for conservation value?
- Land-use history effects on current biodiversity and ecosystem function.
- Interactions between threats: fire, climate, fragmentation, habitat degradation.
- How does climate change interact with other threats such as fire and disease?
- What climate change threats should management focus its efforts on?
- Adaptive capacity to changing disturbances, particularly in fragmented landscape.
- Threatening processes with impacts on many species include increasing deer numbers and noisy miners. How will climate change affect these and what are the scenarios under different levels of management?
- Adaptive capacity of species under different (and interacting) threat scenarios.
- What are the key non-climate-related anthropogenic [originating from human activity] disturbance factors?
- Changing disturbances e.g. drought / heatwaves/ fire.
- What are the risks or perverse outcomes of the conservation intervention?
- What is the physiological tolerance to heat and drought of threatened species in the CP?
- Understanding of the sensitivity to climate change especially warming, as well as exposure. Need for fine scale climate projections for CP microclimates.
- Adaptive capacity of threatened species populations to a warming / drying climate.
- Impacts of climate change on food quality for herbivores.
- How will interactions between species change with predicted climate change. e.g. competition, predation and mutualism [where all species benefit from interaction with each other].
- Use of supplementary watering to mitigate drought mortality.
- Effect of temperature on hollow breeding species.
- Effect of changing climate on expected vegetation community trajectories -will the expected forest types change in certain aspects?
- What is the level of exposure to heat and drought in the CP? Are there areas of high / low exposure? How much variation is there within sites and among sites and areas?
- How do native herbivores impact Cumberland Plain flora? What does an optimal grazing regime look like?
- How to calculate parameters that inform ecological triage? How to define the associated ethics?
- Which species and ecosystems in what condition will recover by removal of threats alone (assisted natural regeneration)?

- Which species and TECs will be the next to be listed as threatened?
- Succession processes, especially in regenerated sites.
- Recovery (succession) from extreme events - crown fire, prolonged drought, outbreaks of insect herbivores etc.
- Succession within and between ecological communities - are trajectories fixed or random?
- Effect of changing climate on expected vegetation community trajectories (will the expected forest types change in certain aspects)?
- Importance of species and / or functional diversity.
- Is there genetic variation for climate change held within populations, areas and the CP for threatened species? If not, can we pull in populations for genotypes with enhanced tolerance?
- For foundation / ecosystem dominant species such as eucalypts, as well as for threatened, restricted range species, there is a need to understand patterns of genotypic and phenotypic diversity, and how these influence resilience to climate change and ecosystem function.
- Establish genetic knowledge infrastructure to support restoration practices (e.g. seed production areas) across multiple representative TEC species.
- Viability, vulnerability and adaptive potential of threatened species. Genetic knowledge to support long-term survival, prioritisation and genetic translocation strategies.
- Genotype augmentation in restoration and management planting.
- Identify suitable climate-resilient sources and develop genetic mixes across multiple target species that enable climate responses and ensure overall fitness and adaptability.
- Halting declines in distributions is predicated on offsetting future clearing - what do the current trends in the way offsetting is undertaken suggest about future conservation status?
- How might phylogenetic and functional diversity be lost while technically achieving no net loss to biodiversity under the offsets scheme?
- Remnant size to provide resilience against threats and climate change.
- Impact of 'islands' throughout the CP and ways to reduce these impacts. What is the smallest viable patch size to manage a population?
- What potential exists for reversing fragmentation in a highly cleared and urbanised context?
- Connectivity and potential resilience of remnant patches of TEC need to be quantified and monitored using targeted genetic studies on representative species (within and outside CP).
- Where are the current drought refugia for peri-urban species? How do we protect this during the CPCP?
- Factors determining translocation success for threatened plants.
- Commitment to long-term monitoring the outcomes of biodiversity.

- State-and-transition models for EECs and understanding of thresholds.
- Given that we generally only measure vegetation, we need to test assumptions that vegetation-based metrics can be used as surrogates for faunal habitat quality.
- Can habitat be improved to assist existing species and possible future translocated species.
- What management actions are most effective for enhancing species persistence?
- How do we manage weed infestation when restoring landscapes?
- Can cultural burning be used to improve management and community engagement?
- Re-engagement with cultural burning.
- Do cultural burns benefit any threatened species or communities?
- Is the lack of cultural burning impacting on species and community engagement?
- How to find out what all the different projects are - hard to even find within one's own department - so many different entities within one department.
- Interactions with existing policy frameworks (i.e. local development plans).

