

AUSTRALIAN RESEARCH COUNCIL
Linkage Projects
Proposal for Funding Commencing in 2019

LP

PROJECT ID: LP190100295

First Investigator: Prof Patricia Fleming

Admin Org: Murdoch University

Total number of sheets contained in this Proposal: 138
--

Information on this form and its attachments is collected in order to make recommendations to the Minister on the allocation of financial assistance under the Australian Research Council Act 2001 and for post award reporting. The information collected may be passed to third parties, including being sent to overseas parties for assessment purposes. It may also be passed to any other Australian Government Department or Agency where required, and noting information contained in this application can be disclosed without your consent where authorised or required by law.

Part A - Administrative Summary (LP190100295)

A1. Application Title

(Provide a short title. (No more than 75 characters approximately ten words).)

Alternative fuel load reduction methods for urban bushland
--

A2. Person Participant Summary

(Add all people participating in this application as a Chief Investigator or Partner Investigator. A Chief Investigator must: not be undertaking a Higher Degree by Research during the project; reside predominantly in Australia for the Project Activity Period; and be an employee for at least 0.2 FTE at an Eligible Organisation, or be a holder of an honorary academic appointment (see sections 6.26, 6.27, 6.28, 6.33, 6.34 and 18 of the grant guidelines) at an Eligible Organisation. Note that a person's RMS email address must be used to invite them to participate in this application. Refer to the Instructions to Applicants for further information.)

Number	Name	Participant Type	Current Organisation(s)	Relevant Organisation
1	Prof Patricia Fleming	Chief Investigator	Murdoch University	Murdoch University
2	Prof Giles Hardy	Chief Investigator	Murdoch University, Murdoch University	Murdoch University
3	Mrs Bonnie Beal Richardson	Partner Investigator	CITY OF MANDURAH	CITY OF MANDURAH
4	Dr Ben Miller	Partner Investigator	Department of Biodiversity Conservation and Attractions	DEPARTMENT OF BIODIVERSITY CONSERVATION AND ATTRACTIONS
5	Dr Megan Barnes	Partner Investigator	DEPARTMENT OF BIODIVERSITY CONSERVATION AND ATTRACTIONS	DEPARTMENT OF BIODIVERSITY CONSERVATION AND ATTRACTIONS
6	Dr Paul Barber	Partner Investigator	ARBOR CARBON PTY LTD	ARBOR CARBON PTY LTD

A3. Organisation Participant Summary

(Add all organisations participating in this application. Refer to the Instructions to Applicants for further information.)

Number	Name	Participant Type
1	Murdoch University	Administering Organisation
2	CITY OF MANDURAH	Partner Organisation
3	DEPARTMENT OF BIODIVERSITY CONSERVATION AND ATTRACTIONS	Partner Organisation
4	ARBOR CARBON PTY LTD	Partner Organisation

A4. Application Summary

(Provide an Application Summary (which is used by the Minister to consider the application), focusing on the aims, significance, expected outcomes and benefit of this project. Write the Application Summary simply, clearly and in plain English. If the application is successful, the Application Summary is used to give the general community an understanding of the research. Avoid the use of acronyms, quotation marks and upper case characters. (No more than 750 characters, approximately 100 words))

Since 1850, more than 800 Australians have died as a result of wildfire, and there has been catastrophic loss of property. One of the most critical issues facing Australian society today is therefore how to manage environmental fuel loads to protect human lives and properties. It is particularly difficult to control fuel in urban bushland due to social and environmental constraints that limit the use of prescription burning; alternative methods of fuel load reduction (FLR) are therefore required. Our data will provide training for residents, establish long-term monitoring, and provide empirical data for a range of wildfire mitigation tools to inform Structured Decision-Making for management.

A5. List the objectives of the proposed project

*(List each objective separately by clicking 'add answer' to add the next objective. This information will be used for future reporting purposes if this application is funded. (No more than 500 characters, approximately 70 words per objective).
(This question must be answered))*

Objective

1. Implement and test a range of alternative manual fuel load reduction (FLR) tools to increase management choices for bushfire risk mitigation in urban landscapes. Urban bushland management is challenging: proximity to property increases risk of damage, but also increases difficulty of applying prescription burning. Consequently, as cities have developed around them, many urban reserves have not been well managed for fire, leading to marked variability in bushfire risk levels between reserves.

