Clean Air and Urban Landscapes Hub

National **Environmental Science** Programme

Research Plan 2019

Version 5

CONTENTS

CERTIFICATION OF RESEARCH PLAN

Hub Leader Certification

As the Hub Leader, I certify that:

• the research projects contained in the Research Plan are linked to the Activity Outcomes for the Clean Air and Urban Landscapes Hub as outlined in the Funding Agreement;

• the research projects in the Research Plan address the NESP Research Priorities for Clean Air and Urban Landscapes Hub;

• funds are available to meet all approved projects and the additional projects included in this Research Plan; and

• this Research Plan was prepared in consultation with the Hub Steering Committee.

Signed:

Hub Leader Name: Dr Kirsten Parris

Date: 9/11/2018

Hub Steering Committee Chair Certification

As the Steering Committee chair, I certify that:

• this Research Plan was prepared in consultation with the Hub Steering Committee;

• any issues of concern or matters raised during Steering Committee meetings or the Department during its assessment process have been adequately resolved, amended or incorporated into this Research Plan; and

• this Research Plan was endorsed by the Steering Committee on 26 October 2018.

Signed:

Hub Steering Committee Chair Name: May Carter

Date: 11/11/18

INTRODUCTION

The National Environmental Science Program

The National Environmental Science Program (NESP) is a long-term commitment to support environmental and climate research. The key objective of the NESP is to improve our understanding of Australia's environment through collaborative research that delivers accessible results and informs decision making. The focus of NESP is on practical and applied research that informs on-ground action and that will yield measurable improvements to the environment.

The Program builds on its predecessors – the National Environmental Research Program and the Australian Climate Change Science Program – in securing for decision makers the best available information to support understanding, managing and conserving Australia's environment.

The NESP is delivered through multi-disciplinary research Hubs or consortia, hosted by Australian research institutions.

The NESP seeks to achieve its objective by supporting research that:

- is practical and applied and informs on-ground action

- addresses the needs of the Australian Government and other stakeholders by supporting and informing evidence-based policy and improving management of the Australian environment

- is innovative and internationally recognised

- enhances Australia's environmental research capacity

- is collaborative and builds critical mass by drawing on multiple disciplines, research institutions and organisations to address challenging research questions

- produces meaningful results accessible to government, industry and the community

- includes synthesis and analysis of existing knowledge

- builds relationships between scientists and policy-makers to encourage collaborative problem solving on environmental issues.

NESP end-users will be a broad range of stakeholders whose decisions may impact on the environment, and include the Australian Government, state governments, industry, business, community groups and Indigenous land managers (or Indigenous Communities).

The intended outcomes of the NESP are:

- Enhanced understanding of, and capacity to manage and conserve Australia's environment.

- Improved climate and weather information for Australia through a greater understanding of the drivers of Australia's climate.

- Timely research that is used by policy and decision-makers to answer questions and provide solutions to problems.

- Research outcomes that are communicated clearly to end-users and the general public, and stored in a manner that is discoverable and accessible.

Hub Role

The Commonwealth Government established the Clean Air and Urban Landscapes (CAUL) Hub of the National Environmental Science Program (NESP) to undertake "Research to support environmental quality in our urban areas". This includes research on air quality and air pollution to improve liveability and environmental quality in urban areas; greening, biodiversity and ecological improvement of urban landscapes; and incorporation of NESP research into the development and implementation of on-ground environmental programs.

The end-user focus of the CAUL Hub will include application of NESP research by our diversity of stakeholders across all levels of government, the private sector, industry and in urban communities across Australia. CAUL's research will improve the understanding of how best to increase and integrate green and blue infrastructure and reduce the environmental impact of buildings and transport to improve air quality, reduce greenhouse gas emissions, maintain biodiversity, and enhance critical ecosystem services.

By connecting scientists, policy makers, industry and citizens, the CAUL Hub is delivering a strategic, integrated research program to improve the liveability of Australia's cities and towns.

As detailed in this Research Plan V 5, the CAUL Hub continues its approach to addressing the current and future research needs of policy makers and practitioners by committing our expertise to known research gaps whilst remaining flexible to emerging priorities.

Purpose of Research Plan

This Research Plan has been developed by the CAUL Hub, in consultation with the Department of the Environment and Energy and other key stakeholders.

The purpose of the Research Plan is to outline:

- the research priorities the Hub is funded to investigate

- the research projects that will address these priorities

- how the output of the research will be communicated and brokered to key stakeholders

- how the impact of the research will be measured

- how Hubs will work collaboratively within and across Hubs.

Research Prioritisation → Research Delivery → Knowledge Brokering & Communication → Measuring Impact

This Research Plan also provides appropriate detail on the management and governance of the Hub, including outlining the broader funding profile, key staff and research organisations, and the risks needing to be monitored to ensure success.

HUB ADMINISTRATION & GOVERNANCE

Hub Leadership and governance

Hub Leaders

The CAUL Hub is led by Dr Kirsten Parris (The University of Melbourne), one of Australia's most prominent urban ecologists. The Deputy Hub Leader is Dr Joe Hurley (RMIT University), whose research focuses on urban sustainability, and urban planning governance and systems.

Hub Leadership Team

The CAUL Hub Leadership Team is comprised of established and emerging research leaders with a range of expertise across key themes – urban greening, clean air, liveability, urban systems, knowledge transfer, and practical solutions. The Hub Leadership team is supported by a suite of outstanding investigators within each of the themes listed above across five broad research projects. More information on the CAUL Hub Leadership Team and researchers can be found at www.nespurban.edu.au/people/ while Figure 1: CAUL Hub Organisational chart shows the research themes and projects of the CAUL Hub.

From August 2017, the Clean Air and Urban Landscapes Hub has moved to a two-tiered leadership structure, with an Operational Leadership Group meeting monthly and a Strategic Leadership Group meeting quarterly. Both of these meetings are minuted.

The Clean Air and Urban Landscapes Hub's Operational Leadership Group is responsible for:

- Execution of the research plan, including monitoring delivery of milestones and deliverables

- Undertaking annual reporting and other reporting and administrative requirements

- Coordination of project meetings

- Driving communication between projects and institutions

The Clean Air and Urban Landscapes Hub's Strategic Leadership Group is responsible for:

- Developing and implementing the Hub' s strategic and research direction and priorities

- Providing oversight of the reporting requirements, including the annual progress reports and financial reports, and any other reporting required by the Department

- Working with the Executive in monitoring and evaluating the impact of the projects and the Hub as a whole

- Providing oversight of the Hub' s finances and budgetary allocations

- Identifying and prioritizing emerging issues

- Identifying and fostering strategic collaborations with other NESP Hubs

- Leadership in project ethics and Indigenous engagement protocols to ensure cultural competency throughout the CAUL program and achieve appropriate and genuine acknowledgement of Indigenous knowledge and partners

- Reporting to the Steering Committee

CAUL Hub Executive

The CAUL Hub Executive is coordinated by the Hub Leaders and based at the School of Earth Sciences at The University of Melbourne (the Administering Organisation). The CAUL Hub Executive team consists of a Business Manager, Communications Officer and Knowledge Broker, and is responsible for the management of all administrative and reporting components of the CAUL Hub. See Figure 1 for the CAUL Hub organisational chart.

Steering Committee

The Hub Steering Committee provides strategic supervision over the Hub's performance against its objectives. The roles, responsibilities and membership of the Steering Committee are outlined in its terms of reference, and include:

- ensuring the alignment of research activity to the policy needs and interest of the Department and other key stakeholders

- connecting the Hub's research questions, activities and outputs to relevant research activity and policy initiatives outside the Department

- overseeing the development and implementation of the Research Plan, including the review and amendment of the Research Plan, as required

- directing, and endorsing, the development, and delivery of any reporting, monitoring and evaluation requirements under this agreement

- reviewing, monitoring and guiding project performance.

Please see the Clean Air and Urban Landscapes Hub's website for further details on the members of our Steering Committee: http://www.nespurban.edu.au/people/#steering

Indigenous Advisory Group

The CAUL Hub's Indigenous Advisory Group provides advice on a range of matters relating to our research, communication and knowledge-brokering activities, with respect to Indigenous Engagement and Participation.

The responsibilities of Indigenous Advisory Group members include:

- Overseeing the development and implementation of Indigenous engagement, collaboration and participation in the CAUL Hub Research Plan

- Endorsing the evaluation requirements with respect to the IEPS in overall CAUL Hub reporting

- Encouraging alignment and coordination of the Hub's IEPS with other initiatives including those led by other NESP Hubs, government, community, industry and the broader scientific community

Please see the Clean Air and Urban Landscapes Hub's website for further details on the members of our Indigenous Advisory Group: http://www.nespurban.edu.au/people/#iag

Figure 1: CAUL Hub Organisational chart
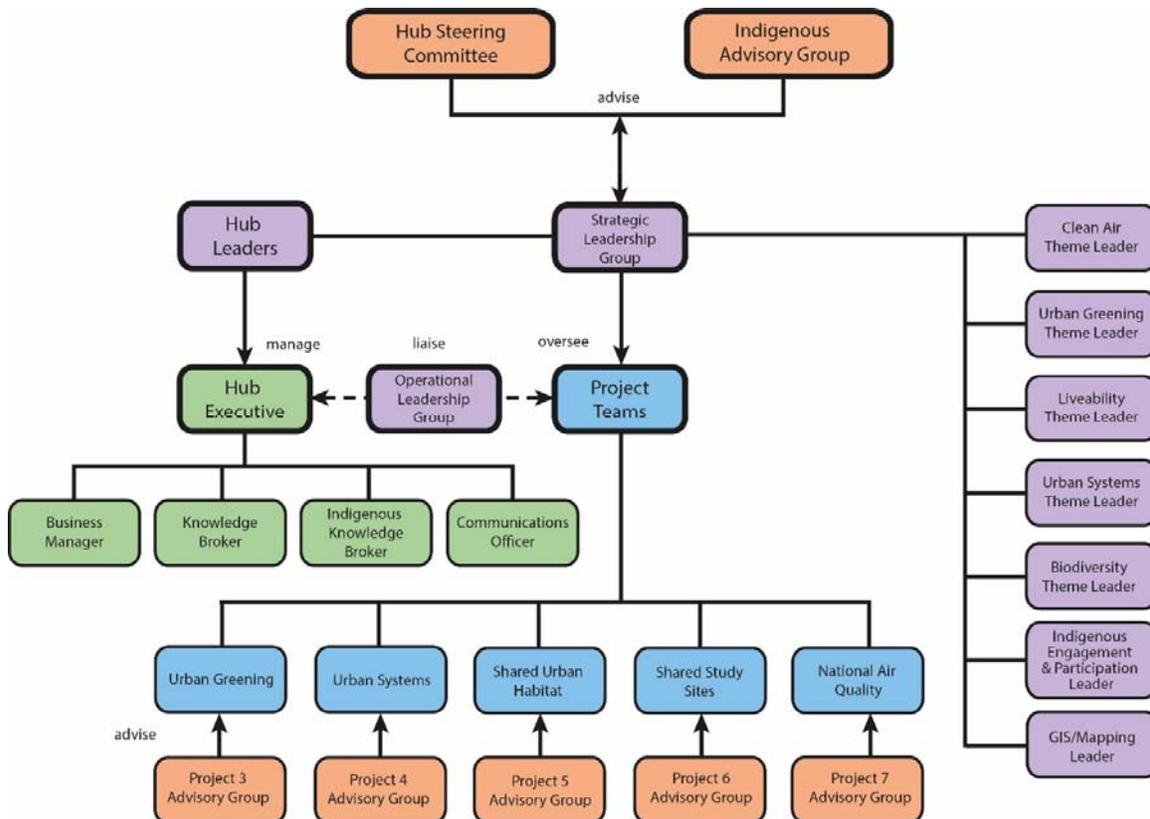
The Department of the Environment and Energy

The Department of the Environment and Energy has responsibility for managing the National Environmental Science Program, including the approval of this Research Plan, assessment of progress of projects under this Research Plan and payment of any funding associated with the Hub agreement.

Importantly, the Department is the key end-user of research under the NESP, and works closely with the Hub and other key stakeholders in determining and negotiating the delivery of research under the Research Plan.

The Minister

The Minister for the Environment and Energy provided approval to fund the CAUL Hub and has authority to approve major changes to the scope and funding allocation to the Hub and to endorse annual versions of the Research Plan.

RESEARCH PRIORITIES

The CAUL Hub is committed to a body of activity that includes short and long-term research projects. Each activity year the Department of the Environment and Energy will work with the Minister, the Hubs and other key stakeholders to identify and refine research priorities and develop projects that align with these priorities.

This research prioritisation is a rolling process and key milestones in each activity year, like the Annual Progress Report and submission of the next Research Plan, will inform the process.

This constant consideration and evaluation of research output and impact builds confidence in the performance of the Hub and the effectiveness of the program. It also provides the basis for the flexibility needed in the CAUL Hub to engage in new themes of research in an adaptive manner, and ensures that the Hub's focus is fixed on the delivery of relevant and practical research.
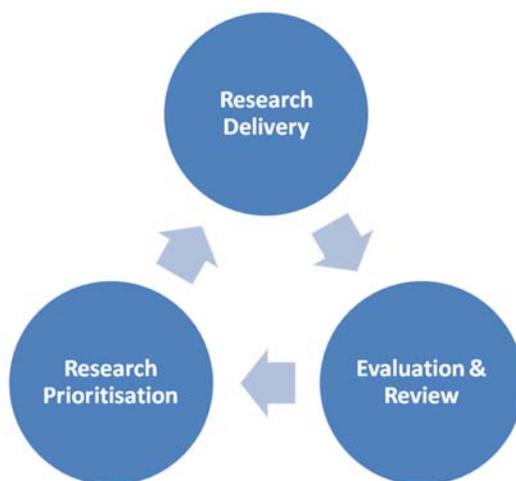
Broadly, the research priorities of the CAUL Hub are listed under two groups:

Group A: Increasing our understanding of the environmental and social impacts of air pollution in urban and peri-urban areas to inform management actions

1. Contribute to the design of, and inform the development or, a program for monitoring and reducing atmospheric particulate matter levels in Western Sydney.

2. Identify and prioritise significant sources of air pollution and their impact on the environment and public health to better target government investment.

3. Identify key sources of emissions of air pollutants, including sulphur dioxide and particulate matter, in Australian urban centres and the risks they pose to the environment and human health. This work should complement the current reviews of the National Environment Protection (Ambient Air Quality) Measure relating to a) PM standards and b) the standards for sulphur dioxide, nitrogen dioxide and ozone, as well as other efforts underway to reduce point source emissions of these pollutants.

4. Identify features of Australian urban landscapes that influence the impact of air pollution on humans and the environment (e.g. landform, local climatic conditions, urban design).

5. Quantify the co-benefits for air quality, human health, biodiversity and the environment of measures to reduce greenhouse gas emissions in urban and peri-urban areas. Such measures could include active transport, improved public transport, increased energy efficiency of buildings and changes to the urban form.

6. Study the exposure and risks to the environment and human health of chemicals and persistent organic pollutants arising in everyday products, including chemicals newly listed under the Stockholm Convention, in the urban environment – from indoor and outdoor sources, flows and use through to disposal via current urban infrastructure such as sewers and landfills.

7. Identify and evaluate effective systems and tools for detecting and managing air pollution in urban areas, including a focus on monitoring, reporting and forecasting systems, strategic planning in infrastructure and urban development, and measures to reduce point source emissions.

8. Assess existing and identify new information systems and processes needed to achieve air quality objectives, identify trends and evaluate outcomes.

9. Support existing and emerging cross-government clean air initiatives such as the Clean Air Agreement.

Group B: Quantifying the benefits of urban greening for humans and other species in cities to inform Australian Government policy and programs, and management actions by all levels of government, the community and industry

10. Work with major cities to assess the effectiveness of various current and new approaches to managing urban ecosystems, such as greening plans, and how these can be incorporated into greening plans to maximise positive outcomes for biodiversity including threatened species, air and water quality, and human health. These outcomes could support the development of a framework for greening cities which would consider multiple benefits such as absorption of atmospheric pollutants, sequestration of carbon, mitigation of the urban heat-island effect, provision of habitat and landscape connectivity for biodiversity, strengthening of social capital, and the reconnection of humans with nature in urban areas.

11. Demonstrate the relative cost effectiveness of different approaches to planting and managing urban green spaces for air and water quality and human well-being. These approaches could include the choice of species to be planted, the location and configuration of plantings, irrigation of plantings with stormwater to improve survival and growth rates and reduce runoff to local streams, and preservation of upland drainage lines in new developments to provide green space and a range of environmental and health benefits for residents.