Workshop - Restoring and reconstructing ecosystems

- Is it possible to create small top-quality cores and manage natural spreading and regeneration? What size cores? Effective over what distances?
- How to rationalise competing demands, e.g. lots of trees for koalas vs true community restoration.
- What soil conditions lead to / prevent restoration success? Can they be promoted / counteracted? In particular, are there specific plant-soil feedbacks (influence of previous plant communities) that prevent recovery? These can involve nutrient and carbon availability, pH, soil microbiome, others.
- How important is invertebrate diversity to successful restoration?
- Can we identify microbes that enhance the establishment of key species for restoration?
- How can we support the soil to address dominant pastural weeds when planting natives?
- Models for soil recovery: what are the necessary inputs? (Other than herbicide).
- What are the below-ground characteristics for a functional resilient ecosystem - microbial, invertebrates, chemistry, properties?
- Potential for soil translocation from good condition remnants to poor condition sites.
- Once sites are restored, fire should be an essential ecosystem process. Previous work gives some idea of fire frequency effects. Knowledge gaps here include: best season of fire (spring versus autumn) and what range of fire frequencies will best maintain biodiversity (determined by experiment, not observational approaches).

- How can we use fire, including cultural burns, to manage invasive species / biodiversity?
- How do we best include fire to maximise restoration success? What are the risks of perverse outcomes?
- Climate change will lead to more frequent and more intense fires. Fire intensity effects are known from other systems, but not for CPW. Intensity effects on CPW eucalypt populations are likely to be similar to other systems.
- How does ecological connectivity influence restoration?
- What is the value of restoration in enhancing population holding capacity and landscape connectivity?
- What options are available to improve connectivity or facilitated movement between patches for vertebrates?
- Where are our baseline remnants? OR what are our targets / benchmarks?
- What should a mature, climax phase CPW look like in terms of tree stocking and age / size classes?
- What is a minimum area that might be considered 'resilient'? What are the common features of these areas?
- Reconstruct to what previous condition?
- What stem density of tree cover should we be 'aiming' for in different areas?
- What are the variations in structure and species composition of CPW across environmental gradients?
- We need to model progression of restoration sites towards reference or desired states. This will guide intensity and mode of additional active interventions.
- No control over inappropriate use of natural areas e.g. rubbish dumping, informal tracks.
- How to incentivise the uptake of restoration on private land.
- How can the community be engaged to best assist with long-term monitoring capacity?
- Be cognisant of the land tenure and level of protection. Is the study location protected in perpetuity?
- The largest challenge will be to encourage private landholders to set aside land for conservation.
- What are the most robust indicators of ecosystem function which are cheap and simple to measure?
- Given uncertainty, how do we allocate funds to maximise success?
- Cost-benefit analysis of restoration from different starting levels of degradation vs conservation of pristine sites.

- Cost-effective and ecologically effective methods / techniques for large scale restoration projects e.g. 1020 ha of land.
- Can we calculate $ value of particular sites / bio values based on irreplaceability, opportunity cost etc.
- Long-term thinking needs to be adopted for restoration grants. For example, let's not do what happened with the 20 million tree funding, which equated to 20 million plastic tree guards in the environment and no funding in the future to remove the guards. Species selection will be very important when thinking about future climate change conditions.
- How do you take a pasture-improved paddock and get it to a state where you can start restoration? Would be good to have accessible guidelines.
- How does historical land use affect restoration methods and outcomes?
- Comparing the restoration outcomes in terms of the biodiversity assessment method improvement values in areas with varying soil-chemistry histories.
- How best to manage / control invasive exotic plant species and other pests (insects, pathogens, etc).
- What changes occur between urban edge and bushland that influence establishment / naturalisation of invasive species?
- What are the most important reasons for restorations failing? What are the risks that can predict these failures?
- We don't know how well the conservation areas (BSAs) will be placed within the Strategic Conservation Areas.
- How to assess resiliency? How to assess self-sustainability? Is it even possible?
- How do we embed research programs in proposed restoration and re-wilding projects to value-add and implement adaptive management based on the outcomes?
- Planning policy does not allow for the best possible ecological outcome - ecological restoration in the private sector (Part 4) is hamstrung by planning policy. Conditions of consent typically have a 1-year time frame for all weeding and planting works followed by up to 5 years maintenance. 12 months to remove all weeds, collect provenance seed, propagate and install does not allow for the best possible ecological outcome. The 12-month practical completion timeframe is a mechanism to grant construction / occupation certification.
- Assuming restoration is feasible, recent surveys tell us that the restoration sector does not have the capacity or structure to undertake large CPCP-type targets. How can we address this in Sydney?
- Can we respond with monitoring when natural events test resilience? What happens if these events occur before we're ready?