Objective

2. Enable Local Government Authorities to better deal with corporate risk and liability. Identifying biodiversity outcomes (tree health, native plant communities, weed presence, soil condition, wildlife activity, habitat for fauna costs) and social values (hazard reduction, residual risk, and effectiveness) will assist managers to determine the best bushfire mitigation options under different circumstances.

Objective

3. Develop a model system for engaging local community participation in bushfire risk mitigation in urban bushland. Increasing the range of tools that local residents can implement and engaging them with training to improve confidence in the effectiveness and suitability of hazard mitigation measures.

A6. National Interest Test Statement

(Outline the extent to which the research contributes to Australia's national interest through its potential to have economic, commercial, environmental, social or cultural benefits to the Australian community. Write Your description of national interest simply, clearly and in plain English. (No more than 1125 characters, approximately 150 words).)

Wildfire represents one of the greatest challenges we are facing today, affecting the lives of every Australian. The consequences of wildfire around urban centres is especially dire, while bushfire mitigation for urban bushland is also particularly challenging. As cities have grown, bushland patches have become more isolated, weeds have spread, and increasingly hot and dry summers exacerbate fire risk and reduce windows for safe controlled burns. Consequently, alternative hazard reduction methods are required. In high biodiversity value and high risk reserves, a range of intensive mechanical (i.e. raking, slashing, thinning and rolling) or chemical (i.e. use of herbicides) fuel load reduction (FLR) measures could be beneficial. Such approaches have been quantified for forestry landscapes, but less has been done in the urban context. The impact of these activities on biodiversity and social values are poorly understood, and such data would underpin effective urban bushfire mitigation planning. This project will therefore have substantial scientific, social and management outcomes.

A7. Is this application similar to a previously submitted unsuccessful application in the LP19 round?

(The ARC would consider an application to be similar if the aims and methodology of the Project Description and

participants have not substantially changed.)

No

A8. Provide the application ID and detail how this application differs from the previous application(s).

(For each of the unsuccessful application submitted in the LP19 round, please enter the application ID and describe how the current application differs from the previously submitted application(s). (No more than 750 characters (approximately 100 words))

Part B - Classifications and Other Statistical Information (LP190100295)

B1. Does this application fall within one of the Science and Research Priorities?

Yes

Science and Research Priority	Practical Research Challenge
Environmental change	Options for responding and adapting to the impacts of environmental change on biological systems, urban and rural communities and industry.

B2. Field of Research (FOR)

(Select up to three classification codes that relate to the application. Note that the percentages must total 100.)

Code	Percentage
050211 - Wildlife and Habitat Management	40
060208 - Terrestrial Ecology	25
070503 - Forestry Fire Management	35

B3. Socio-Economic Objective (SEO-08)

(Select up to three classification codes that relate to your application. Note that the percentages must total 100.)

Code	Percentage
961310 - Remnant Vegetation and Protected Conservation Areas in Urban and Industrial Environments	55
961010 - Natural Hazards in Urban and Industrial Environments	45

B4. Interdisciplinary Research

(This is a 'Yes' or 'No' question. If you select 'Yes' two additional questions will be enabled:

1. Specify the ways in which the research is interdisciplinary by selecting one or more of the options below.
2. Indicate the nature of the interdisciplinary research involved. (No more than 375 characters (approximately 50 words))

Does this application involve interdisciplinary research?

Yes

Specify the ways in which the research is interdisciplinary by selecting one or more of the options below.

Investigatory Team
Methodology

Indicate the nature of the interdisciplinary research involved. (No more than 375 characters, approximately 50 words)

Our strong collaborative research team has complementary skills and expertise across fire science, tree health, wildlife biology, education for sustainability, and decision science. The Structured Decision Making method will allow articulation from fundamental biological knowledge to informed management options addressing a critical issue facing Australian society today.

B5. Does the proposed research involve international collaboration?

(This is a 'Yes' or 'No' question. If you select 'Yes' two additional questions will be enabled:

1. Specify the nature of the proposed international collaboration by selecting one or more of the options below.

2. Specify the countries which are involved in the international collaboration.)

No

B6. What is the nature of the proposed international collaboration activities?

(Select all options from the drop-down list which apply to this application by clicking on the 'Add' button each time you select an option.)

B7. If the proposed research involves international collaboration, specify the country/ies involved

(Commence typing in the search box and select from the drop-down list the name of the country/ies of collaborators who will be involved in the proposed project. Note that Australia is not to be listed and is not available to be selected from the drop-down list.)