12. Prioritise climate adaptation measures for managing the impacts of climate change on environmental quality and human health in urban areas, such as expanding urban forests and improving the even distribution of tree cover across our major cities for equity of access.

Table 1: Progress on CAUL Research Priorities

Research Priority	Status
1	Ongoing. (Subproject 7.1)
2	Ongoing. (Subprojects 7.1 and 7.4)
3	Ongoing. (Subproject 7.1)
4	Ongoing. (Subprojects 4.1, 7.1 and 7.4)
5	Ongoing. (Subprojects 4.1 and 4.3)
6	Ongoing. (Subproject 7.3)
7	Ongoing. (Subproject 7.1)
8	Ongoing. (Subproject 7.1)
9	Met
10	Ongoing. (Projects 3, 5 and 6; subprojects 4.2 and 4.5),
11	Ongoing. (Projects 5 and 6; subprojects 3.3, 3.11, 4.2, 4.3 and 4.5)
12	Ongoing. (Project 6; subprojects 3.9 and 3.11)

LIST OF RESEARCH PROJECTS

A list of research projects funded under the CAUL Hub can be found at Attachment A – Research Projects. For more detail on each specific project, please refer to the CAUL Hub website, www.nespurban.edu.au.

EXPECTED OUTCOMES AND OUTPUTS

The expected outcomes of the NESP are to produce research that:

- enhances our understanding of Australia's environment, climate and weather

- is communicated clearly to relevant stakeholders and the general public

- is discoverable and accessible

- informs decision-making and addresses environmental priorities.

Research under the NESP is expected to inform the policy and program delivery of the Department of the Environment and Energy. More broadly, it will engage and inform all key stakeholders with an interest in the outputs of environmental and climate science research, including state and local governments, business and industry, community groups, Indigenous land managers (or Indigenous Communities) and education institutions.

<u>**Hub Outcomes and Outputs**</u>

The activity on any problem can be grouped into four stages; identify, investigate, plan and communicate. Outputs arise from the communication phase and outcomes are behaviour changes we can attribute, at least partly, to these outputs – See Table 2 for a summary of CAUL Hub Outcomes and Outputs. We need to acknowledge at the outset the limitations of our scope. Research conducted by the CAUL Hub will provide the evidence base for such behaviour change. Sometimes implementation will be easy, since it is an improvement in current practice, but much of our communication will be into heavily contested policy arenas.

Our knowledge brokering and communication strategy is designed to tailor our input to the needs of policy makers, industry, the private sector, NGOS and the broader community, to ensure as far as practically possible, implementation of the Hub' s research.

Outputs will be tailored for particular end-users. Given the range of end-users with interests in cities this implies a broad range of outputs, both in type and content. These range from briefings for policy makers and practitioners to apps to gather data and improve public engagement with urban environments.

There will be significant syntheses of policy and practical advice given around Air Quality in Western Sydney (previously known as the Clean Air Plan for Western Sydney) and opportunties for increasing urban greening.

It is important to recall that NESP funding is listed as category 1 research funding by the Department of Education. Thus, standard research outputs are also important for the success of the Hub, including published papers and conference presentations.

Finally, we will produce a range of outputs tailored for the general public, because much of the urban landscape is under private control and the citizens of Australia's cities have a large stake in the ongoing state of urban environments. Thus, advice on improving the environmental status of private space will be another important output.

Table 2: Expected CAUL Key Outcomes and Outputs 2019-20120

Project 3 – Urban greening for liveability and biodiversity

- Guidelines for green space governance, including tools for public participation
- Data on urban forest tree species suitable for future climates
- A public report on future risks and opportunities for green space in Australia, arising from horizon-scanning workshops on future urban forests in different capital cities
- Public report on the framework for urban forest interventions in areas of biodiversity significance
- Report on Noongar perspectives on city planning and urban nature in Perth

Project 4 – Improved urban systems for liveability

- Increased understanding of the impacts of a changing vehicle fleet on air pollution
- Enhanced decision-making to dictate funding at different levels of government in relation to commuting, traffic emissions, and urban greening
- Data on commuting burdens and productivity, and energy and emission costs, by industry, occupation and transport mode, along with data on productivity and transport costs of employment centres
- Justification for increased investment in green infrastructure, through articulation of the benefits, current state of the art and the potential opportunities for further greening
- Increased extent and depth of understanding about liveability in regional Australian centres through the development of regional and rural liveability indicators, including audit reports, a journal article, and additional dissemination
- Improved decision making and understanding of the barriers and opportunities for enhancing the ecosystem services that can be delivered through urban greening

Project 5 – The shared urban habitat

- A critical framework enabling land managers to decide which species to bring back into urban environments, assess the risks and benefits involved, and explicitly consider ecological, social and cultural factors
- An integrated, national urban citizen science program (including easy-to-use apps for flying-foxes, frogs and beneficial insects), that mobilises city-dwellers to engage with biodiversity in their neighbourhood while providing key information to improve understanding, and assist the management of these urban species.
- Practical conservation strategies to mitigate processes that are threatening the persistence of native fauna (including bell frogs, native beneficial insects), including habitat loss, habitat fragmentation, habitat isolation, disease and a loss of habitat complexity
- Strengthened connections between university researchers and local Indigenous communities; increased awareness and application of Indigenous knowledge to the management of urban biodiversity; and a participatory arts-science event (The Living Pavilion) to foster greater understanding (amongst researchers and the general public) of Indigenous perspectives of biodiversity in the city.

- Identification of conservation opportunities for threatened species and other biodiversity in urban environments, including a synthesis of knowledge regarding which conservation actions may be most effective, and identification of potential sites for implementing practical actions.

Project 6 – Network of shared study sites

- Practical actions for researchers and educators to move beyond an inclusion model of Aboriginal and Torres Strait Islander people and knowledge to Indigenous-led agendas in both research and teaching
- Better understanding of the ecological, biodiversity, social and cultural benefits of urban greening initiatives to assist in decision making for improved outcomes, with a focus on indigenous species, verges, green space and waterway rehabilitation, and deprived suburbs
- New knowledge to assist in evidence-based policy-making for enhancing the ecological, cultural and community benefits of street verges, including a typology of street verges
- Provision of recommendations for management of street verges and streetscapes in Australian cities to promote the use of native plants, including flora of importance to local Indigenous stakeholders
- Establishment of standardised approaches to measure the health and wellbeing impacts of urban greening initiatives that can be used to monitor and evaluate projects
- Documentation and dissemination of the Upper Stony Creek collaborative process to determine the value for the approach to be transferred to other contexts

Project 7 – Air quality in Australia

- An improved emissions baseline that contributes to the National Pollutant Inventory, leading to more cost-effective improvements in air quality
- Reduced cost of estimating traffic emissions at street or suburb level through use of open-source modelling framework
- Potential for a nationally consistent approach to meso-scale traffic emissions modelling through adoption of this framework
- Improved understanding of pedestrian exposure to pollution from traffic through street-level measurements
- Improved understanding of biogenic emissions, leading to better air-quality forecasting and climate simulations
- Improvements in mitigation and responses to smoke pollution arising from improved knowledge of health effects
- Demonstration of improved air quality (reduced concentrations of VOCs and $PM_{2.5}$) due to implementation of fragrance-free policies
- Improved consumer advice on the use of domestic fragranced products
- New understanding of the extent of noise pollution in Australian urban environments
- Improved health outcomes from more targeted mitigation of air pollution and noise
- Mapping of the noise environment and its impact on urban ecosystems

COMMUNICATION AND KNOWLEDGE BROKERING

Integral to the success of the NESP in influencing decision-making is the clear and effective communication and brokerage of research outputs to key stakeholders. The CAUL Hub maintains a Knowledge Brokering and Communication Strategy and annual implementation plans that:

- strongly align with this Research Plan;

- describe how the Hub will facilitate knowledge sharing between researchers and reserach-users;

- include activities that bring researchers, policy makers, industry and citizens together to facilitate evidence-based decision-making in all levels of Government, private and community-based practice in cities;

- detail the research outputs and other knowledge translation events to be produced by the Hub; and

- describe how data produced by the Hub will be stored and made accessible to the general public, industry and government.

Data Accessibility

The NESP guidelines expect that all information (including research data) produced under the program is made publicly and freely available on the internet. The CAUL Hub recognises the need to promote open access to public sector and publicly funded information, and has the following strategy for data dissemination:

- all CAUL outputs, including data, documentation and analysis, will be made available through the CAUL website either directly or as links to publicly accessible repositories;

- we will make use of the notification templates and procedures to ensure that the Department (particularly ERIN) and industry groups are aware of any upcoming data sets;

- we will continue to use AURIN capabilities as necessary to support visualisation of CAUL data on the website; and

- we will make direct links between researchers, data repositories and discovery services such as the Australian National Data Service (ANDS).

To ensure the availability of data sets produced through CAUL's research we:

- use internal publication templates to refer to new data sets. These serve to inform stakeholders (the Department in particular, but also relevant industry or community groups interested in the data) and other parts of CAUL.

- include a section on upcoming data sets as part of regular project updates submitted to the operational leadership group each month. This ensures each project will be aware of new data sets produced from all other projects.

Finally, there has been ongoing discussion between CAUL staff and curators of several state repositories of data, in particular the Victorian EPA and OEH in New South Wales. The status and strategies of such repositories is different in each state but we will use the map of CAUL data sets mentioned previously to alert state agencies of potential CAUL data and discuss how they might use it.

MONITORING & EVALUATION

Monitoring & Evaluation Plan

The Monitoring & Evaluation Plan (M&E Plan) provides the framework through which the progress and success of the Hub is measured. It enables clear performance assessment via a common set of high level indicators used across the program, along with qualitative, narrative based reporting of project progress and impact.

Key Performance Indicators for each NESP Hub are aligned to a number of key themes:

Research Prioritisation	working together to identify research priorities	Measuring Impact	proving that research is informing decisions.
Research Delivery	delivering research projects in line with the Research Plan	Indigenous Engagement	meaningful engagement and collaboration with Indigenous groups
Knowledge Brokering & Communication	Providing research output to those who need it.	Hub Administration	the administrative and financial governance of the Hub

Two important elements of the Monitoring and Evaluation Plan are annual project reporting and the two program evaluations.

Project and Financial Reporting

Under the terms of the NESP funding agreement, the following reports are required to be submitted to demonstrate Hub performance and project progress:

- **Annual Progress Report**: to be submitted in April of each year and describes, in quantitative and qualitative terms, the progress of work against the Research Plan.

- **Financial Information and Audit**: submitted with the Annual Progress Report to show amongst other matters the budget and actual income and expenditure of the Hub, and in summary the Other cash contributions and in-kind support.

- **A Final Report**: submitted at the conclusion of all Hub activity.

Evaluations

Two evaluations were scheduled as part of the program. The mid-term evaluation used data from Research Plans, Annual Progress Reports, surveys, interviews and focus groups and was completed in 2018. It made some suggestions for improvement, but demonstrated that the program is on track to meet its outcomes. A final evaluation is scheduled for the program conclusion.

Performance Measures

The single key performance indicator for the NESP in the Department of Environment and Energy's Annual Report is quantitative assessments that measure whether projects have at least one research user who is reporting that research outputs are being used for decision-making.

COLLABORATION AND PARTNERSHIPS

The CAUL Hub is comprised of well-connected researchers across four institutions and many disciplines. The CAUL Hub encourages a collaborative, multi-disciplinary approach to our research agenda. Key to the success of the Hub is the capacity to foster partnerships across projects, universities and with a wide range of relevant research stakeholders and end-users relevant to environmental research in and for cities.

As an example, there are shared institutional and researcher-level links with the Earth System and Climate Change Hub (UoM and Rayner) and the Threatened Species Recovery Hub (UoM/Parris, UWA/Hobbs, RMIT/Bekessy). The AIRBOX LIEF grant is comprised of 9 partners including UOW and UoM in an integrated measurement facility for air quality.

In our projects focused on air quality, the CAUL Hub works with the Office of Environment and Heritage NSW, EPA NSW, CSIRO Oceans and Atmosphere Flagship and Bureau of Meteorology and ANTSO.

To realise a National Framework for Urban Greening we're actively collaborating with CSIRO Land and Water Flagship, CSIRO Data 61, OEH NSW, 202020 Vision, DEWLP (VIC), Resilient Melbourne, Macquarie University, the National Green Infrastructure Network, AILA and a range of state, territory and city government and private sector partners.

The CAUL Hub's Indigenous Engagement and Participation Strategy, guided by the Indigenous Advisory Group, is another aspect of the Hub involving substantial collaboration within and

outside the CAUL Hub. The CAUL Hub has established partnerships with RMIT, Indigenous Architecture and Design Victoria, ARUP, the City of Melbourne, CSIRO, Kalinya Communications, Greenshoots Consulting, Garawana, and other NESP Hubs to deliver unique and powerful knowledge-translation opportunities of our IEPS activities.

The multi-disciplinary nature of the Hub calls for a wide spectrum of communications and knowledge transfer activities to be harnessed, including social and traditional media, industry publications and research journals, and face-to-face communications through innovative events and workshops.

As an example, The Living Pavilion is a major knoweldge, enagagement and research activity started in 2018 for delivery in 2019, showcasing CAUL's collaboration with a range of research, industry and First-Nations partners. The Living Pavilion is a collaboration between the CAUL Hub, the Thrive Research Hub (Melbourne School of Design), the New Student Precinct at the University of Melbourne, the Australian Institute of Landscape Architects, Ecodynamics & CLIMARTE. The Living Pavilion will combine horticulture, sustainable design and community engagement to transform an urban space into an accessible, equitable and thriving ecological and social gathering place. Installed at the University of Melbourne, The Living Pavilion will be a platform for celebrating the site's local flora and fauna, as well as hosting events and performances by local Indigenous and non-Indigenous leaders, artists and scientists. The Living Pavilion is based on an award-winning global placemaking initiative by Dr Tanja Beer, 'The Living Stage', which has been successfully realised in New York, Glasgow, Cardiff, Armidale and Lorne. Part event, part garden and part growing demonstration, The Living Pavilion in Melbourne (1-17 May 2019) will take place as part of CLIMARTE's ART+CLIMATE=CHANGE 2019 festival (23 April – 19 May).

For each of our key stakeholders, research users and audiences, relevant communication intentions and approaches have been identified.Table 2 below summarises our major identified partner and collaborator groups, and associated activites aligned for Research Plan 5. Table 3 details some of the specific stakeholder groups that we will be working with in 2019, noting that this isn't exhaustive.

Table 2 Knowledge Brokering and Communications Approach for Key Stakeholder Groups				
	Partners/Investors	**Hub Researchers**	**Research Users**	**Public Audiences**
Intentions	Ensure communications align with short and long-term goals of each project.	Assist with internal communications and provide research opportunities for continuous development of researchers' skills and outputs.	Shape knowledge transfer practices to provide input into research protocols and an enhanced ability to use the research outputs.	Provide new ways of understanding urban environments and an enhanced capacity to improve these environments.
Type	External	Internal	External	Public Outreach
Approach	Produce 3 Urban Beat newsletters in 2019, including one Indigenous issue during NAIDOC week. Produce policy and practitioner synthesis reports to present research outputs, focused on reserach-user needs. Hold diverse forums for relevant researchers, policy-makers, industry, private sector, NGOs and citizens ; aligned to Research Plan milestones.	Regular leadership group meetings. Annual conference for all CAUL Hub members/staff in an innovative unconference and virtual format. Workshops for CAUL researchers with our Indigenous Advisory Group to increase Indigenous perspectives within the research program. Professional development of knoweldge transfer, brokering and communications for ECRs. Project Groups to monitor individual knowledge brokering and communications activities.	Personal contact and workshops to allow iterative, user-focused refinement of research projects. Produce synthesis reports in a range of knowledge formats to ensure research outputs are focused on research-user needs. Hold diverse-format forums for relevant researchers, policy-makers, industry, private sector, NGOs and citizens ; aligned to Research Plan milestones Update The Chirp Continue to generate original content for Twitter, Facebook and Website.s Host workshops on Sustainable Development Goals – Nature Based Solutions, and Indigenous Cultural Frameworks	Online tools, mapping/visualisations to foster long-term public engagement. Update The Chirp with any project developments. Communicate with local community organizations and representative bodies to promote research outcomes and recruit people for citizen science projects. Engage new audiences for science communication with art-science collaborations focused on data mapping/visualization, to gather information on how public interacts with CAUL research.