- Private land set aside for conservation may not be connected.
- Public support for conservation will underpin success.
- Ensure that vision is not limited to CP, but that relevant communities and distributions are also considered in the research project. This will value add to the outcomes and also better facilitate long-term resilience across natural systems.
- How do we ensure short-term gains are translated to long-term success?
- Creating suitable habitats to support species to adapt to climate change - evolutionary potential.
- Enhance the capacity of species and ecosystems to withstand or respond to environmental change.
- What is the role of mammal herbivores in controlling *Bursaria* encroachment?
- What are the roles of native and exotic herbivores in limiting restoration success? Including largely locally extinct macropods such as wallabies, are possible reintroductions.
- Restoration species complexity (genetics, diversity) to maximise adaptive capacity (in response to expected climate influences for 50 - 150 years from now). Which species do we choose and which model of community?
- Should we focus less on recreating certain TECs and focus more on creating functional, self-sustaining ecosystems that provide the functions and services we desire?
- What level of diversity is required to build a functioning ecosystem? Genetic, species, functional, trophic. Above and belowground.
- What ecosystem functions are contributed by different vertebrates, including non-threatened species currently sparsely distributed in CP e.g. wombats.
- Are there critical associations among organisms (microbial-plant-animal) required for functional resilience?
- Develop restoration practices that go beyond the focus of single vegetation types, but that focus on shared diversity and functional representativeness.
- Ameliorate loss of specific ecological functions.
- Sue Prober's work in White Box woodland showed *Themeda* [kangaroo grass] was a keystone species, reducing soil nitrate via high-C litter. Are there other C4 grasses in CPW with this property?
- How is functional resilience measured and can a common metric be developed?
- Use of 'micro-habitat' components in establishing functioning patches.
- Supporting species from being functionally extinct due to climate change.
- Biota of the CP require various habitat requirements to maintain diversity in the CP. How can we make generic recommendations that can be applied to many habitats? If a full diverse seed mix

cannot be sown at a site, getting a native C4 grass mix going would be a good initial step to take to return plant-soil interactions toward low-N status. Other species can be added subsequently.

- What vertebrate species are absent but 'belong' in these CP areas? Have / can the causes of extinction be addressed?
- Where are we at in understanding the effectiveness of artificial tree hollows and their use by different fauna groups, including native versus introduced species?
- Define strategy for establishment of 'novel ecosystems' (from gene to species). What are we trying to achieve and what is the best way to define, assess, and monitor success?
- How novel is too novel for ecosystem reconstruction?
- Support the establishment of genetically informed seed production areas across a range of key species to facilitate the sourcing of adequate source material across CP and beyond (local and future proofed).
- Establish genetic knowledge infrastructure to support restoration practices (e.g. seed production areas) across multiple representative TEC species.
- Genomic adaptation.
- Promote in situ genetic adaptation.
- As foundation species, eucalypt foliar chemistry is a regulator of ecosystem processes, including herbivory, nutrient cycling and koala habitat quality; how does foliar chemistry vary across the CP, especially with soils; how will global warming affect it? Can we select genotypes for restoration plantings to produce favourable, resilient outcomes?
- Develop empirically based guidelines to genetically improve currently isolated and bottleneck populations to increase viability, self-sustainability and resilience (as well as facilitate between-remnant connectivity).
- What would target-based ecological compensation look like for the Cumberland Plain?
- How do we know when active restoration is NOT required - i.e. may lead to perverse outcomes at offset sites?
- Should we be making it easier to propagate threatened species for restoration?
- Is restoration more successful when done in stages e.g. do we focus on more common species first or try to plant the full complement of species in a community?
- Scalping topsoil and re-sowing with diverse seed mix is best approach to restoration. There may be sites where this is not possible, and other, more low-key approaches may start the restoration process.
- Social research - impacts on restoration success.
- What are the ecological constraints and their threshold values prohibiting successful restoration?

- What site prep / land management can be done in advance of restoration to make restoration successful?
- What are the socio-economic constraints and their threshold values prohibiting successful restoration?
- Is there a role for ecological thinning to overall CPW restoration (e.g. overplanting trees and shrubs then felling and leaving in situ?)
- How can we improve successful use of landscape-wide tube stock plantings?
- What meta-analysis has been conducted recently for successful restoration - what are the key variables this would address?
- Where do you source material? How far away from the site before it is not locally adapted?
- The efficacy of using supplementary watering to support restoration in the event of extended dry periods relating to climate change.
- How to define / select the best restoration approaches for specific conditions and outcomes.
- How do we ensure that biological propagation material is available for all restoration programs, from plant genetic to soil biodiversity?
- The impact of absent or enhanced growth-form groups in restoration.
- Testing the model - rates of increase and enhancement of growth forms in management.
- How does coarse woody debris contribute to restoration success (and natural regeneration)?
- 'Gated communities' - assessing the response of natural and restored areas to animal re-introductions.
- Fire and cultural burning: there is an excellent opportunity to test results from cultural burning against more conventional fire treatments, or other management options.
- Assessments of historic restoration (techniques and approaches) from across SE Australia will be important to informing approaches.
- Assess representativeness and relative success of existing restoration programs. What have we learnt, and how can it be improved?