B8. How many PhD, Masters and Honours places will be filled as a result of this project?

(The ARC is capturing the number of Research Students that would be involved in this application if it is funded. Enter the number of student places (full-time equivalent) that will be filled as a result of this project.)

Number of Research Student Places (FTE) - PhD

2

Number of Research Student Places (FTE) - Masters

0

Number of Research Student Places (FTE) - Honours

2

Part C - Project Description (LP190100295)

C1. Project Description

(Upload a Project Description as detailed in the Instructions to Applicants and in the required format. Ensure that the Project Description responds to the Assessment Criteria listed in the grant guidelines. (No more than ten A4 pages))

Uploaded PDF file follows on next page.

PROJECT TITLE Alternative fuel load reduction methods for urban bushland

Structured Decision Making to compare biodiversity and social outcomes for bushfire hazard reduction alternatives

AIMS AND BACKGROUND. The issue: Managing urban bushland for fire risk represents a complex social and ecological problem. The issue of fire risk management for urban bushland is increasingly important as human population in Australia's cities grows, weeds spread, and increasingly hot and dry summers exacerbate fire risk and reduce windows for safe controlled burns. Australian cities each have their own stories to tell. Here in WA, four devastating recent fires have peaked awareness of fire risk among urban and peri-urban residents (Table 1). The December 2019 fires in Yanchep (burning at the time of writing this) were exacerbated by blistering heat, with a week of temperatures over 40°C.

Table 1. Four recent fires around peri-urban Perth, Western Australia, that have damaged/destroyed property, and taken human lives.	Year	Location	Extent	Property loss	Lives lost
	Dec 2019	Yanchep	12,000 ha	Several (currently burning)	
	Jan 2016	Waroona and Yarloop †	69,000 ha	180 homes destroyed	2 fatalities
	Jan 2014	Parkerville	386 ha	44 homes destroyed	
	Feb 2011	Kelmscott and Roleystone	1,000 ha	72 homes destroyed, 37 damaged	
† on the southern border of Mandurah, and adjacent to proposed research sites					

The gap: Urban bushland reserves are complex: they vary in vegetation composition, area, history of hazard reduction, and degree of weed invasion. They are also surrounded by urban landscapes to varying degrees and support diverse wildlife populations and other environmental values. A range of hazard reduction methods are therefore required to address the complex social and environmental challenges of urban risk management. In high-value and high-risk urban bushland reserves, in addition to or as an alternative to prescription burning, a range of intensive manual, mechanical (e.g. raking, slashing, thinning and rolling) or chemical (i.e. use of herbicides) fuel load reduction (FLR) measures are implemented. While previous studies have investigated FLR approaches in forestry landscapes, less has been done in the urban context. The impact of these activities on biodiversity and social values are poorly understood, and such data would underpin the decisions that result in effective bushfire risk mitigation planning. **Our partnership:** This proposal draws together a cross-disciplinary research team and committed partner organisations: the City of Mandurah is a Local Government Authority (LGA) that is proactive about environmental research; the Department of Biodiversity Conservation and Attractions (DBCA) is responsible for management of fire risk public lands across the state; and ArborCarbon is a small business that is developing remotely captured assessment tools for ecological monitoring. Our **AIM** is to use the careful and organised analysis of natural resource management decisions under a Structured Decision Making process [1, 2], to assess the biodiversity, social and risk outcomes of alternative FLR approaches for bushfire hazard mitigation, and therefore derive decision support tools for complex urban bushland interface areas. Our **PROJECT OBJECTIVES** are to:

1. Quantify outcomes of alternative bushfire hazard reduction methods for protection of human lives and property in urban landscapes: (A) BIODIVERSITY outcomes for tree health, native plant communities, weed presence, soil condition, wildlife activity, and habitat for fauna; (B) SOCIAL VALUES for urban bushland in terms of amenity and cultural values; and (C) COST, EFFECTIVENESS and MANAGEABILITY for emergency services.
2. Use these data in a Strategy Evaluation to allow managers to directly compare the consequences of alternative options for each objective, addressing a key priority for Mandurah and DBCA.
3. Increase local capacity for bushfire management by Mandurah residents and emergency services teams.