Table 3 CAUL's Key Research Partnerships, Users and Collaborators

Partnership Type / Roles	Partners	Role Alignment with Hub Project/s
Hub Partner organisation	The University of Melbourne	Host of CAUL Executive team, Hub Leader Expertise in ecology, biodiversity, threatened species, urban greening, air quality, governance and policy, Indigenous engagement and participation
	RMIT University	Hub Deputy Leader Expertise in biodiversity, urban greening, transport emissions and productivity, infrastructure, planning green space mapping, governance, liveability and policy, Indigenous perspectives of planning
	University of Western Australia	Expertise in biodiversity, green space mapping, policy, liveability, air quality, ecology, urban greening
	University of Wollongong	Expertise in air quality, productivity, infrastructure. Indigenous engagement and participation
Other NESP Hubs	TSR	Shared research activities and shared Postdoctoral Fellows (Project 5) IEPS collaboration
	ESCC	IEPS collaboration
	NAER	IEPS collaboration
	TWQ	IEPS collaboration
	MB	IEPS collaboration
Sub-contractors	Kalinya Communications	Telling CAUL's Indigenous engagement and participation stories Project 6.1
Research collaborators and research-users	DoEE	Key stakeholder and principal setter of research priorities
	Cities Unit, Department of Infrastructure, Regional Development and Cities	Key stakeholder and key driver of research priorities
	New Student Precinct, The University of Melbourne	Major partner in The Living Pavilion project
	Hort Innovation	Major partner in urban greening research
	OEH NSW	Major partner in green space mapping and policy projects
	DEWLP	Major partner in green space mapping and policy projects
	Lund University	Major partner in nature-based solutions and policy projects
	THRIVE Research Hub	Major partner in The Living Pavilion project

Partnership Type / Roles	Partners	Role Alignment with Hub Project/s
	Indigenous Advisory Group	Key advisors for Indigenous engagement strategy
	202020V	Major industry partner in green space mapping and policy projects
	City of Melbourne	Key partner in urban biodiversity and green infrastructure projects
	Indigenous Architecture and Design Victoria	Key advisors for Indigenous engagement strategy
	ARUP	Research partner in urban greening and Indigenous – led research projects
	NITV / SBS	Media partner for Indigenous engagement projects, such as The Living Pavilion
	Edith Cowan University	Research partner in Sub-project 5.4, Ecology and conservation of native wildlife in cities
	University of Tasmania	Research partner in urban greening and green space policy projects
	City of Brimbank	Research partner in Stony Creek project
	City West Water	Research partner in Stony Creek project
	Indigilab	Partner for Indigenous engagement projects, such as The Living Pavilion and Sustainable Development Goals and Cultural Frameworks project
	ACT Government	Research end-user of urban greening, biodiversity projects
	ACT Commissioner for Sustainability and the Environment	Research end-user of urban greening, biodiversity projects
	Infrastructure Australia	Research end-user of urban greening, and productivity projects
	City of Moreland	Research partner urban greening project
	Western Australia Local Government Association (WALGA)	Research partner for various urban greening and biodiversity projects
	SouthWest Aboriginal Land and Sea Council	Research partner for Noongar perspectives on city planning and urban Nature in Perth
	Several LGAs in the Perth Area (inc. Stirling, Vincent, Fremantle, Subiaco, Belmont, Bayswater	Research partners for various urban greening and biodiversity projects
	Parks Victoria	Cash and in-kind support for Sub-project 5.3 (Environmental Psychology)

Partnership Type / Roles	Partners	Role Alignment with Hub Project/s
	Friends of Westgate Park	In-kind support for Sub-project 5.3 (Pollinator observatories)
	Threatened Species Commissioner	Research end-user (subprojects 5.3, 5.4 and 5.6)
	Birds in Backyards/BirdLife (5.6)	Research end-user
	Keeping Victoria Beautiful	Research end-user
	City of Glen Eira	Research end-user
	Royal Botanic Gardens Victoria	Research end-user
	Green Fleet	Research end-user
	Melbourne Water	Research end-user
	University of Sydney	Research collaborator
	Federation University	Research collaborator
	ANU	Research collaborator
	City of Moonee Valley	Research end-user
	Mullum Mullum Indigenous Gathering Place	Research end-user
	Wurundjeri Tribe Council	Research end-user
	City of Maroondah	Research end-user
	Australian Institute of Landscape Architects	Research end-user and co-designer
	Frasers property developer	Research user
	Green Building Council of Australia	Research user
	Urban Forest Consulting	Research collaborator
	Property Council	Peak body, Research User
	Council Alliance for a Sustainable Built Environment (CASBE),	Research user, collaborator
	NATURVATION	Research collaborator, Sustainable Development Goalss and Nature Based Solutions workshop

INDIGENOUS ENGAGEMENT

The CAUL Hub is committed to meaningful Indigenous engagement and collaboration during all phases of the delivery of the NESP. Where relevant, due consideration will be given to actively involving key Indigenous stakeholders in research prioritisation, research delivery and, especially, the communication of research output. The Hub's approach to Indigenous engagement is detailed in its Indigenous Engagement Strategy.

In summary our IEPS has a Vision and Purpose:

> To increase awareness, collaboration and participation of Indigenous Australians in order to improve the development and uptake of research, business operations and knowledge and communications activities of the Clean Air and Urban Landscapes NESP Hub.

The CAUL Hub IEP Strategy forms a key element of the research planning process and our knowledge brokering and communications strategy and the opportunities for key stakeholders are detailed here:

- For *project investors*, the IEP Strategy will ensure that CAUL Hub activities are culturally appropriate, inclusive and have provided opportunities to add Indigenous Australian knowledge to the research outcomes. It will also ensure existing Indigenous Australian projects or programs such as Reconciliation Plans at our four research institutions are used as guides and added to where possible

- For *project researchers*, the IEP Strategy will assist their cultural awareness and provide opportunities for improvement in their research outputs

- For *research users*, the IEP Strategy will enhance research outputs by providing opportunities for Indigenous Australian knowledge to shape research protocols

- For *public audiences*, the IEP Strategy will provide new ways of understanding Indigenous Australian perspectives of the urban environments

- For *Indigenous Australians*, the IEP Strategy will recognise the value of Indigenous Australian perspectives, give an opportunity for these perspectives to shape our cities into the future, and will help establish long-term partnerships between Indigenous Australians and major urban stakeholders.

A major opportunity for CAUL Hub lies in its highly interdisciplinary nature. Integrating an Indigenous Australian perspective across these different disciplinary areas is a continuing focus of the IEP Strategy in 2019. We will focus on maximising participation activities that best align with CAUL Hub's strategic research plan and are achievable with available resources, specifically: identifying key Indigenous organisations and people in the cities where our research is focused, or whose expertise covers our research project areas; personal contact and workshops with Indigenous stakeholders allowing iterative refinement of research projects in a respectful and collaborative manner. To complement these activities, we will also access the expertise or existing strategies of CAUL Hub hosts and partners, and will employ Indigenous Researchers to lead Indigenous perspective research programs in Research Plan version 5; these include one program to explore research projects involving Indigenous perspectives of the built environment (Project 6) and another program exploring Indigenous perspectives of biodiversity and ecology in cities (Project 5).

To ensure expectations for the inclusion of Indigenous peoples and or knowledge are clearly defined for all research, the Indigenous Advisory Group assume that all research activities are assessed against three levels (categories) of engagement. These categories, described below, are similar to those used by other NESP Hubs.

Category One

The definition of a **Category One** project is a research project that is anticipated to be undertaken with direct collaboration with an Indigenous community, organisation, group or

individual. A Category One project will be expected to:

- Clearly identify how the research will be relevant, co-managed and of benefit to Indigenous communities and/or organisations.

- Provide opportunities for Indigenous engagement, employment or skills transfer, and the sharing of knowledge and the increase of cultural awareness amongst all parties.

- Ensure the research is conducted according to the highest ethical standards and respects Indigenous priorities and values.

- Develop a co-managed process for the generated knowledge, data and research results to be effectively shared, presented and communicated between Indigenous peoples, communities and organisations.

Category Two

The definition of a **Category Two** project, is a research project that has a field component within the project, but does not have direct collaboration with an Indigenous community, organisation, group or individual. A Category Two project will be expected to:

- Clearly identify how the research will be relevant and of benefit to Indigenous communities and/or organisations and if not why.

- Ensure the research is conducted according to the highest ethical standards and respects Indigenous priorities and values.

- Explore opportunities for Indigenous engagement, employment, skills transfer, sharing of knowledge and the increase of cultural awareness amongst all parties.

- Develop a process for the generated knowledge, data and research results to be effectively shared and communicated between Indigenous peoples, communities and organisations.

Category Three

The definition of a **Category Three** project, is a research project that is laboratory or desktop based and does not have direct collaboration with an Indigenous community, organisation, group or individual. A Category Three project will be expected to:

- Develop a process for the generated knowledge, data and research results to be effectively shared and communicated between Indigenous peoples, communities and organisations.

Under the CAUL Hub IEPS individual project leaders have responsibility for

- obtaining necessary training in cultural competency, especially where Category 1 or 2 activities are planned

- ensuring researchers follow appropriate Indigenous Engagement protocols

- maintaining relationships with Indigenous Communities through the life of the project

Figure 2 summarises the key activities completed and planned under the CAUL Hub IEPS.

Attachment A includes a summary statement for each project for assessment against the three categories upon advice by the Indigenous Advisory Group of the CAUL Hub in 2017. A summary of these assessments is given in Table 4 below.

Table 4: Summary of the CAUL Hub's Indigenous Engagement and Participation Categories

Project/ Subproject	Title	IEPS Category
3.3	Understanding the psycho-social dimensions of urban greening	1
3.8	Green space policies and governance for changing green urban landscapes	2
3.9	Managing urban green space	1-2
3.11	Species selection for the urban forest: a multi-faceted question	1-2
3.13	Indigenous Noongar perspectives in city planning and urban nature	1
4.1	Transport futures	3
4.2	Making greening happen in consolidating cities	2-3
4.3	Liveability	3
4.5	Green mapping tools and techniques: a guide	2-3
5.2	Bringing nature back into cities	1
5.3	Developing an integrated urban citizen science program	1-2
5.4	Ecology and conservation of native wildlife in cities	1-2
5.5	Indigenous-led research on biodiversity in the city	1
5.6	Australian cities as targets for threatened species conservation	2
6.1	Towards an Indigenous-led research agenda	1
6.2	From footpaths to ecosystems: understanding the role of the verge in delivering urban ecosystem services	2
6.3	Social and biodiversity benefits of the Upper Stony Creek Transformation Project	2
6.4	Biodiversity benefits of specific site-based greening actions	2
7.1	Emission sources and air quality	2
7.3	Indoor air quality	2
7.4	Ambient air quality, noise and health	2

Figure 2: CAUL Hub IEPS Key Activities
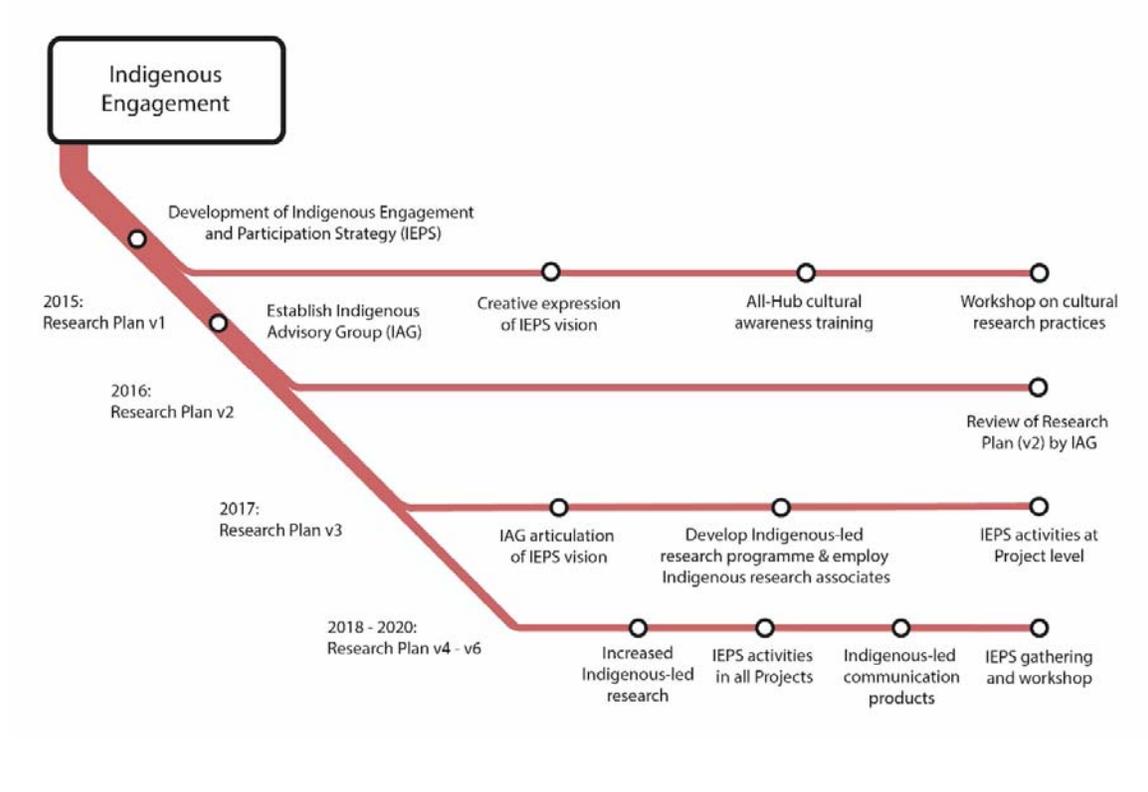
ATTACHMENT B – CLEAN AIR AND URBAN LANDSCAPES HUB PROJECT PLANS

Project 3 – Urban greening for liveability and biodiversity

Project length: 5 Years
Project start date: 1/1/2016
Project end date: 31/12/2020
Project current status: Project extension submitted for approval
Project Leader: Dr Cristina Ramalho (FTE – 20%)
Deputy Project Leader Dr Judy Bush (FTE – 20%)
Lead research organisations: The University of Western Australia, The University of Melbourne
Project leader contact details:

- cristina.ramalho@uwa.edu.au (08) 6488 4565, 0416 786 644
- judy.bush@unimelb.edu.au 0477 879 738

PROJECT DESCRIPTION

Project Summary

Green cities are healthier and more pleasant places to live, for people and other species. We know that rapid environmental change (e.g. urban heat and climate change) and social change (e.g. densification, cultural diversification) are occurring. We also know that the strong intersection of social and ecological issues in urban environments, and the consequent emergence of novel challenges and opportunities, demands thoughtful approaches to planning and management. This project will develop knowledge and guidelines to help govern, manage, monitor and evaluate Australia's urban green and blue spaces in a landscape of change.

Project Description

Two major lessons from the first years of research conducted through CAUL's Urban Greening for Liveability and Biodiversity Project have been:

1. There are challenges in managing trade-offs between the multiple benefits (e.g. health and wellbeing, biodiversity, ecosystem services) of urban greening; and
2. Governance and management of urban greening is happening in a rapidly changing social and ecological environment (e.g. climate change, densification), and therefore historic knowledge is likely to be less useful in guiding future activities.

Further research is needed to help green-blue space planners and managers create and maintain multi-functional green-blue spaces that continue to provide multiple benefits in future environments, for different people. In 2019, the project will address this problem through five sub-projects:

Sub-project 3.3 – Psycho-social dimensions of urban greening (Extension)

Little is known about how effectively new kinds of urban green space support psycho-social benefits. In addition, very few studies have considered how specific characteristics of urban greening – particularly plant types, plants traits and vegetation complexity influence these benefits. Green roofs have the potential for psycho-social benefits across a range of novel contexts. For example, green roofs could provide benefits for city employees during work, through glances outside the window or nearby lunchtime visits. They could help boost workplace outcomes such as positive work behaviours, concentration, and performance. Furthermore, green roofs also have the potential to influence great numbers of people living and working in dense cities.

Project 3 – Urban greening for liveability and biodiversity

We have obtained significant funding from Hort Innovation to study the psycho-social dimensions of green roofs using a new demonstration green roof to be built by the City of Melbourne in 2019. This research will be conducted over 2019 and 2020. A key priority for this project is to improve understanding of how green roofs may influence psycho-social and health outcomes for city employees and to understand how this relates to aesthetic preferences for green roof plant characteristics. Understanding benefits in this context, as well as links between plant/landscape characteristics and benefits, will build capacity in urban green space planning, design, management, and maintenance.

This research will be entirely funded by an external grant awarded by Hort Innovation that will support a Postdoctoral Fellow working on the project (noting that this funding is in addition to the funding set out in the budget table above, and that outputs and milestones for this subproject are currently being developed in conjunction with Hort Innovation).