BACKGROUND: The proportion of Australians living in cities and regional centres is approaching 90% [3]: capital city population growth rate (1.9% in 2017-18 alone) in Mandurah is nearly double that of rest of the country (1.0%; [4]). Despite this urbanisation, Australians love the bush: it inspires us, provides ecosystem services, health benefits, shapes our identity and history, and supports biodiversity that we protect through laws, international treaties and increasing social expectations and awareness. The number of Australians living near urban and peri-urban bushland reserves is large and these populations strongly value and use these areas for a diversity of purposes.

Fire is an integral component of many global biomes [5], with some of the most fire-prone being in Mediterranean biodiversity hot-spots [6, 7] such as in south-west Western Australia (WA). Unfortunately, humans are also a major cause of fire: increasing urbanisation together with climate change has contributed to increased flammable weed invasion, deliberate ignitions, and accelerated rate of fire spread (Fig. 1). With growing populations in cities, today we face increased fire hazard for people, property and biodiversity. Urban bushland such as Banksia Woodlands of the Swan Coastal Plain, are now recognised as Threatened Ecological Communities (TECs; listed under the Environment Protection and Biodiversity Conservation Act), with urbanisation, weed invasion and changed fire regime listed as threatening processes.

Of the environmental factors that influence the behaviour and spread of a fire, fuel load and arrangement is the

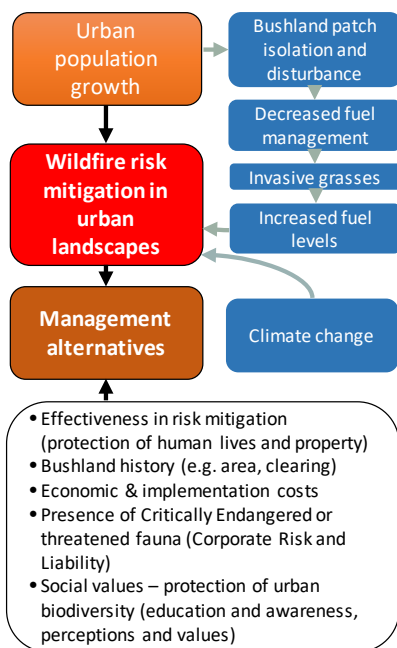


Fig. 1. Interactions among processes and diverse drivers in urban bushland management.

only one that can be manipulated to reduce bushfire intensity and severity, and to mitigate risk to life and property. The arrangement, continuity, bed depth, height of the most continuous strata, and proportion of dead fuels play critical roles in determining fire properties: rate of spread, flame height, flame residence time, spotting potential, and intensity of the flame front [8]. Reducing fuel loads around assets such as homes and infrastructure is therefore a vital management response to reduce the likelihood of bushfire losses.

Management of bushfire risk is therefore undertaken largely by fuel management. Prescription burning is a key tool employed by management authorities for hazard reduction [9]; however, applying hazard reduction burning in urban bushland is complex for many reasons. Social acceptability of prescription burning are affected by implementation risks and cost, loss of amenity value, concern for smoke production, traffic control impacts, and risk of escape. Burning in urban reserves also has consequences for weed invasion, with subsequent potential perverse outcomes for fire hazard (enhanced risk due to increased grass invasion) and negative amenity and biodiversity outcomes. There is also reduced resilience of native vegetation and fauna as a result of fragmentation, disturbance, vulnerability to predators, pathogens, and weeds; for example, steadily increasing isolation of urban reserves means urban fauna have limited movement options. This complexity decreases opportunities and increases the cost and scale of effort relative to extent of risk reduction. **The**

question: Can we reduce fuel loads without compromising tree health, impacting vital habitat for urban fauna, or losing the amenity values and sense of place we attach to urban bushland? Manual, mechanical or chemical FLR has successfully been used in other parts of the world (e.g. USA), and to a very small and targeted extent in parts of Australia [8]. For example in the USA, large areas of forest have been mechanically thinned as part of a strategy to reduce the risks of wildfire, such as the 600,000 ha of forests treated under the Collaborative Forest Landscape Restoration Program [8]. In urban bushland, clearing weeds and woody debris, thinning, raking and slashing are undertaken as required, but few studies have quantified the biodiversity impacts, consequences for community perception and support, effectiveness in risk reduction, and costs of such activities.

INVESTIGATORS. We have brought together a very strong collaborative research team with complementary skills and experience; all CIs and PIs will jointly supervise the project and disseminate research outcomes. The CIs have a proven track record of fruitful collaboration and publishing together in ecology and transdisciplinary research (Fleming-Hardy: 23 co-authored publications, co-supervision of 15 research students, 10 joint research grants; Hardy-Miller: 2 co-authored publications).

Murdoch University researchers have worked closely with the Mandurah since 2003 (~16 years), including LP0346931, LP0668195, LP150100451, the WA State Government-funded Centre of Excellence (CoE) for Climate Change, Woodland and Forest Health, and more recently LP160100441. We have collaborated towards understanding the causes and impacts of tuart (*Eucalyptus gomphocephala*) decline, quantified the vital role of tuarts in ecosystem health, identified methods for tuart restoration, determined where quenda (*Isodon fusciventer*) persist within the urban matrix, and carried out planting trials with mycorrhizal inoculum. This collaboration has been extremely fruitful in terms of scientific outcomes (e.g. [43,2,42,40,35,39,5]), community outreach (41 events over the last 3 years), and contribution towards practical management solutions. | **CI FLEMING (0.2FTE)** leads the western Wildlife Ecology and Behaviour (WEB) research group (www.westernWEB.net) – working on global issues of wildlife responses to human-induced environmental disturbance. Her experience with project management and track record of developing robust experimental design and analysis will ensure project outcomes. | **CI HARDY (0.2 FTE)** is a forest pathologist with a wealth of expertise in broad-scale ecological studies such as this one. CI HARDY will provide expertise on tree health, assistance in the soil and mycorrhizal work, and direct communication with community and industry stakeholders.

City of Mandurah. Mandurah is a tree-change suburb and regional city south of Perth, of 85,000 people (growing 7.6% 2013-8). Mandurah's 2017-2037 Strategic Plan includes Environment and Social strategic directions. Under 'Environment' the strategy highlights: 1) a healthy natural environment, (2) increased scientific knowledge and understanding, (3) community ownership of natural assets, and (4) factoring climate change prediction into land-

use planning. Under 'Social' the strategy highlights: 1) community confidence in Mandurah as a safe city, (2) opportunities, services and activities that engage young people, and (3) social, recreational, entertainment and learning experiences for our residents and visitors. This proposal addresses aspects from all of the above. | We have substantial support from **PI BEAL RICHARDSON (0.2 FTE)**, Senior Environmental Education Officer, City of Mandurah. Her role is focussed on connecting community and the environment through the coordination of programs that provide improved sustainability outcomes for Mandurah, the development of effective partnerships and the building of community capacity through the incubation of community-led initiatives. She has been involved in research partnerships, including LP160100441 - Backyard Bandicoots: engaging community in urban bushland conservation. The proposed project will also involve significant contribution from four staff directly engaged with the fuel load reduction treatments (each contributing **0.2FTE** in year 1): **Project Officer - Bushfire Mitigation, Coordinator Emergency Management, Senior Environmental Management Officer, and Environmental Management Officer**. Furthermore, an **Environmental Education Officer (0.2FTE)** will be involved in surveys of public response to the treatments in Years (Y) 1 and 2.

DBCA is responsible for managing conservation of threatened species and communities across more than 31 million hectares of conservation estate and is responsible for fire preparedness over almost 90 million hectares of unallocated Crown land and unmanaged reserves. DBCA has a substantial Regional and Fire Management Services Division. | **PI MILLER (0.1 FTE)** is a plant ecologist with >25 years in fire research. Lead of the DBCA Fire Science Program, and previously Director of Science at Kings Park (Botanic Gardens & Parks Authority; now in DBCA), his work focusses on providing advice and research bridging applied science and conservation/ management needs. He established Kings Park's fire research program to specifically focus on research for urban bushland fire and biodiversity management, a priority need of the BGPA. He will provide fire risk and plant ecology expertise, assisting with experimental and monitoring design. | **PI BARNES (0.1 FTE)** is an outstanding early career researcher with 7 years' experience in decision science. Her work is trans-disciplinary and focuses on understanding social and ecological impacts of multi-objective management decisions. She now supports Structured Decision Making across the DBCA portfolio. PI Barnes will provide expertise in evaluation, provide training in Structured Decision Making, workshop facilitation, and she will support evaluation and dissemination of social science findings.