Sub-project 3.8 – Green-space governance in a changing urban landscape (Extension)

Urban green-blue spaces (incorporating terrestrial and wetland landscapes) in public parks and streetscapes and private gardens provides multiple benefits for city dwellers. Recognition of this multi-functionality is bringing opportunities for inclusion of green-blue spaces across policy domains, but also presents challenges for largely monofunctional governance, management and budgetary systems. Green-blue spaces are governed by a complex set of institutions including Local Government Areas (LGAs), government agencies, non-government organisations (NGOs), nursery growers, landscape architects, and community groups including local people and traditional owners. These challenges are potentially amplified by the impacts of climate change and urban densification. This project will develop guidelines, tools and frameworks for multifunctional governance and participatory approaches that link policy domains, facilitate green-blue space management and evidence-based policy processes. A key knowledge gap identified by end-users that will be addressed in this research is the need for mechanisms to improve public participation and inclusion in green-blue space decision-making processes.

Sub-project 3.9 – Informing management of changing urban green spaces (Extension)

Expected changes to urban green-blue spaces driven by climate, demographic change and urban densification have enormous implications for urban land managers and our cities. There is currently little guidance to inform management of green-blue spaces (e.g. plant selection, site amelioration, water quantity and quality management) in a changing environment to maintain and enhance the multifunctional benefits they provide. This project will further knowledge of the likely changes to species, resources and conditions facing urban green-blue space managers, initially through a horizon-scanning exercise involving end-users and researchers from CAUL and other institutions. This exercise will canvass a range of issues including changing climate, urban densification, demographic change, water, wetland and waterways issues, biodiversity and human health and wellbeing. This project will also extend the work done in RPv3 (on species climate change risks and function-attributes) by identifying the green-blue space benefits at risk from increasing temperatures, and identify new species potentially suitable for future climates and harsh urban environments that could maintain or enhance these benefits. These outcomes will build capacity in urban green-blue space management and inform future management of urban green-blue spaces across Australia.

Sub-project 3.11 – Biodiversity and human-Nature considerations in urban forest management **(Extension)** (previously *Species selection for the urban forest – biodiversity considerations*)

Worldwide, the urban forest is increasingly recognized as a tool to mitigate the impacts of the urban heat island (UHI) and climate change. In Australia, most capital cities and respective LGAs are in the process of implementing their urban forest plans. However, there is a recognized lack of a scientific-driven framework that provides a solid foundation to interventions within and across different cities. While sub-project 3.9 focuses on species suitability for the urban forest from the perspective of their vulnerability to future climates, sub-project 3.11 explores biodiversity and human-Nature considerations that should be taken into account in urban forest management. In particular, this sub-project will focus on the Perth and Peel Metropolitan Regions, which are located on the southwest Australia global biodiversity hotspot. This region has a Mediterranean drying climate with increasing fire risk, some of the highest rates of insect and bird plant pollination in the world, ground-water dependent ecosystems, and two iconic endangered black cockatoos that use urban trees as important food resources. This research project will synthesize existing knowledge on urban forestry in areas of significant biodiversity conservation concern, and develop a framework to guide urban forest interventions in these areas to better consider biodiversity, while still considering fire risk, human health and wellbeing and ecosystem service provision.

Sub-project 3.13 – Indigenous Noongar perspectives in city planning and urban Nature **(New)** (collaboration between all CAUL projects)

This new sub-project draws from an ongoing conversation that was recently facilitated by CAUL and the Northern Australia Environmental Resources Hub in Perth on the 25th July 2018, and that brought Indigenous Noongar and non-Indigenous people working in Perth-based cultural projects to discuss what could be done that was useful from a Noongar perspective in the space of city planning and urban Nature. A clear collaboration pathway emerged from this meeting, and since then a project has been drafted, and its scope and key ideas are being finalized. This sub-project aims to collate place-based Noongar perspectives on city planning and urban Nature in Perth in a format that is recognized among urban planners and environmental managers. The sub-project proposes to employ an Indigenous researcher that will work towards the collation of information, facilitate the organization of a workshop (involving Noongar people and strategic planners from State and Local Government), and be involved in the production of a report. This sub-project will seek to fund an Indigenous researcher on 0.8 FTE for 2 years and is currently seeking co-funding opportunities to cover half of the salary and operational costs. This project is a collaboration between P3, P4, P5, P6 and P7. The delivery of this project will depend on the success of getting most of the funding required within the next few months, and on the identification of a suitable person for the position.

Cross-CAUL collaborations

Collaboration across multiple projects in the CAUL Hub has been identified as an important element to bring to the RPv5, as the hub works towards consolidation of its research and impact. Several opportunities for cross-project collaboration have been identified in the description of each sub-project and proposed extensions above. As a summary, they are the following:

- Review planned under RPv4 on the relevance of urban forests for biodiversity conservation – P3/P5 collaboration;
- New sub-project on Indigenous Noongar perspectives in city planning and urban nature – P3/P4/P5/P6/P7 collaboration.

How will research inform decision-making and on-ground action?

As with previous research plans, research in RPv5 for Project 3 will be conducted in close collaboration with end-users such as state and local governments and non-government organisations. Separate outputs will target end-user and academic outcomes. Strategies such as targeted, co-branded reports with particular land managers, public events to engage the broader urban greening industry, and workshops involving academic and industry partners, will continue to be used to effectively communicate findings to decision-makers and policy-makers.

Summary of changes since previous Research Plan

Sub-project 3.3 has been rolled over again to RPv5 and is now externally funded. The four new sub-projects proposed in RPv4 (3.8, 3.9, 3.10, and 3.11) were planned for two years, 2018/2019, and therefore will continue in RPv5. A new extension to 3.8 is being proposed in RPv5 for 2020 in view of consolidation of the CAUL research. The delivery of this extension will depend however on funding availability in early 2020. One new sub-project has been suggested in RPv5 (3.13) and this has been planned for 2019/2020, dependant of funding.

Inclusions (in scope)

A targeted communication strategy will be needed for many Indigenous groups, and will be developed as part of the CAUL Hub's overarching Indigenous Engagement and Participation strategy. Appropriate Indigenous representation will be actively sought to ensure involvement in workshops, research design, planning and implementation

Exclusions (out of scope)

The project team will be confined to research activities rather than actual implementation of the on-ground urban greening experimental interventions, which will be done by our partner organisations**.**

NESP 2017 Research Priority Alignment

Project 3 directly addresses the 2017 Research Priorities for the CAUL NESP hub by assessing the effectiveness of management and developing frameworks around the multifunctional benefits of urban greening (Priority 10, sub-projects 3.3, 3.8, 3.9, 3.10 & 3.11), exploring the cost effectiveness of urban greening interventions through a monitoring and evaluation and species selection frameworks (Priority 11, sub-projects 3.9, 3.10 & 3.11) and managing the impacts of climate change in urban areas (Priority 12, sub-project 3.8, 3.9 & 3.11). Projects design and implementation will consider the NESP cross-cutting themes of climate risks, social and economic value, the targeting of high conservation areas, and integration with other NESP hubs.

PATHWAY TO IMPACT

Outcomes

For practice:

- Strengthen and facilitate green-blue space governance and contribute to adaptation to future landscape and urban change (3.8);
- Increase the sustainability of future green-blue space plantings through the use of more suitable plant species (3.9);
- Improved management of multifunctional green-blue space benefits (3.9, 3.11);
- Increased public participation and inclusion in green-blue space governance (3.8);
- Improved ability for land managers to justify investment in green space interventions, to plan green space interventions, and to monitor the multiple outcomes of these green space interventions (3.10);
- Increased land manager awareness of biodiversity and human-Nature connection considerations that can guide urban forest management (3.11);
- Increased understanding of Indigenous Noongar values and perspectives that should be considered in urban planning and urban greening in the Perth Area (3.13);

For capacity building in the sector:

- Improved capacity of land managers to effectively govern and manage green-blue spaces in a changing environment (3.8, 3.9, 3.10, 3.11);
- Improved collaboration between research and practice (all sub-projects);

For research:

- Furthering global scientific knowledge on the governance and management of multifunctional green space in a changing environment and at different scales (3.8 & 3.9);
- Improved understanding of the challenges facing urban green-blue spaces in a changing environment (3.9);
- Synthesis of knowledge on public participation and inclusion in green space governance (3.10);
- Better understanding of the importance of the urban forest for biodiversity conservation and human-Nature connection (3.11)
- Synthesizing Indigenous Noongar perspectives on urban planning and urban greening (3.13)

Research-user	Engagement and communication	Impact on management action	Outputs
Council officers at Melbourne, Moreland, Hume and others, State and Federal Government officers, NRM and wetlands management, NGO, Agency, industry and community reps	Workshops, action research, meetings and emails	Influence on urban green space governance arrangements	Guidelines for green space governance, including tools for public participation, will be developed (3.8). These will be made publicly available through the CAUL website
David Callow & Kelly Hertzog, City of Melbourne (and other LGA/ agency reps)	Regular meetings, emails, workshops and a public report	Influence urban tree selection	Urban forest tree species suitable for future climates data (3.9). Data will be made publicly available on the CAUL website

Project 3 – Urban greening for liveability and biodiversity

Research-user	Engagement and communication	Impact on management action	Outputs
Various researchers and industry representatives in Melbourne, Canberra, Perth and Europe (Scandinavia)	Horizon scanning workshops in different capital cities	Influence policy and management to better incorporate future challenges for green space management	Organization of horizon scanning workshops on future urban forests in different capital cities, and Lund Sweden and a public report on future risks and opportunities for green space in Australia with a comparison to Europe (3.9) will be made available on the CAUL website
Nicole Mitchell, WALGA; Geoff Barrett, DBCA; several LGAs in the Perth Area (inc. Stirling, Vincent, Fremantle, Subiaco, Belmont, Bayswater)	Meetings, workshops and emails	Inform green space interventions to improve outcomes for biodiversity	Public report introducing the framework (3.11) will be made available on the CAUL website
Perth Local Governments, WALGA, SouthWest Aboriginal Land and Sea Council	Workshops, meetings, emails and individual consultations	The research will be used by the Noongar community in their pursuit for better consideration of cultural values in urban planning. It also has the potential to be used by local, state and federal government	Report on Noongar perspectives on city planning and urban Nature in Perth

Additional outputs

For research:

- Peer reviewed journal articles that contribute to global scientific knowledge on urban greening. Preprint versions of these papers will be made available on the CAUL website.
- Scientific conference presentations that foster networking and knowledge sharing in the scientific community
- Case studies and models that can be shared with international parties at (for example) Ramsar and Convention on Biological Diversity CoPs.

<u>Indigenous Consultation and Engagement</u>

Four main directions for Indigenous engagement are being planned for RPv5:

- A new sub-project (3.13) focusing on Noongar perspectives on urban planning is being proposed. As mentioned before, this project is dependent on funding availability at UWA to cover salary expenses and also on us finding a suitable person for the position;

- In the scope of sub-project 3.8, recruitment for an Indigenous research assistant to support the organization and running of a workshop and focus groups, has been arranged through the Murrup Barak, the University of Melbourne's Institute for Indigenous Development. This way, applications for the research assistant role are being sought from Indigenous students, to provide employment opportunities and support skills development in urban research;

- Sub-project 3.11 was renamed (and re-framed) so that it could reflect a slight change of focus – from biodiversity only to biodiversity and human-Nature connection considerations (of urban forest management). This shift of focus will more easily allow us to explore aspects related with Indigenous perspectives on urban forests and urban greening;

- We will also be seeking opportunities to collaborate with Indigenous Australians in the workshops, focus groups and interviews as part of 3.8, 3.9, and 3.11.

DATA MANAGEMENT AND ACCESSIBILITY

Project output	Data Management and Accessibility
Report from sub-projects 3.8, 3.9, 3.10, 3.11	CAUL website, submitted via research product form to DoEE
Data from sub-project 3.9	CAUL website, submitted via research product form to DoEE
Academic articles from sub-projects 3.8, 3.9, 3.10, 3.11	CAUL website, submitted via research product form to DoEE, and electronic journals
Outputs from project 3.13, including report	To be determined, given the cultural sensitivities of the project; some form of output will be released on the CAUL website

LOCATION OF RESEARCH

Research outputs are designed to impact planning and management of urban green space in capital and regional cities in all states and territories, with a particular focus on end-user partners in Melbourne and Perth. Research will occur at case study sites across Melbourne (3.8, 3.9 extension) and Perth (3.11, 3.13) and continue at shared study sites at Stony Creek in Sunshine, Melbourne, and in the Melbourne CBD (3.8, collaboration with Project 6).

PROJECT KEYWORDS

Urban Greening, Urban forest, Climate Change, Co-benefits, Ecosystem Services

Project 4 – Urban Systems for Liveability

Project length – 4 Years

Project start date: - 01/01/2016

Project end date: - 31/12/2020

Project current status: Project extension submitted for approval

Project Leader: Marco Amati (FTE – 20%)

Lead research organisation: RMIT

Project leader contact details: <u>marco.amati@rmit.edu.au</u> *ph. 03 9925 9887*

PROJECT DESCRIPTION

<u>*Project Summary*</u>

There is a need to study the links and intersections between factors that influence the liveability and sustainability of urban environments such as land-use, air pollution, transport and urban heat. This project investigates how urban systems interact to define how residents experience major Australian cities, and works to create policy environments that improve these outcomes.

Based on three years of work that has assessed the feasibility of data collection and uses for benchmarking the national performance of cities, the project team will now seek to consolidate these achievements by producing a synthetic set of findings and recommendations concerning the way that urban systems interact to produce liveability. We will take the opportunity to further impact the policy environments at the Federal, State and Local levels by transferring the knowledge generated in 4.1, 4.2 and 4.3 to stakeholders. This project will also work towards the long-term goal of integrating Indigenous knowledge into strategic planning in cities.

Sub-project 4.1– Consolidating liveability indices and transport futures (Extension)

Project length – 12 months

Project start date – 1 January 2019

Project end date – 31 December 2019

Research

The introduction of more low-emission vehicles would make a significant contribution to Australia's legislated target of net zero greenhouse gas emissions. In addition to strategies to improve the fuel efficiency of existing vehicle fleet, increasing the uptake of electric vehicles (EV) can accelerate this change. The lack of a strong national policy framework in Australia has led to limited overall support and incentives and, in turn, a comparatively low EV uptake compared to other countries (ClimateWorks 2016). This project will explore current patterns of EV adaptation and infrastructure in Australian cities, and investigate possible policy interventions that can accelerate future EV uptake. To achieve this goal, the project will involve six inter-connected working stages.

This project has been developed in collaboration with the Department of Environment's Future Fuels and Climate Change sections, coordinated by the NESP secretariat. The discussion has involved multiple rounds of email communication plus a series of teleconferences and in-person meetings in Canberra and Melbourne. The final project description was agreed with the Department.

The ongoing and extension project activities are:

Activity 4.1.6: Exploring overall costs and benefits of commuting

Transition in motor vehicle fuel and technology

Tasks: This project will explore and project scenarios of cost benefit of future social and spatial distribution regarding Vehicle Fleet Emission (VFE) and alternative energy in the private vehicle fleet. In particular the project will seek to estimate the likely uptake of electric vehicles and further calculate the implications for charging points and the energy grid.* Following advice from the Indigenous Advisory Group, we will seek to understand how these scenarios may impact on Indigenous communities, with respect to the cost of commuting and the health impacts from diffuse air-pollution sources. These potential scenarios will feed into other areas of CAUL. In the context of examining the links between urban social structure and energy patterns of the fleet, the following types of factors will be examined:

- The capacity of the households that are most reliant on motor vehicles for transport to buy vehicles with improved fuel technology.

- The social differences in household exposure to transport-energy costs and the adaptability of households in the use of modes and vehicle types

- The implications for productivity in cities of different transport mix scenarios*

*NB: These more detailed aspects of sub-project 4.1 are dependent on the outcome of funding for an ARC Discovery grant and/or an AHURI grant.

The new project activities are:

Activity 4.1.7: Future electric vehicle (EV) uptake and policy interventions

Stage 1: **Understanding current social and spatial patterns of EV uptake in Australian cities**
- Establish relationships between EV uptake and social spatial factors.
- Inter alia: Spatial analysis of motor vehicle registration data (AURIN) and the latest vehicle use survey (ABS) for each city; analyse the characteristics of areas (postcode or suburb) with high/low uptake of EVs

Stage 2: Tracking changes in EV uptake and identify enablers and barriers
The work will investigate the scale and speed of uptake of EVs within Australia's urban vehicle fleets, through a longitudinal analysis of motor vehicle registration datasets over multiple years. This will require the compilation of new motor vehicle registration data for 2019 that will be joined to our existing dataset for 2014.

Stage 3: **Spatial forecast of future EV uptake**
Drawing on the outputs from stage 1 and stage 2, the future EV uptake on urban areas will be assessed using a Multi Criteria Analysis (MCA) model combined with a discrete choice model. The novel part of our model against previous works (e.g. CSIRO) is it incorporates a more explicit transport analysis and modelling that link the household vehicle type with vehicle trips, e.g. whether people driving on short distance and frequently at a low speed tend to own an EV. An agent-base simulation model (available at RMIT CUR lab) can be potentially used to offer further insight of that issue. Essentially, the new spatial forecast will rank the probability of EV uptake in each area using multiple social, spatial, and transport factors.

Stage 4: Testing policy scenarios
This stage will test the government policy scenarios and their effects on EV uptake spatially. Our approach can combine a range of policy scenarios with household travel data (VKT) to assess whether a stronger policy that offers more than current trend (e.g. market-led) in EV uptake in the existing vehicle fleets would generate greater benefits. The analysis will strengthen our

understanding of the value of EV uptake, and economic benefits of implementing stronger EV strategies in Australian cities. It will consider a range of government initiatives from different agencies to promote the uptake of EVs and their adaptability for households, including:

- Infrastructure planning and investments including improved public charging systems to support EV travel.
- Land use planning to offer areas for developments with car parks with charging points
- A higher fuel tax program to help make EV more economically competitive
- Improved financial incentives to increase household capacity to shift to EV – especially for those on low income but drive more.
- Industrial policy to help produce more affordable EV models.
- Strategies to better integrate EV infrastructure with existing energy infrastructure.

Stage 5: Planning charging infrastructure for future EV uptake

This stage will investigate how future EV uptake informs charging infrastructure development in Australian cities.

- Spatially overlay the future uptake of EV assessment with journey to work (JTW) routes and transport routes for other activities.
- Identify popular road links have high volume of EVs (both directions) which are originated from the areas with high levels of EV uptake.
- Identify the best possible locations for charging infrastructure deployment based on the density of activities, travel routes, vehicle volumes, and travel distance thresholds.

Stage 6: Implications of future EV uptake for national electricity infrastructure

This stage will link the estimated EV charging infrastructure (stage 5) with the existing national electricity infrastructure distribution in Australia to identify potential spatial mismatches and suggest locations for future electricity network investment to achieve better EV and energy infrastructure synergies. This will be done by a spatial analysis of estimated charging infrastructure hotspots with electricity infrastructure distribution in Australian cities.

Sub-project 4.2– Making greening happen in consolidating cities **(Extension)**

Project length – 12 months

Project start date – 1 January 2019

Project end date – 31 December 2019

Activity 4.2.2 Embedding urban green space monitoring, analysis and communication in state and local government

Through relationships developed with the WA, Victorian and NSW State governments, this project is well placed to enter a phase of consolidation and synthetic recommendations. Overall, 4.2 represents a working model of how cities' greening performance can be benchmarked against one another as a contribution to City Deals. It presents the methods to interrogate greening against land-use development; and results of interrogation to understand the impact of urban development on greening and to inform strategic urban planning and policy reform to better balance urban consolidation and urban greening objectives.

The next phase of this work involves in-depth analysis of the relationships between vegetation, urban heat and urban development across multiple case study cities; building on the methodological development of earlier research within project 4.

Indigenous Masters by Research student: An important part of the process of embedding urban green-space knowledge at different levels of government is to identify some of the areas in which local government can work more effectively with Indigenous communities. A particular challenge is

to position small, localised stories within a large national benchmarking framework. The alternative – benchmarking performance nationally – runs the risk of homogenising our understanding of Indigenous Australians. This project will explore ways to adopt a protocol approach instead of a benchmarking approach.

Recognising the potential cultural burden for the student involved, we will ensure there are strong links between this team and the research team for Project 3.13 (Noongar perspectives on city planning and urban nature) which will include an Indigenous Research Fellow or Knowledge Broker. Consequently, the Masters student will sit at UWA but will be supervised by a joint RMIT-UWA team. This will involve considerable brokering and engagement. This work will deliver results and reflections for Activity 4.2, 4.3 and 4.5.

Activity 4.2.5: Turn down the heat I - understanding how information about heat can affect movement in Australia's metropolitan areas

Interest in heat in cities remains politically salient yet understanding the lived reality of movement, heat and its costs is an under-explored area. This part of the project will build on the capacity gained in the team around heat through RPv3-4. In collaboration with the City of Greater Bendigo (CoGB), funded by the Federal Government's Smart Cities and Suburbs scheme, the team have developed an index of accessibility according to heat. The team will develop an App that records as a diary sensation of heat while moving around the city. While this will be developed and tested for the CoGB in the first instance, the opportunity exists to extend out to other areas and cities where the team already have well-established networks and data assets (Perth, Melbourne, Sydney). The adoption of a digital ethnographic approach to ground-truth remotely sensed information allows the project to interact more sincerely with the lived reality of Indigenous and non-Indigenous community members.

A key finding from project 3.1 and work already underway for project 4.2.6 has been the relationship between heat and the different land covers in Australian cities. A significant amount of feedback has been received on this work from CAUL's interaction with 202020 Vision. Consequently, the aim of this research is to build on that interaction and pilot work that tests transdisciplinary links between urban green mapping, climate resilience and the shaping of the future forest (4.2 and 3.2).

Activity 4.2.6: Turn down the heat II – predicting the impact of vegetation loss on urban temperatures

This part of the project will build on the capacity gained by the team around understanding the policy drivers and built environment predictors of vegetation cover on private and public land in residential neighbourhoods. Using Perth as a case study, predictors of residential vegetation cover have been established as well as the relationship between vegetation structure and land surface temperatures (LST) using high resolution vegetation information (Urban Monitor). Moving forward, the sub-project will identify the relationship between densification and vegetation loss patterns as a function of R-code changes in Perth. Once identified, vegetation-loss estimates will be coupled with LST temperature estimates to illustrate how vegetation loss will manifest as increases in LSTs at the neighbourhood level.

This sub-project will result in the following outputs:

- Publication 1 – relationship between densification (R-code change) and vegetation loss
- Publication 2 – prediction of increases in LSTs as a response to vegetation loss through densification

Sub-project 4.3– Liveability **(Extension)**

Project length – 2 years

Project start date – 01/01/2018

Project end date – 31/12/2019

Research

This project will continue to build upon previous research investigating the liveability of capital cities across Australia into regional contexts through the development of a conceptual framework of liveability in for the 21 largest cities in Australia, and additional cities in Victoria. The framework will be tested through the development of relevant regional indicators of liveability that can be used for future monitoring and reporting purposes.

Activity 4.3.5: Assess the liveability of regional cities in Victoria, using a liveability performance framework

This activity builds on the foundational work to develop a liveability performance framework that can be used to benchmark and monitor progress towards the development of healthy, liveable cities. The consultation process with regional cities, local governments, the Victorian Government and the Australian Government and key stakeholders will inform modification of existing indicators, data sourcing and the development of new indicators as required.

Indicators will be developed for Geelong, Ballarat, Bendigo, Wodonga, Shepparton, Benalla and Seymour.

Activity 4.3.6: Develop new national indicators combining access to public open space and green space

Building on the work being undertaken in sub-project 4.2, this activity will involve the construction of indicators that assess the extent to which the residents of capital and regional cities have access to green space, either as private green space (e.g. backyards) or public open space (parks, recreational areas, natures reserves).

Public open space measures will be constructed from open data sources, including OpenStreetMap. Greenness measures will be derived from vegetation data obtained through the processing of high resolution areal and satellite imagery. These measures will be combined at individual household level, to identify areas where people lack access to either public open space or private green space. An update of the National Cities Performance Framework is due in early 2019, and the indicators generated in this activity will replace the current access to green space measure.

Activity 4.3.7: Disseminate regional liveability and green-space indicators through the Urban Observatory

Indicators constructed in Activity 4.3.5 and Activity 4.3.6 will be made available through RMIT University's new Urban Observatory prototype, whereby users can view interactive indicator maps for each of the 21 cities in the National Cities Performance Framework. This will enable policy-makers and practitioners to understand not just how cities compare, but how areas within a single city compare. Better insights will lead to better policies and better targeted interventions, improving the health and liveability for the residents of our capital and regional cities which together comprise 80% of our national population.

Sub-project 4.5 –A publication for local government on the tools and techniques to increase greening (Extension)

Project length – 2 years

Project start date – 01/01/2018

Project end date – 31/12/2019

As local governments worldwide attempt to green their urban environments to redress local temperature increases, stormwater surges and increase liveability they require a guide to successful examples of green infrastructure deployment. The range and scope of the literature on this topic is bewildering in its diversity, depth, scope and longevity. This means that both practitioners and scholars rarely obtain a helicopter view of the field, which can help in identifying and furthering innovation. The outputs for this project will cater to the needs of local government and will include a report or other publication. This pathway to impact is detailed in the Pathways to Impact Table.

This project traces how local governments develop green infrastructure strategies and points to the pathways that urban decision-makers such as planners, arborists and environmental professionals can use in developing green infrastructure.

It draws on past work in CAUL, specifically 3.1, 3.8, 3.9, 4.2 and 3.10, but also seeks to integrate the work that is being done in this area by other groups such as 202020Vision, Macquarie University and Victoria University. (Note that a section of this work, specifically about preserving urban trees on private land, is dependent on funding.) Finally, this activity seeks to involve the in-kind support of international researchers working in this area.

During 2018, many of the milestones due for this project have been delayed. They will be shifted to 2019 and included more broadly under communications and outreach, including a publication and associated activities. The team have applied for funding from Hort Innovation for support to identify tools that enable local government to protect trees on private land internationally.

NESP 2017 Research Priority Alignment

Part B NESP Research Priority Alignment provides a focus on greening and the health impact of Australian urban citizens. The above set of sub-projects directly target the area of air pollution from diffuse sources (4.1) and the various ways of mitigating this by understand where greening is taking place in cities (4.2). The health and liveability of cities is dependent on greening. 4.3 and 4.5 help contribute a rich understanding to local governments on how the liveability of cities can be maintained and lifted.

PATHWAY TO IMPACT

This section describes how the project will inform decision making and on-ground action, and the outputs that will be delivered to research-users throughout the life of the project.

Outcomes			
- Increased understanding of the impacts of a changing vehicle fleet on air pollution (4.1) - Enhanced decision-making to dictate funding at different levels of government in relation to commuting, traffic emissions, and urban greening (4.1, 4.2) - Justification for increased investment in green infrastructure, through articulation of the benefits, current state of the art and the potential opportunities for further greening (4.2 and 4.3) - Increased extent and depth of understandings about liveability in regional Australian centres (4.3) - Improved decision making and understanding of the barriers and opportunities for enhancing the ecosystem services that can be delivered through urban greening			
Research-user	**Engagement and communication**	**Impact on management action**	**Outputs**
City Deals and Engagement Branch, Cities Division, Department of Infrastructure, Regional Development and Cities, Victorian Government Department of Health, Local Governments across Victoria.	Victorian State Government and Local Governments will be partners in development and conceptualisation of regional and regional liveability	Research findings will be shared with all identified stakeholders and impact assessment will be conducted post development of the pilot indicators to understand how they have been used in local regional and rural contexts.	This research has been developed according to the specific needs of policy makers. They have sought partnership to develop these regional and rural liveability indicators. Development of liveability audit reports based on the developed conceptual frameworks will be delivered to all of the Victorian local government partners. Journal article summarising the development and application of the framework. Short policy brief or Conversation article for additional dissemination.

Project 4 – Urban Systems for Liveability

Research-user	Engagement and communication	Impact on management action	Outputs
Victorian Planning Authorities (VPA) and Department of Environment, Land, Water and Planning (DELWP) in Victoria government will be the users and stakeholders for the research activity 2	The needs of research and specific research questions/targets were identified based on the round table discussion of urban policy research meeting between RMIT research team and VPA in 2017. The finding of the research will be presented to VPA and DELWP via research workshops and briefings of research progress and findings	The results of the analysis will be used to evaluate the Victoria Government's transport plan and suburban centre development plan	Data on commuting burdens and productivity for workers by industry and occupations and transport modes Data on energy and emission costs of commuting for workers by industry and occupations and transport modes Data on productivity and transport costs of employment centres These research outputs have been agreed with VPA to assist policy making on future infrastructure investments
Local government	The research for 4.5 will be targeted to local government through reports and briefings	As part of the researcher's ongoing interest in the field the reception of these materials will be tested during the roadshows and other CAUL activities	A report, media releases and an accessible publication written with a wide audience in mind.

Additional outputs

- Continued contribution to the development of indicators included in the National Cities Performance Framework and the Australian Government's Smart Cities Plan (whole of 4)
- Journal articles to be published in high-ranking planning journals and transport journals e.g. Environment and Planning A, Land use Policy, etc. (whole of 4)
- New research collaborations with other industry partners or government agencies (whole of 4)
- New research grant submission, e.g. ARC Linkage and AHURI in 2018 (whole of 4)
- Publication to be delivered showcasing different successful approaches to urban greening (4.5)

Indigenous Consultation and Engagement

Project 4 has been reviewed to assess potential areas of research focus for Indigenous engagement and participation. Opportunities highlighted include Indigenous engagement, participation and potential Indigenous student involvement in sub-projects 4.2, 4.3 and 4.5. The different levels of government that will be involved in the next stages of project 4.2 will be consulted on their existing Indigenous strategies. 4.2 includes the recruitment of an Indigenous Master student.

DATA MANAGEMENT AND ACCESSIBILITY

Project output	Sub-project	Data Management and Accessibility
Publications	4.1, 4.2	CAUL website, submitted via research product form to DoEE
Ecological and social data		Submitted via research product form to DoEE, CAUL website, NESP portal
Reports and guidelines		CAUL website, submitted via research product form to DoEE

The CAUL Hub has a uniform approach to the management and accessibility of data and information. Subject to agreements with data providers, all data produced by the CAUL Hub will be made publicly available. The primary means by which this will happen will be through the CAUL website. All journal publications will be made publicly and freely available within 12 months either in open access journals or on accessible repositories. These repositories will be linked from the CAUL Hub website. Other outputs of the CAUL Hub will be made available on the CAUL Hub website and in publication repositories of the partner institutions.

LOCATION OF RESEARCH

Research outputs are designed to impact planning and management of liveability in Metropolitan and regional Victoria. Additional work will be conducted in Perth, Brisbane and Sydney.

PROJECT KEYWORDS

Liveability, air pollution, urban greening, Indigenous urban research theory, heat islands

Project 5 – Shared Urban Habitat

Project length: 5 years 6 months
Project start date: 01/06/2015
Project end date: 31/12/2020
Project current status: Project extension submitted for approval
Project Leader: Dr Caragh Threlfall (FTE – 10%), Deputy Leader Dr Kylie Soanes (FTE – 10%)
Lead research organisation: The University of Melbourne
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PROJECT DESCRIPTION

Project Summary

The construction and expansion of cities often leads to the loss of native species and ecological communities, to the detriment of biodiversity but also the detriment of the human urban experience. Of direct relevance to the Department of the Environment and Energy, state agencies and local government, this project is addressing the broad question of how humans can effectively share the urban habitat with other species. This includes the protection and/or restoration of important habitat elements within cities, and the conservation of threatened species, threatened ecological communities and other aspects of urban biodiversity. The project will also consider how to engage people with nature in the city more effectively, and measure the benefits that people derive from everyday encounters with urban biodiversity.

Major lessons from research conducted to date are:

- A review of existing on-ground actions for biodiversity in urban areas is needed to document the evidence base for or against prioritising particular species or actions in a variety of settings (public land, but also private land including backyards).
- There is still a disconnection between urban land managers, urban research and Indigenous Australians, and we need to make space for Indigenous-led research on biodiversity in urban environments.

Project Description

When cities are constructed, they often displace other habitats and the species that live there. However, Australian cities remain notable for their biodiversity, supporting significant remnant vegetation, threatened ecological communities and populations of many threatened species. To conserve these species and communities into the future – and urban biodiversity more generally – we need to engage all levels of government as well as the urban-dwelling citizens of Australia in identifying and implementing practical solutions to this ongoing problem. We also need to measure and properly value the benefits that urban biodiversity provides to city-dwelling humans.

This project aims to better understand the ecology of species in cities, identify opportunities and pathways for conservation action, clarify the social, cultural, ecosystem and health benefits of biodiversity in cities, improve urban residents' connection to urban nature, and raise the profile of urban nature and its conservation.

Summary of changes

All sub-projects identified in RPv4 will continue in RPv5, with new activities aimed to delivering outcomes described in previous research plans, build upon and synthesise previous work, and maximise engagement with stakeholders, Indigenous communities and the general public.