ArborCarbon is a small business of vegetation health and remote sensing experts, providing services in diagnosis, monitoring and sustainable management of vegetation. Their expertise in Forest Pathology, Urban Forest Science, Vegetation Monitoring, Remote Sensing, and Disease Diagnostics make a natural fit to our multidisciplinary team, and will provide access to airborne technology to complement our on-ground assessments. | **PI BARBER (0.05FTE)** is a forest pathologist, remote sensing scientist and Founding Director of ArborCarbon. | **ESLICK (0.1FTE)**, Research Scientist, ArborCarbon, will contribute expertise in image processing and data analysis.

SIGNIFICANCE AND INNOVATION. This project is highly significant and innovative, directly addressing knowledge gaps around biodiversity and social outcomes for alternative methods for bushfire hazard reduction in urban and peri-urban bushland reserves. Biodiversity and social impacts of manual FLR in urban or peri-urban bushland have not been quantified (previous studies have focussed on forestry landscapes). Our multidisciplinary approach to developing science that informs management action via a Structured Decision Making framework is innovative, integrating fire mitigation measures with community and management action for the first time.

This project addresses an important problem for the industry partners: **1.** A range of alternative FLR approaches would increase management options for controlling bushfire risk around human lives and property. Managing urban bushland fire risk is fundamental for protection of property and lives as well as for conservation objectives. Urban bushland represents a significant quandary for management: proximity to property increases risk of damage, but also increases difficulty of applying prescription burning. Consequently, as cities have developed around them, many urban reserves have not been well managed for fire, leading to marked variability in risk levels. **2.** The work will enable LGAs to better deal with corporate risk and liability, as well as demonstrate due diligence in planning to reduce risk to threatened species or threatened ecological communities when reducing fuel loads. By documenting the costs, hazard reduction effectiveness, residual risk, and impact of different FLR treatments, we will assist residents and land managers to determine the best FLR option(s) under different circumstances to better manage bushfire risk without unintentionally triggering State or Federal environmental legislation (i.e. The Biodiversity Conservation Act 2016 (WA) or Environment Protection and Biodiversity Conservation Act 1999) through detrimental impacts on a threatened species. **3.** Our study will develop a model system for engaging local community action in bushfire risk mitigation in urban bushland. Locally, increasing the range of tools that local residents and land managers can implement, and engaging them with training, will improve confidence in the effectiveness and impact of hazard mitigation measures. More broadly, applying a formal Structured Decision Making process to this complex challenge will allow transfer widely across Australia.

This project addresses three ARC Science and Research Priority items: **1.** Help to build Australia's capacity to respond to environmental change in cities. This project will lead to more resilient urban infrastructure by informing alternative bushfire risk mitigation treatments for urban and peri-urban bushland. This is especially important because heatwaves, drought and rainfall extremes (high and low) have dominated Australian summers over the last decade – a recipe for disaster in terms of increased intensity and frequency of wildfire. Climate change has resulted in increased fire danger weather and greater risk of wildfire occurring [10], and the length and intensity of the fire weather season has increased over recent decades for much of the Australian continent [11]. **2.** Significantly enhances links with industry. Engaging with community and enhancing natural spaces within cities are an important part of creating healthy environments for urban communities. Developing novel tools for future management of urban bushland reserves help with Living in a Changing Environment. **3.** Advance our knowledge base by establishing long-term data collection needed for informed management in the face of a rapidly changing environment. Long-term data sets are powerful indicators of potential threats, and continuous data collection, especially including the remotely sensed high resolution 11 band multi-spectral data, will allow us to study long-term changes. Our transdisciplinary approach will inform social and environmental principles relevant for international peer-reviewed journals and international conferences, and we will provide training for postdoctoral research fellows, PhD and Honours students.

APPROACH AND TRAINING. EXPERIMENTAL DESIGN. We will use a Structured Decision Making approach (Fig. 2) to compare data for FLR alternatives. We will collect data to quantitatively estimate the consequences (red dashed line in Fig. 2) of six FLR treatment alternatives (Fig. 3), each applied to 1-ha plots, with four replicates of each (total 24 ha). **TIMELINE.** We require 5 years funding for this project (Table 2). We will carry out experimental manipulation treatments in year 1 and capture immediate plant and fauna responses to our treatments in the subsequent two years (with the ambitious aim of scientific outputs within this 3-year time frame). Mandurah has the first tranche (\$50k) in their current budget in preparation for an immediate commencement of the manipulation work, which we propose to carry out in the Austral spring (Sp) 2020. Monitoring sites will then follow in autumn (A) each year. We expressly request additional time (Technician in Y4 and Y5 to assist the CIs/PIs) to extend the monitoring period as responses to the fuel manipulations are expected to take more than 2 years to manifest. Furthermore, we intend to fully incorporate these biological data into decision science, management outcomes, and education outputs over the following two years; we cannot commence the social science work until we have completed collection of the biological data (Y 1-3).

EXPERIMENTAL TREATMENTS. Current Department of Fire and Emergency Services (DFES) guidelines, like those in other states, identify fuel management outcomes (not treatment approaches) appropriate for protecting properties. Approaches to fire hazard assessment applied across southern Australia address fuels in horizontal strata, with each strata influencing different elements of fire behaviour [12]. For instance, a common objective for hazard reduction in WA is to reduce near-surface fuel (grasses, low shrubs, suspended, but not on-ground litter) and elevated fuel (tall shrub and understorey layer) hazards from High to Moderate scores. These actions are formally

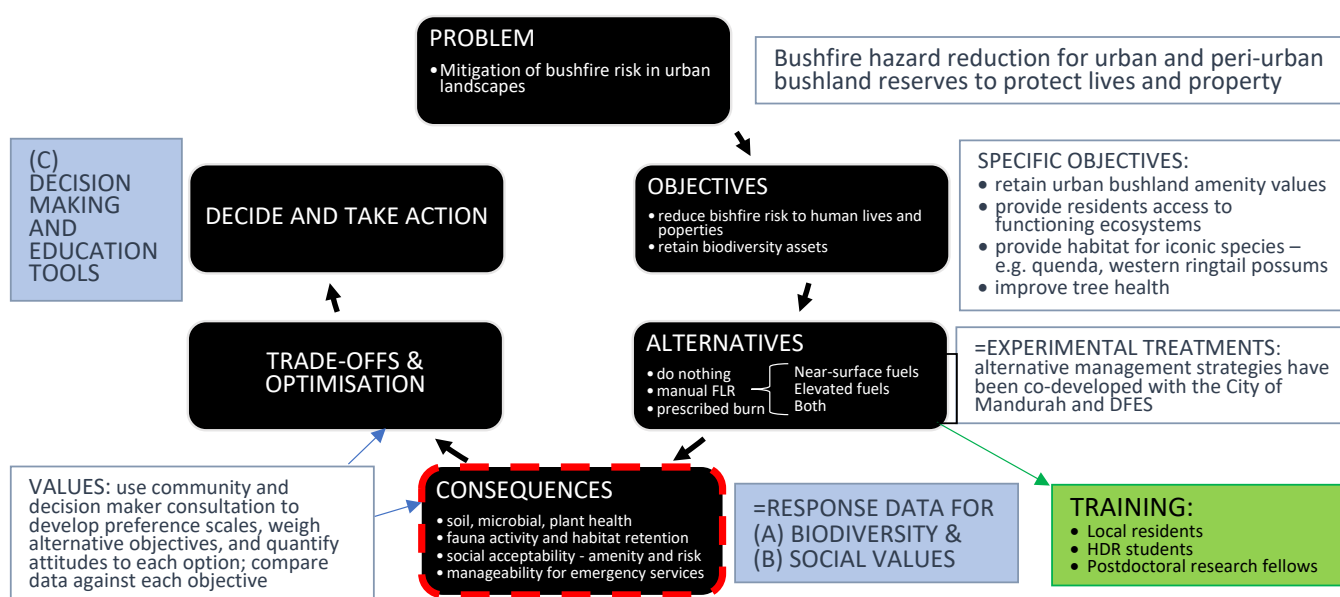


Figure 2. Structured Decision Making approach to compare data for FLR alternatives

described in Hazard Assessment Guides [e.g. 13], and contribute to models of flame heights and rate of spread. Applying these published methods, we will carry out a combination of manual FLR and prescription burning (Fig. 3) in spring 2020 (Table 2). We will work directly with Mandurah contractors and volunteer emergency response groups (local bushfire brigades, fire and emergency response teams) to implement control actions; these activities represent substantial in-kind for this project (~\$100,000).