Sub-project 5.2 – Bringing nature back into cities (Extension)

This sub-project is investigating opportunities to bring species back into urban environments as a way to reverse the trend of species loss, restore ecological function and ecosystem services, and reconnect people with traditional Aboriginal knowledge. We propose the following activities/outputs for RPv5:

- Develop a protocol for a practical 'Bringing nature back into cities' program, which includes a decision-tree model to assess the suitability of animal species for targeted actions (Milestone 25), and an opinion piece (Milestone 24). Planned output completion mid-2019.

Sub-project 5.3 – Developing an integrated urban citizen science program (Extension)

This sub-project is developing an integrated program of urban citizen science projects in capital and regional cities around Australia. This includes 5.3.1 the CAUL Urban Wildlife mobile app with three modules (flying foxes, bell frogs and beneficial insects (including pollinators)), and 5.3.2 a web-based environmental psychology survey to measure benefits people gain from experiencing nature in the city. In RPv5 we propose to:

- Continue to engage stakeholders and end-users to collect data using all urban wildlife modules (flying foxes, frogs, and beneficial insects (including pollinators)) and the environmental psychology survey (Milestone 40 and 43)
- Develop a peer-reviewed report/journal article describing our integrated citizen science program and its application (Milestone 14)

Sub-project 5.4 – Ecology and conservation of native wildlife in cities (Extension)

This sub-project is investigating the ecology of and conservation strategies for native wildlife in Australian cities across three taxonomic groups – frogs, flying foxes and beneficial insects (pollinators, predators and parasitoids). In RPv5 we propose to:

- Report on the impact of the chytrid fungus on populations of motorbike frog from WA (continued from RPv3)
- Report on the drivers of influx events of grey-headed flying fox camps, with a view to predict future risks in urban locations, and manage community expectations.
- Combine the noise-exposure model for Perth, Sydney or Melbourne (to be developed in Project 7) with data on the distribution of bell frogs (motorbike frog, green and golden bell frog or growling grass frog) in that city, to undertake an initial assessment of the impacts of urban noise on their acoustic communication

Sub-project 5.5 –Indigenous-led research on biodiversity in the city (Extension)

All urban environmental practices, research and policy occurs on and in Aboriginal Country. No matter the focus, approach, personnel, timing or framing, all of these practices have an impact on the lives and futures of Aboriginal people. A key challenge, then, is for urban practitioners and researchers to respond meaningfully to the expectations, rights and aspirations of Indigenous communities in urban areas. The proposed project seeks to meet this challenge within the realm of Indigenous perspectives on biodiversity in the city. Planned activities for RPv5 include:

- Research outputs to be delivered through the delivery of The Living Pavilion April - May 2019, at the New Student Precinct University of Melbourne, include:
  - o Stories of 'place' that include both Indigenous and scientific knowledge systems
  - o Exploring Indigenous perspectives of biodiversity
  - o Examining the social and biodiversity benefits of urban greening
- Further activities to be determined by the new Research Fellow, Zena Cumpston, who commenced in October 2018

Sub-project 5.6 – Practical actions for conservation in Australian cities (Extension)

This project will identify opportunities to make conservation gains in urban areas, exploring opportunities to enhance urban biodiversity, preserve threatened species, and connect people with nature. We seek to build momentum/encourage local conservation action in urban environments, highlighting value to decision-makers. There is a clear need to develop and test novel, creative management actions for species that are tailor-made for cities and towns, and to understand better the degree to which urban environments can contribute to conservation in Australia. We propose to continue current activities, including:

- Developing an expanded inventory of actions for conserving urban biodiversity via a second larger data collection phase.

Cross-project initiatives

In 2019 we propose to strengthen collaborations across many of the CAUL projects via specific cross-project investigations, including across Projects 3-7.

NESP 2017 Research Priority Alignment

This project responds to CAUL Hub research priorities 10 and 11.

The project includes a strong focus on the conservation of threatened species, identified by the previous Threatened Species Commissioner Mr Gregory Andrews as a crosscutting theme within NESP.

PATHWAY TO IMPACT

Outcomes
The overarching outcomes for each sub-project are: ● 5.2 Bringing Nature Back - A critical framework enabling land managers to decide which species to bring back into urban environments, assess the risks and benefits involved, and explicitly consider ecological, social and cultural factors. ● 5.3 Urban Citizen Science - An integrated, national urban citizen science program (including easy-to-use apps for flying-foxes, frogs and beneficial insects), that mobilises city-dwellers to engage with biodiversity in their neighbourhood while providing key information to improve understanding, and assist the management of these urban species. ● 5.4 Practical conservation strategies to mitigate processes that are threatening the persistence of native fauna (including bell frogs, native beneficial insects), including habitat loss, habitat fragmentation, habitat isolation, disease and a loss of habitat complexity ● 5.5 Strengthened connections between university researchers and local Indigenous communities; increased awareness and application of Indigenous knowledge to the management of urban biodiversity; and a participatory arts-science event (The Living Pavilion) to foster greater understanding (amongst researchers and the general public) of Indigenous perspectives on biodiversity in the city. ● 5.6 Identification of conservation opportunities for threatened species and other biodiversity in urban environments, including a synthesis of knowledge regarding which conservation actions may be most effective, and identification of potential sites for implementing practical actions.

Research-user	Engagement and communication	Impact on management action	Outputs
State and local government, and other groups	Workshop on bringing nature back (2016), CAUL roadshows 2017,	Support for land managers to make good decisions about which	A protocol for a practical 'Bringing nature back into cities' program,

involved in managing urban biodiversity (City of Melbourne, Rodney van der Ree)	The Living Pavilion, other meetings and regular email communication	species and approaches to invest in	including a decision-tree model to assess the suitability of animal species for targeted actions (5.2)
DoEE, State and local government, and other groups including NGO's and community groups involved in managing urban biodiversity (Nationwide)	Consultation, meetings and briefings have occurred throughout the app development with end-user groups (e.g. Parks Victoria, Friends of Westgate Park, Earthwatch Institute Australia), including provision of example or prototypes for trial.	Information on the distribution, habitat use, and foraging behaviours of EPBC-listed bell-frogs and flying foxes in urban environments, which will contribute to their management and conservation.	Citizen science programs for frogs, beneficial insects and flying-foxes to engage users in the CAUL Urban Wildlife Apps (5.3)
Research-user	**Engagement and communication**	**Impact on management action**	**Outputs**
Scientific community	CAUL roadshow meetings 2015 and 2017	Inform new user groups of the apps and their application	Peer-reviewed article describing our integrated citizen science framework and its applications (5.3)
State and local government agencies, NGOs and community groups in the Perth region	Presentations to relevant stakeholders	Inform conservation managers about the impact of this disease and how it can be reduced	Written report on the impact of the chytrid fungus on populations of motorbike frog from WA (5.4)
Local government, state agencies, urban practitioners such as landscape architects, architects and urban planners	May include written materials, presentations to relevant stakeholders, social media (to be determined by the Indigenous researcher), the Living Pavilion.	Increased awareness and application of Indigenous knowledge to the design and management of biodiversity in urban landscapes	To be determined by the Indigenous researcher (5.5)
Scientific community	Presentations at conferences, social media	Establishment of a framework for Indigenous-led research on biodiversity in urban environments	To be determined by the Indigenous researcher (5.5)

Project 5 – Shared Urban Habitats

Local Governments (e.g. City of Melbourne, Rodney van der Ree; Central Coast Council, Rochelle Lawson; Joondalup Council, Lucy Sheehy; ACT Government, Richard Milner), Developers (Riverview Group, Jessica Stewart)	Workshop, meetings and regular email communication	Influence policy and management of species and consideration of which actions are appropriate in urban contexts	A publicly available report on challenges and opportunities for urban conservation action (5.6), targeted to land-managers and decision-makers.
Research-user	**Engagement and communication**	**Impact on management action**	**Outputs**
DoEE and broader NESP	Share findings with DoEE and NESP more broadly through regular updates in internal comms (e.g. email updates, NESP newsletters)	Inform NESP community about CAUL's research achievements	CHIRP/Urban Beat/Internal Comms.

Additional outputs

The Living Pavilion (April–May 2019) will offer these further outputs and outcomes:

1. Indigenous-led approach

   New knowledge, increased skills and experience in working with First Nations perspectives and protocols, stronger First Nations networks and links

2. Research

   New knowledge systems and holistic research acquired through transdisciplinary engagement, increased skills in cross-cultural research

3. Engagement

   New ways of engaging people in transdisciplinary knowledge – including First Nations perspectives, ecological science and art, increased skills in disseminating research; stronger community connections and understanding of place

4. Festival

   New ways of engaging people in transdisciplinary knowledge – including First Nations perspectives, ecological science and art, increased skills in disseminating research; stronger community connections and understanding of place

Indigenous Consultation and Engagement

The following activities are planned for RPv5:

- Funding to support and Indigenous researcher to lead work on the new sub-project 5.5 investigating Indigenous-led research in urban biodiversity (0.5 FTE for 2 years in the first instance).
- A participatory arts-science event (The Living Pavilion) that will foster greater understanding of Indigenous perspectives on biodiversity in the city.
- Collaboration with Indigenous Units of the University of Melbourne, RMIT University's Centre for Urban Research and University of Western Australia in establishing a complementary research program relating to Indigenous perspectives on the sustainability of built form in cities. This innovative project will expand Indigenous research capacity, identify knowledge gaps and establish a research agenda for the conservation and enhancement of biodiversity in cities that is co-designed and delivered by Indigenous communities.
- Research investigating the degree to which current urban conservation practices incorporate Indigenous knowledge and perspectives, through a series of interviews and surveys with urban conservation practitioners (5.6), and review of current threatened species management in urban areas (5.1).
- Funding to support an undergraduate summer Indigenous internship in partnership with The University of Sydney, for a 6-week internship focussed on Indigenous perspectives of urban biodiversity and its management.
- Written contributions will be made, including co-authorship, by Indigenous researchers into the cultural dimension of the 'Bringing nature back into cities' opinion piece and decision-making model (5.2).

DATA MANAGEMENT AND ACCESSIBILITY

The CAUL Hub has a uniform approach to the management and accessibility of data and information. Subject to agreements with data providers, and consistent with human and animal ethics approvals, all data produced by the CAUL Hub will be made publicly available via the CAUL website. All journal publications will be made publicly and freely available within 12 months either in open access journals or on accessible repositories. These repositories will be linked from the CAUL Hub website. Other outputs of the CAUL Hub will be made available on the CAUL Hub website and in publication repositories of the partner institutions.

Project output	Data Management and Accessibility
Publications and research tools *5.2 An opinion piece on bringing nature back into cities, including ecological, social and cultural considerations.* *5.2 A decision tree model to assess the ecological, social and cultural suitability of animal species for bringing nature back into cities.* *5.2 Public elicitation online platform.* *5.4 Peer-reviewed article on the insect biodiversity of different types of urban green space.*	*CAUL website, submitted via research product form to DoEE*

Project output	Data Management and Accessibility
Ecological and social data produced under all sub-projects *5.3.3 Data on plant-pollinator interactions for each green space participating in the pollinator observatories project.* *5.6 Data on actions and success stories for actions for urban biodiversity (e.g. a list of common actions, and their current success rate)*	*Submitted via research product form to DoEE, CAUL website, NESP portal*
Reports and guidelines *5.4 Summary of Linking Nature in the City project* *5.3 Summary of findings from Westgate Park pollinator observatories* *5.6 Report on opportunities and challenges for urban conservation actions (final format to be determined following stakeholder consultation)*	*CAUL website, submitted via research product form to DoEE*

LOCATION OF RESEARCH

On-ground works and data collection will be undertaken at relevant survey sites across a variety of cities including Perth, Melbourne, Wollongong and Sydney. These will be identified in collaboration with the Department of the Environment and Energy, local Indigenous groups and other key stakeholders. The scope of this project encompasses urban and peri-urban areas Australia-wide

PROJECT KEYWORDS

Urban ecology, Conservation biology, Threatened species, Citizen science, Environmental psychology

Project 6 – Social, cultural and biodiversity benefits of urban greening: An integrated network of sites

Project length: 3.5 years
Project start date: 01/07/2017
Project end date: 31/12/2020
Project current status: in progress
Project Leader:

- *Cecily Maller (FTE – 10%)*
- *Luis Mata (FTE – 10%)*
- *Natasha Pauli (FTE – 10%) (Total FTE – 30%)*

Lead research organisation: RMIT University (with University of Western Australia)
Project leaders contact details:

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PROJECT DESCRIPTION

Project Summary

The overarching aim of Project 6 is to establish an integrated network of urban greening study sites across Australian cities to understand, quantify and qualify the multiple benefits of urban greening, focussing on social, cultural and biodiversity outcomes. The project takes a multidisciplinary methodological approach, with an important output from this project being a series of standardised sampling protocols that can be adapted for use at diverse urban greening projects at a range of different sites and scales.

Project 6 will foster collaborations between CAUL Hub researchers and Indigenous story telling experts to showcase how university-based knowledge systems are coming to recognise Indigenous knowledge and authority in urban environments. This approach will provide a greater understanding of Indigenous perspectives of CAUL's research and approach to Indigenous engagement and participation (IEP), which is a critical next step in the CAUL Hub's Indigenous-led research agenda.

Project Description

Project 6 is establishing an integrated network of urban greening study sites that will become vital research infrastructure for the CAUL Hub and other institutions investigating the multiple benefits of urban greening such as CSIRO and other higher education institutions not currently linked with CAUL. Establishing an integrated network of study sites that incorporate stakeholders' urban greening projects will allow CAUL Hub (and other) researchers to understand, quantify and qualify the multiple benefits of urban greening. The project will develop sampling protocols and methods that can be implemented at varying spatial and temporal scales and then test and use these methods at different urban greening projects. A specific output of the project will be a 'handbook' of how to research the social, cultural and biodiversity benefits of urban greening and other related urban restoration projects.

Environmental research and Indigenous philosophies represent complex knowledge systems, and while both these ways of knowing have much to offer they can often seem inaccessible to the general public. Project 6 will also strive to highlight the critical role that Indigenous knowledge plays in environmental research, with a strong cross-cultural commitment to Caring for Country.

Project 6 – Social, cultural and biodiversity benefits of urban greening: An integrated network of sites

It will be important to assess social, cultural and biodiversity status prior to urban greening projects, and then track how the benefits accrue over the lifespan of the projects. It will also be important in some cases to monitor comparative green spaces, grey spaces, blue spaces and public open space that do not undergo urban green initiatives, so as to assess the impact of inter-annual variability and increased community awareness. These control sites will be closely matched for socioeconomic and environmental characteristics. The integrated network of study sites will also provide opportunities to study the process of how urban greening initiatives are implemented and how or why they are successful.

Establishing an integrated network of study sites requires strong collaborative planning with local stakeholders to understand the actors, drivers, successes and barriers of different urban greening initiatives. Importantly, they will provide an evidence base that will allow researchers to compare the social, cultural and biodiversity benefits of different urban greening initiatives according to landscape context and scale. It is intended that the work and subprojects in Project 6 will provide a unique and truly multi-disciplinary assessment of urban greening initiatives. They will further highlight the need to address competing objectives through scientific process understanding, optimisation and compromise. The research will be undertaken using a number of techniques, including:

- The development of a meta-data catalogue of urban greening study sites with relevant partner and research information to encourage collaboration across and beyond CAUL Hub projects;
- Establishment of an integrated network of study sites, including urban greening projects and control sites (where feasible) to assess the multiple benefits of urban greening; and
- Development of a series of standardised protocols to collect social, cultural and biodiversity data in a transparent and reproducible way.

Project 6 seeks to identify opportunities to consolidate CAUL research (particularly in Projects 3, 4 and 5) on the social, cultural and biodiversity benefits of urban greening initiatives in cities around Australia. Opportunities to bring relevant findings together from these projects, and disseminating their key messages, will be an ongoing activity.

Summary of changes from Research Plan version 4

All subprojects identified in the revised version of RPv4 will continue in RPv5. However sub-projects focused on the biodiversity evaluation of site based urban greening actions have been consolidated under sub-project 6.4. New activities listed include:

1. delivering outcomes described in RPv4 for 2019;
2. new activities in existing subprojects;
3. producing a science communication template to disseminate baseline data from the Integrated Network of Study Sites;
4. completing the first draft of Project 6's 'Handbook', a CAUL Hub legacy document on how to research the social, cultural and biodiversity benefits of urban greening; and
5. mapping and documenting Indigenous and local government stakeholders for all active sites.

Subproject 6.1 – Towards an Indigenous-led research agenda (Extension)

The Hub is working to position Indigenous knowledge as critical in environmental research, showing a cross-cultural commitment to Caring for Country. Environmental research and Indigenous philosophies represent complex knowledge systems. Both have much to offer broad audiences but can seem inaccessible. CAUL is collaborating with Indigenous story telling experts to expand our research on and share widely how university-based knowledge systems are coming to recognise Indigenous knowledge and authority in urban environments through projects undertaken at CAUL since 2015. This approach will provide a greater understanding of Indigenous perspectives of CAUL's research and approach to Indigenous engagement and participation (IEP), which is a critical next step in our Indigenous-led research agenda.

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CAUL's Indigenous Advisory Group will guide this project, as an extension to 2017 and 2018's Towards an Indigenous-led research agenda outlined in RPv3's Project 4. In RPv3 Professor Porter and Lauren Arabena's research considered how to rethink CAUL's research from the principles of being 'Indigenous-led'. Over 2017 they held workshops with Indigenous professionals in the built environment, Traditional Custodians and non-Indigenous university researchers on what it means to move beyond a model of 'inclusion' of Aboriginal and Torres Strait Islander people in research and teaching especially within an urban context. This knowledge translation phase will distribute the findings from this research and other IEP Category 1 and 2 projects to a wide range of stakeholders, Indigenous and non-Indigenous.

The outputs from this project will include:

- A research paper that includes a literature review and the findings from all the data that has been collected via the Indigenous led research project in RPv3
- Recommendations for communications products for researchers and practitioners to use when considering what it means to work alongside Aboriginal and Torres Strait Islander communities
- Recommendations for communications products for Aboriginal and Torres Strait Islander communities to use when thinking what it means to do work alongside urban researchers and practitioners.

New activities or outputs proposed for RPv5 include:

- CAUL communications products on Indigenous engagement, participation and led research;
- Narratives to include CAUL's '3 Category' approach to model how urban environmental researchers in Universities can work in more collaborative ways with Indigenous communities; The Living Pavilion Project, and a case study of Indigenous engagement and participation project at University of Wollongong.

Subproject 6.2 – From footpaths to ecosystems: understanding the role of the verge in delivering urban ecosystem services (Extension)

Street verges can play a key role in providing green space and ecosystem services through shading and reducing heat, allowing for water infiltration and reducing run-off, giving habitat for wildlife, providing an amenity for residents including food production and connection with nature. There is a rapidly evolving area of policy change and community interest in the way that street verges are managed and used. To date, most research on street verges has necessarily focussed on street trees. However, a street verge can also include ground covers, shrubs, and the underlying soil. Evidence-based, policy-focussed research on the role of the entire street verge in providing a variety of ecosystem services is needed, especially as vegetation loss continues on private land as a result of densification and infill.

This subproject investigates the value of the street verge system for promoting urban greening and biodiversity and increasing community cohesion, focussing on the lower vegetation and ground strata. it takes a multidisciplinary approach and will include the establishment of a network of street verges planted with native and waterwise species. Research activities will include: i) reviewing local government authorities (LGA) use and management of street verges in selected cities, and identifying exemplar case studies for in-depth analysis as shared study sites; ii) consultation with LGAs and key stakeholders regarding the role of street verges in urban greening and biodiversity; iii) soliciting and analysing community views and use patterns of street verges (including plant selection, water and nutrient use); iv) exploring geospatial and field-based methods for assessing geographic patterns in street verge patterns; and v) assessing the above-ground biodiversity and habitat values associated with exemplar street verges including the impact of spatial arrangement of habitat patches. The key outcome of the research will be to provide recommendations for management of street verges and streetscapes in Australian cities.

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The following activities are proposed for RPv5:

- Continued analysis of qualitative information and quantitative data from residents on the values and uses of street verges and associated transformation; Interviews and engagement with key stakeholders on the role of street verges and streetscapes in urban greening including representatives from government entities, non-government organisations, Indigenous community, consultants, industry, developers and key individuals.

- Completion of ecological surveys for plants, birds and insects in a range of converted street verges across the Perth region;

- Investigation into techniques for geospatial assessment of street verges, via remote-sensing and ground-truthing methods.

Subproject 6.3 – Social and biodiversity benefits of the Upper Stony Creek Transformation Project (Extension)

The long-term goal of this research project is to determine the impact of a major urban greening project (Upper Stony Creek Transformation) on residents, with a focus on human health and wellbeing, and biodiversity related outcomes associated with the revitalisation of an urban wetland and waterway. This subproject is based on a pre- and post-greening longitudinal design to measure social and biodiversity dimensions to compare baseline and medium, long and short-term outcomes.

The social science component pre-greening included a resident survey on psychological, social, physical health benefits and in-person interviews about residents' perceptions of their neighbourhood, the Creek, green spaces and biodiversity, and their health and wellbeing. Seasonal site observations were also undertaken. The survey included questions about residents' existing use of natural areas including the Creek, their level of physical activity, mental health and wellbeing (subjective well-being, levels of depression, stress and anxiety), connection with nature, and attitudes towards the local area and the environment. Recruitment and data management was designed to provide scope for recontact of participants in the future. Data was geocoded for residence, allowing analysis of benefits relative to proximity to the Upper Stony Creek Transformation Project. Twenty interviews were conducted in residents' homes whose dwellings were in closest proximity to the Creek. The interviews used a semi-structured format and included questions on residents' knowledge and use of green spaces in the local area including Upper Stony Creek, what types of activities they use these spaces for, their preferences and concerns about local plants and animals, and their health and wellbeing.

The interviews and survey formed Stage 1 (pre-greening) to provide baseline data prior to full implementation of the Upper Stony Creek Transformation project. Further stages (post-greening) are planned but dependent on the timing and completion of the initiative (due to be completed September 2019) and the availability of further partner funds to complete further research. The biodiversity component included plant-insect and plant-bird ecological interactions surveys as per Project 6.4. At present, there is no capacity to capture the cultural benefits specifically for Indigenous stakeholders. This is likely to be pursued in the future, dependent on co-funding.

We propose the following activities or outputs for RPv5:

- Maintaining an ongoing relationship with the Upper Stony Creek industry partners through discussions and workshops about future research post-greening at the site.

- Dissemination of the social science findings pre-greening from the interviews and survey.

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Subproject 6.4 – Biodiversity benefits of specific site-based greening actions (Extension)

This subproject includes a selection of identified site-based greening actions to conduct pre- and post-action biodiversity evaluation. The sites and associate activity is listed below.

1. Tunnerminnerwait and Maulboyheenner Marker. A greening action and public artwork developed by the City of Melbourne to commemorate Tunnerminnerwait and Maulboyheenner, two Tasmanian Aboriginal men who were publicly hanged in Melbourne in 1842. The key partner is Melbourne City Council. The baseline data for the Tunnerminnerwait and Maulboyheenner site was collected just before the site was transformed in April 2016. Post-greening surveys were successfully completed in 2017 and 2018. Another post-greening survey will occur in 2019

2. Westgate Park Southern Grassland. The key partner in this site is the Friends of Westgate Park, as part of broader collaboration with the City of Melbourne entitled 'Providing for pollinators in Westgate Park'. Baseline biodiversity data for the Southern Grassland site was collected before the site was transformed in the Winter of 2017. Post-greening surveys were successfully completed in 2018, and are planned to continue for 2019. While in-kind support for this subproject is provided by the CAUL Hub, the field work component of this research is being funded by the Friends of Westgate Park.

3. University Square transformation project. Baseline biodiversity data for University Square was collected as part of The Little Things that Run the City project (a component of subproject 5.4) in 2015 and again in 2018. Further post-greening surveys are unlikely due to site access limitations.

4. City of Melbourne laneways and streetscape projects. The key partner is Melbourne City Council. A total of eight small-scale sites form part of this subproject, including: Guilford Lane, Meyers Place, Coromandel Place, Katherine Place, Arden Street, Clowes Street, Park Street and Docklands Drive. Baseline biodiversity data for these eight sites was collected in 2017 prior to any transformations. Post-greening surveys were conducted in 2018, as well as further pre-greening surveys, as not all sites had been transformed by 2018 as planned. Further post-greening surveys are planned for 2019.

5. City of Melbourne 2017-18 MPavilion installation. The key partner is Melbourne City Council. Biodiversity data for the 2017-18 MPavilion site was collected in Spring of 2018. No further surveys are planned for this site, as the 2017-28 MPavilion was moved to another location in February of 2018.

6. Fraser Street transformation project. The key partner is the City of Moonee Valley. Baseline biodiversity data for the Fraser Street site was collected before the site was transformed in Autumn of 2017. Post-greening surveys were successfully completed in 2018, and are planned for 2019. While in-kind support for this subproject is provided by the CAUL Hub, the field work component of this research is being funded by the City of Moonee Valley.

7. City of Moreland greening initiatives. The key partner is the City of Moreland. There are two sites being investigated, Sheils Reserve and JP Fawkner Reserve. Baseline biodiversity surveys were conducted in Spring-Summer 2018. Post-greening surveys are planned for 2019.

Project outputs for RPv5:

- Pre- and post-greening biodiversity surveys of selected sites
- Prepare and present interim findings on site evaluations to partners where appropriate

Project 6 – Social, cultural and biodiversity benefits of urban greening: An integrated network of sites

<u>**NESP 2017 Research Priority Alignment**</u>

Project 6 directly address NESP Research Priorities 10, 11, 12 (Group B) concerned with the multiple benefits of greening activities in urban landscapes across a range of sectors and impact areas. In particular, this new project builds on work established in Research Plan 4 to better understand the different impacts of urban greening and biodiversity projects, including how different species and different groups of people respond to a range of urban greening and biodiversity projects, and how to maximise the impacts from these projects for biodiversity, human health and wellbeing, and social and cultural benefit.

PATHWAY TO IMPACT

Outcomes
- Practical actions for researchers and educators to move beyond an inclusion model of Aboriginal and Torres Strait Islander people and knowledge to Indigenous-led agendas in both research and teaching   - Better understanding of the ecological, biodiversity, social and cultural benefits of urban greening initiatives to assist in decision making for improved outcomes; with a focus on indigenous species, verges, green space and waterway rehabilitation, and deprived suburbs   - New knowledge to assist in evidence-based policy-making for enhancing the ecological, cultural and community benefits of street verges, including a typology of street verges   - Provision of recommendations for management of street verges and streetscapes in Australian cities to promote the use of native plants, including flora of importance to local Indigenous stakeholders   - Establishment of standardised approaches to measure the biodiversity, health and wellbeing impacts of urban greening initiatives that can be used to monitor and evaluate projects   - Documentation and dissemination of the Upper Stony Creek collaborative process to determine the value for the approach to be transferred to other contexts

Project 6 – Social, cultural and biodiversity benefits of urban greening: An integrated network of sites

Research-user	Engagement and communication	Impact on management action	Outputs
City of Perth and other Perth metropolitan LGAs including Stirling, Vincent, Fremantle and Subiaco, Western Australian Biodiversity Science Institute, Water Corporation	Stakeholder consultations and presentations, email conversations, meetings;	Inform the development of policies regarding street verge management and enhancement in WA; Will support action around management of street verges and future decision making at the local government level	Policy briefs on street verges policies and another on baseline patterns in street verges.
City of Melbourne, City of Moonee Valley, City of Moreland, City of Brimbank, City of Maroondah	Workshops and meetings to identify research needs and interests through prior consultation; Ongoing discussion of regarding research and outcomes via email /phone conversations, presentations and meetings; Dissemination of science communication resources representing findings by email dissemination and presentations to steering committees/project groups	Inform the design and evaluation of current and future urban green space initiatives including the Upper Stony Creek Transformation and the Greening the West initiative, Maroondah City Council's Master plan	Science communication resources (infographics, policy briefs on baseline and other findings from pre and post greening actions; Journal paper on understanding, quantifying and qualifying the social, cultural and biodiversity benefits of urban greening
Westgate Park Biodiversity	Stakeholder consultations and presentations, email conversations, meetings		
City West Water; Melbourne Water; DELWP; Places Victoria; Greenfleet	Workshops and meetings to identify research needs and interests through prior consultation; Ongoing discussion of research and outcomes via email /phone conversations, presentations and meetings; Dissemination of science communication resources representing findings by email dissemination and presentations to steering committees/project groups;		Science communication resources (infographics, policy briefs on baseline and other findings from pre and post greening actions); Journal paper on understanding, quantifying and qualifying the social, cultural and biodiversity benefits of urban greening

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CAUL Hub researchers, other Hubs, DOEE	Workshops and meetings to identify IEPS needs and actions; Working through and developing the IEPS Checklist and cultural competencies	Assist with developing an Indigenous research-led agenda for future CAUL and NESP research; Identification of more collaborative ways to work with urban Indigenous communities; Assist with future integrated transdisciplinary research on social, cultural and biodiversity benefits of urban greening.	Report drawing on lessons and knowledge from across CAUL on Indigenous narratives and story telling; Handbook of methods and protocols for conducting transdisciplinary greening research
Research-user	**Engagement and communication**	**Impact on management action**	**Outputs**

Additional outputs

- Peer-reviewed journal articles published in high ranking planning, geography and multidisciplinary environment focused journals such as Local Environment, Health and Place. For example, potential papers for 6.2 include one on street verge policies, another on public perceptions of street verges. Potential papers for 6.3 include methods papers on multidisciplinary research protocols, papers on public and resident responses to urban greening, biodiversity and waterway restoration projects, and human relationships to urban wildlife/increasing biodiversity in cities.

- Development of existing research collaborations with industry partners or government agencies and the development of new collaborations.

- Development of new funding proposals (e.g. ARC Linkage on the biodiversity and human wellbeing outcomes of urban greening and waterway restorations)

- Social media articles and other dissemination (e.g. conferences including ecological, social and urban planning conferences such as the State of Australian Cities Conference)

Indigenous Engagement and Consultation

Based on new subprojects sharing similar characteristics to 6.3, the Indigenous Engagement and Participation Strategy category for all subprojects is currently 2. Where possible, opportunities will be sought for co-designing research, co-authorship, capacity building and Indigenous employment. Mapping of Indigenous stakeholders for all active sites will be undertaken to identify key contacts and commence building relationships for current and future collaboration.

The partnership behind the Upper Stony Creek Transformation presents an opportunity for Indigenous engagement and participation. Discussions with City West Water and the City of Brimbank are in train regarding their existing Indigenous engagement practices and these will be used a basis for future Indigenous engagement and participation in subproject 6.3. Similar conversations are planned for other subprojects as they develop, in particular drawing on the outputs, knowledge and actions generated by subproject 6.1 and the ongoing advice of the IAG. Subproject 6.2 plans to, through Indigenous engagement, identify species of cultural importance from the Perth region that could be suitable for incorporation in public and private plantings particularly along streetscapes.

As the subprojects develop, opportunities will be identified for the Indigenous communities to contribute to survey designs and assessment of potential sites. Other aspects to be explored include understanding the Indigenous histories of sites pre-modification. Indigenous knowledge will also be considered in establishing the research and method protocols, drawing on the outcomes of subproject 6.1.

DATA MANAGEMENT AND ACCESSIBILITY

The CAUL Hub has a uniform approach to the management and accessibility of data and information as per the NESP Data Management and Accessibility Guidelines. Subject to agreements with data providers, all data produced by the CAUL Hub will be made publicly available where ethics permissions allow.

Project output	Data Management and Accessibility
Science communications resources for subprojects	Available on CAUL website, distributed to partners in electronic and hardcopy for wider distribution; publication repositories of the partner institutions.
Project 6 Handbook	Available on CAUL website
Policy briefs from subprojects	Available on CAUL website; distributed to partners in electronic and hardcopy for wider distribution; publication repositories of the partner institutions.
Academic articles from subprojects	Available on university and CAUL websites, and in electronic journals and databases. All journal publications will be made publicly and freely available within 12 months either in open access journals or on accessible repositories such as provided by universities.
Data from ecological surveys	Available on websites; stored in an open-access repository (e.g. Open Science Framework), where they will be freely available to the public

LOCATION OF RESEARCH

The location of study sites will include a range of sites in cities around Australia including within several Western Australian local government areas (principally the Cities of Stirling, Vincent, Subiaco and Fremantle), the City of Melbourne, the City of Moreland, and the City of Brimbank in Victoria as well as other local council areas.

PROJECT KEYWORDS

Interdisciplinary ecological research, biodiversity, urban ecosystems, social research, mixed-methods

Project 7 – Air quality in Australia

NOTE: This summary only includes changes since RPv4. Please refer to RPv4 for further details on this project.

Project length: *3 Years*

Project start date: *01/01/2018*

Project end date: *31/12/2020*

Project current status: Submitted for re-approval

Project Leader: *Hugh Forehead (20%)*

Lead research organisation: *University of Wollongong*

Project leader contact details: hughf@uow.edu.au, (02) 4239 2330

PROJECT DESCRIPTION

Project Summary

This project will apply some of the outcomes from the Western Sydney air quality study to a national scale. Western Sydney faces some particular problems regarding its air quality, a function of its rapid development and geography. While some of our research has been specific to Western Sydney, much of what we are learning about measuring, modelling and managing air quality is, however, transferable. In response to our user consultation in 2018 this project will explore this extension, taking careful regard of what is truly generalizable from the Western Sydney experience and what is feasible within CAUL's resources. For this reason, the project had a low profile in 2018 and a duration listed of one year. During 2018 we explored the value and feasibility of several national extensions of existing work in Western Sydney. These have been judged feasible and valuable, so this work will ramp up in 2019 as some aspects of the Western Sydney project wind down. We have chosen three aspects to investigate:

1. emissions sources and air quality, traffic, smoke and biogenic emissions
2. indoor air quality.
3. ambient air quality, noise and health

The project will enable policy makers to estimate the benefits of different mitigation strategies to the future air quality in Australian cities.

Project Description

Subproject 1: Emission sources and air quality **(Extension)**

In this sub-project we will focus on ensuring a better understanding of the main sources of atmospheric trace gases and pollutants that impact on urban air quality.

The principle target sources will be:

1.   Traffic related pollution

2.   Smoke from hazard reduction burns, wildfires and wood-smoke from domestic heaters

3.   Biogenic emissions from trees and shrubs (which react with traffic emissions to increase ozone and fine particulate matter in the atmosphere).

Project 7 – Air Quality in Australia

We will also work to finalise the outputs from Project 1 and disseminate the results both scientifically and publicly.

1. Traffic Pollution

   The national pollutant inventory (NPI) is the underlying data set which informs the impact of new emissions and the consequences for health and the environment. It includes point data on industrial emissions and data on diffuse sources like traffic. The modelling of these is patchy and outdated. This project will develop methods scoped previously in P7.1 to improve this. Previous work in Melbourne and Sydney act as trial sites for this expansion but also as the standard against which the more broad-brush work here will be assessed. Outcomes include a more nationally uniform assessment of the impact of traffic emissions on health and a tool for projecting the health impact of future traffic and population changes beyond Western Sydney. It will improve the baseline against which future environmental assessments are made and will be included in future versions of the NPI.

   Networked, low-cost sensors (internet of things or IoT) are becoming increasingly popular with the ever wider deployment of free or cheap public networks, such as Long Range Wide Area Network (LoRaWAN). The quality of these sensors is highly variable, but the measurement of particulate matter shows some promise. To follow on from a federally-funded Smart Cities project with the City of Liverpool, NSW, we will evaluate low-cost sensors to determine their potential for quantifying and mapping $PM_{2.5}$ pollution at street level.

   1. We will design a modelling framework that standardises the interface between the major components of traffic emission modelling; namely traffic modelling, emission modelling, dispersion modelling, and a dashboard (for reporting and visualisation purposes).While jurisdictions may use different packages for each of these modelling components, the adaptability of such a standardised framework ensures the consistent and comparable outputs of emission modelling across these jurisdictions. This work will be carried out at UOW, with contributions from RMIT researchers if resources allow.

   2. The framework will be demonstrated by case studies of traffic emission modelling in Wollongong, Sydney and if time allows, Melbourne. The work will continue to require collaboration with state EPAs.

   3. Evaluate the use of low-cost sensors for estimating $PM_{2.5}$ pollution at street level in Liverpool NSW. We have chosen this location due to its significance as a rapidly expanding urban centre and the opportunities for taking advantage of a newly established research relationship between UOW and the Liverpool City Council. This will be particularly valuable for obtaining access to data and infrastructure. If resources permit, we will establish a new monitoring facility and citizen science program at Liverpool Girls High School in collaboration with NSW OEH. We expect this to outlive the project by some years.

2. Smoke pollution and Air Quality

   We will work towards a better estimate of smoke composition, emissions from hazard reduction burns and improving estimates of population exposure to pollutants in smoke. We will characterise the chemical composition of smoke on UOW equipment, using spectroscopic measurements techniques and if access is possible, we will deploy further instrumentation on the fire ground. Detailed analyses of the data will be used to assess the accumulative effects of all the pollutants in different toxicological classes, so that total potential health impacts may be better understood in the context of other pollution sources. Where possible we will collaborate with the work being undertaken by the NSW OEH bushfires hub, including working towards an understanding of the different emissions scenarios that result from cultural burning practices such as that undertaken by the Mudjingaalbaraga Firesticks Program.

3. Biogenic emissions and air Quality

There is growing recognition of the importance of the chemicals emitted by trees (biogenic volatile organic compounds or BVOCs) on atmospheric chemistry and air quality within urban air-sheds (especially in cities surrounded by densely forested regions). Within Australia many of the major cities have very high levels of atmospheric VOCs that are predominantly emitted by vegetation within the cities and emissions originating from nearby natural forested regions. These chemicals react in the atmosphere leading to increased concentrations of fine particulates and ozone, causing poor air quality and adverse health impacts. Currently understanding of these important atmospheric impacts is hindered by an almost complete lack of measurements of these biogenic emissions from Australian vegetation. Models of atmospheric composition (for air quality forecasting and for climate simulations) rely on assumptions about the amounts and types of these chemicals emitted into the atmosphere by our forests. There is strong evidence from these models that current estimates of the most important emissions are wrong by a factor of two or three.

The Biogenic Ambient Atmospheric Sampling System (BAASS) has been commissioned by the University of Wollongong in order to fill this knowledge gap, and comprises an Agilent Gas Chromatography - Mass Spectrometry (GC-MS) and atmospheric pre-concentration unit from Markes.

BAASS has been deployed at ANSTO, surrounded by forest, to enable measurements of the ambient concentrations of biogenic volatile organic compounds (BVOCs) for a year-round study.

There is a possibility of the Project being the springboard for a larger international campaign named COALA (see https://www2.acom.ucar.edu/campaigns/coala). NCAR are looking to bring 3 tall towers for flux measurements in nearby forested areas and a consortium of Universities from UK are bidding to bring the instrumented FAAM BAE-146 aircraft to fly transects along the east coast to see how emissions vary with vegetation and soil changes. Ideally, these first measurements will be made available to our international collaborators to aid their preparations for the COALA campaign.

Subproject 7.3 – Indoor Air Quality **(Extension)**

In Australia, most human exposure to potentially hazardous air pollutants occurs indoors. A primary source of these air pollutants are common fragranced consumer products, such as cleaning supplies and air fresheners. Emissions from these products have been associated with adverse effects to humans, the economy, and the environment. For instance, more than one-third of Australians report health problems from fragranced consumer products, resulting in lost work days or a job for more than one million Australians in one year (Steinemann 2017). Fragranced product VOCs are both a dominant contributor to pollutants indoors (Goodman et al. 2017) as well as outdoors (McDonald et al. 2018).

As a response, "fragrance-free policies" have been implemented in workplaces, schools, health care facilities, and other indoor environments (e.g., residences with sensitive individuals such as asthmatics). These policies generally restrict the use of fragranced products indoors, and thereby switch to fragrance-free products, no products, or alternative approaches. However, despite the importance and increasing implementation of fragrance-free policies, little if any prior research has investigated whether and to what extent these policies can improve indoor air quality.

This proposed scope of work for the Indoor Air Quality project will investigate the potential improvements in indoor air quality from the implementation of fragrance-free policies. Here, the term "policies" is used broadly and will include both formal and informal protocols and practices, which we will term "interventions." For pollutants, we will examine both volatile organic compounds (VOCs) and particulate matter (e.g., PM 2.5). The particulate matter research will be conducted in collaboration with Associate Professor Clare Murphy and members of the Sub-project 1 team.

The main project tasks will proceed as follows:

1. Perform pre-intervention VOC measurements within indoor environments. We will examine three main environments, which could include educational, occupational, organisational, governmental, or residential buildings. The analytic focus will be on VOCs, specifically terpenes and aldehydes, that are characteristic of fragranced products and that are implicated as the dominant pollutants.

2. Implement interventions. Within each of these environments, we will implement interventions that include but are not limited to the following: switching from fragranced to fragrance-free products (e.g., cleaning supplies, laundry detergents, soaps); using no products (e.g., using plain water instead of a product); removing air fresheners (from toilets and interior spaces); and reducing use of fragranced personal care products.

3. Perform post-intervention VOC and $PM_{2.5}$ measurements within indoor environments. We will take indoor air samples after the interventions, in successive time periods during the year, to track the gradual improvements and the relative effectiveness of different types of interventions.

4. Analyse and quantify effects on indoor air quality from implementing a fragrance-free policy in a previously fragranced environment. We will examine each of the environments and interventions to assess the effectiveness and quantify the spatial and temporal changes (reductions) in concentrations of terpenes and aldehydes.

5. Develop practical guidance, including implementation strategies, measurement protocols, and evaluation methods, for fragrance-free indoor environmental quality policies, which can reduce exposure to potentially hazardous air pollutants.

This fourth year of research in the Indoor Air Quality project will build upon and significantly extend the contributions of the prior three years of research which found that (a) terpenes such as limonene and alpha-pinene, characteristic of fragrance products, are among the most prevalent and highest concentration pollutants indoors, and can react with ozone to generate hazardous air pollutants such as formaldehyde, as well as particulate matter (such as $PM_{2.5}$), (b) significant reductions in limonene concentrations (up to 99%) in air are possible by switching even one product (e.g., laundry detergent) from fragranced to fragrance-free, yet also that (c) fragrance compounds can persist indoors and switching to fragrance-free products will result in immediate but also increasing improvements over time. We foresee that this fourth year will also set up research for the fifth year of the project, which would include an evaluation of potential health benefits (e.g., reduction in sick days) from switching from fragranced to fragrance-free environments.

References cited:

Goodman NB, Steinemann A, Wheeler AJ, Paevere PJ, Cheng M, Brown SK. 2017. Volatile organic compounds within indoor environments in Australia. Building and Environment 122:116-125.

McDonald, B.C., de Gouw, J.A., Gilman, J.B., et al., 2018. Volatile chemical products emerging as largest petrochemical source of urban organic emissions. Science 359 (6377), 760–764.

Steinemann A. 2017. Health and Societal Effects from Fragranced Consumer Products. Preventive Medicine Reports 5:45-47.

***Subproject 7.4 – Ambient Air Quality, Noise & Health* (New)**

Throughout CAUL we have sought to build decision support tools that link urban planning, through emissions scenarios to pollutant concentrations and finally impacts on health and well-being. This sub-project addresses the last link in this chain, the impact of pollutant concentration on health. Although the existence of a link is now well established, quantifying its strength in the Australian context is a necessary step for integrated decision support. For this we need co-located data on pollutant concentrations and health outcomes. We will address two case studies that provide such data.

7.4.1.   Health Impact Assessment of long term exposure to air pollution on mortality and hospital admission, with a sub analysis for Western Sydney.

7.4.2.   Quantification of the relationship between $PM_{2.5}$, NO_2/NO_x and $PM_{2.5}$ absorbance as well as green space exposure and health outcomes in the Health in Men Study (Perth)

7.4.3 Modelling noise pollution

Chronic exposure to high levels of noise is known to be a stressor for humans and other organisms. Furthermore, noise is increasing with increasing traffic, in-fill of suburbs close to city centres and urbanisation in general. It impacts on cardiovascular health and also is a confounder in the relationship between air quality and health. Despite its ubiquity, noise is a neglected area of health research. In Australia we have limited data with which to assess exposure at a population level for epidemiologic research. As with some other pollutants, noise is a highly heterogeneous field and it is impossible to measure it comprehensively. To understand its population effect we need to be able to describe its spatial variation. This is the task of noise models. We already have a preliminary model for Melbourne and one task will be to bring this up-to-date. We will also develop preliminary noise models for Sydney and Perth. This work will also feed the work on noise pollution and urban ecology in Project 5.

NESP 2017 Research Priority Alignment

This project will respond to NESP Research Priorities 2, 3, 4, 6, 7, 8 and 9, which focus on measuring, predicting and managing various aspects of urban air quality, both outdoor and indoor.

PATHWAY TO IMPACT

Outcomes
- Improved emissions baseline by contributing to the NPI, leading to more cost-effective improvements in air quality (7.1)   - Reduced cost of estimating traffic emissions at street or suburb level through use of open-source modelling framework (7.1)   - Potential for a nationally consistent approach to meso-scale traffic emissions modelling through adoption of framework (7.1)   - Improved understanding of pedestrian exposure to pollution from traffic through street-level measurements (7.1)   - Improved understanding of biogenic emissions, leading to better air quality forecasting and climate simulations (7.1)   - Improvements in mitigation and responses to smoke pollution arising from improved knowledge of health effects (7.1)   - Demonstration of improved air quality (reduced concentrations of VOCs and $PM_{2.5}$) due to implementation of fragrance-free policies (7.3)   - Improved consumer advice on the use of domestic fragranced products (7.3)   - New understanding of the extent of noise pollution in Australian urban environments (7.4)   - Improved health outcomes from more targeted mitigation of air pollution and noise (7.4)   - Mapping the noise environment affecting urban ecosystems (7.4)

Research-user	Engagement and communication	Impact on management action	Outputs
Subproject 7.1			
DoEE, NPI	Suggested by DoEE staff at roadshow Workshop, meetings and consultations with agencies	Improved Environmental Assessments	Report and potentially scientific paper
State EPAs	Endorsed at roadshows by Vic-EPA staff	Improved Environmental Assessments	Report and potentially scientific paper
Community groups	Endorsed at roadshows, particularly in Western Sydney	Improved decision support for hazard reduction burns	Report and potentially scientific paper
		Improved Health Impact Assessments	Report on smoke composition
Subproject 7.3			
DoEE, Home owners	Significant public interest and international media coverage	Provide novel scientific results to promote healthier indoor environments	Scientific publication
Departments of Health and Planning	Better information on health costs of environmental pollution	Address a pervasive health and environmental problem	Scientific publication

Subproject 7.4			
Departments of Health and Planning		Better information on the health costs of environmental pollution	Format to be determined

Indigenous Engagement and Consultation

The project's scope for Indigenous Engagement will be developed along with the broader shape of the project.

There has been an Indigenous intern working within Project 1 exploring Indigenous knowledge of weather cycles and we will extend opportunities for employment into subproject 7.1. Subproject 7.1 will be assigned Category 2 and we will explore opportunities to work collaboratively with the NSW OEH bushfire hub as they investigate advantages of traditional burning practices with the Firesticks cultural burning group.

In subproject 7.3, we propose to sample indoor air quality before and after implementation of fragrance-free policies or practices, within a location used by members of an Indigenous community. Four possible locations have been identified for evaluating the effectiveness of fragrance-free policies and practices on indoor air quality. These include an educational facility, a community centre, and two office environments.

DATA MANAGEMENT AND ACCESSIBILITY

The outputs of this project are of three forms: reports, data sets and academic papers. Reports and data sets will all be made available on the CAUL website and reported to DEE following NESP policies. Academic papers will either be referred to from the website or made available in draft form depending on the policies of the targeted journals.

Project output	Data Management and Accessibility
Report from milestone 7.1.1 outlining potential CAUL contributions	Made available to relevant stakeholders
Report from milestone 7.1.2	Available on website, and discussed in detail with DoEE and state EPAs. This report will be the result of a workshop and subsequent review focusing on knowledge gaps around diffuse sources (particularly traffic), and will guide the development of the methodology described in milestone 7.1.2.
Report from milestone 7.1.3	Available on website, and discussed in detail with DoEE and state EPAs.
Report from milestone 7.1.4	Short report to relevant stakeholders.
Report from milestones 7.1.5-7, 10	Available on website, and discussed in detail with DoEE and state EPAs.
Dataset from milestone 7.2.1	Available on website, and both discoverable and curated.
Report from milestone 7.2.3	Available on website and circulated directly with major stakeholders involved in fire management and air quality.
Dataset from milestone 7.1.9	Available on website, and both discoverable and curated.
Article and report from milestones 7.3.4 and 7.3.5	Available on website, and by electronic journals
Reports or academic papers from milestones 7.4.1-7.4.4	Available on website, and by electronic journals
Reports or datasets from milestones 7.4.5-7.4.7	Available on website, and both discoverable and curated

LOCATION OF RESEARCH

The desktop work in 7.1 will take place at UOW, RMIT and UoM. The smoke measurements in 7.1 will take place mainly near Wollongong. The biogenics work will be located at ANSTO in collaboration with scientists there. The indoor measurements in 7.3 will take place mainly in and around Melbourne. The desktop work in 7.4 will take place mainly at UWA, with collaborators from U. Syd, U. Canberra, U. Tas and UQ.

PROJECT KEYWORDS

Air quality, particulates, health, traffic, smoke, emissions, Sydney, measurements, atmospheric modelling, noise