A) During autumn the following three years (x in Table 2), we will carry out HABITAT AND BIODIVERSITY ASSESSMENT MEASURES using a standardised sampling protocol for each 1-ha treatment. Permanent sampling transects with a nested design of quadrats (one 20 x 20 m and four 3 x 3 m sampling quadrats) at the centre of each in the treatment sites will be established (see [14]) for measures at different scales:

(1) Fuel load and arrangement. Background. While some fuel treatments are expected to lead to better outcomes in terms of nature conservation, it is important to determine that these improvements are not being realised at the expense of resident safety in relation to wildfire risk. Fire hazard is assessed by measuring fuel load and its arrangement through both direct field measurements, application of standard visual assessment and remotely sensed data capturing coarse woody debris (logs) and dry matter (weeds) in the 0-1 m layer. These measurements allow prediction of fire rates of spread and flame heights for both wildfires and prescribed burns under different fuel treatments. **Methods.** We will measure litter depth, collect and measure dry mass and volume by particle size in standard fuel classes, assess vegetation structure via intercept touches along a transect, recording live and dead touches within height classes, and assess fuel hazard scores for each strata using the Project Vesta approach [15]. These assessments will then be linked to the multi-spectral data in all height classes and correlations made. These data will be used to predict rates of spread and flame heights associated with different fuel treatments based on the fire spread models currently used by the relevant agencies (DBCA, DFES) [16, 17]. Some of the treatments involve deliberate manipulation of fuel distribution, rather than simply fuel load. The impact of these modifications will be explored using a mechanistic, biophysical model of fire spread [18] that takes the distances between isolated clumps of fuel and the flammability of those clumps as input. **Team track record.** We have applied and refined fuel assessment techniques (e.g. [14]), including in urban and peri-urban systems through a separate Murdoch–Kings Park–DBCA collaboration (LP160100996) (manuscript in preparation). Our industry partner, ArborCarbon, is in the business of providing surface model information and classifying dead wood etc. for correlation with field-based measures (unpublished data under commercial in confidence).

(2) Tree health, vegetation and weed responses. Background. The health of tuart, WA peppermint (*Agonis flexuosa*), marri (*Corymbia calophylla*) and other tree species have been in decline for over a decade in Mandurah [19, 20]. A range of biotic and abiotic factors have been implicated, and these vary between tree species, but the frequency or infrequency of controlled burns has been considered a factor contributing to the decline syndromes of

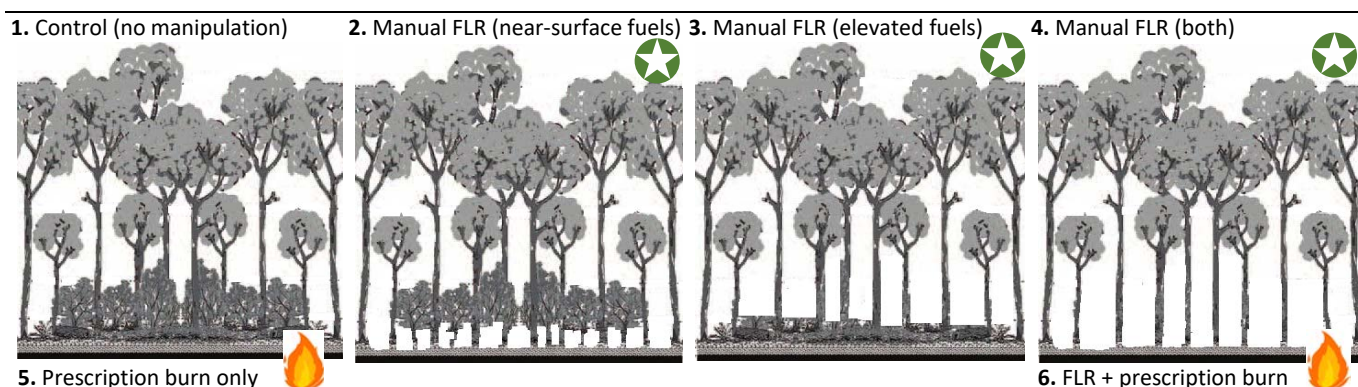


Fig. 3 Schematic of the six fuel manipulation treatments to be carried out Spring 2020. Our manual FLR experimental treatments represent combinations of: removing near-surface fuel (through raking, removing litter from around large trees, creating mineral earth tracks [e.g. posi-track path] between and around patches of habitat such as grasstrees with intact skirts); and removing elevated fuel (through slashing, pruning and thinning shrub and understorey layers). 🌟 Three treatments have follow up herbicide weed management.

Table 2. Timeline and overview of FLR treatments to be compared in this study. Fuel load reduction (FLR) will be carried out in the Austral spring 2020; monitoring sites will follow in autumn (A) each year after treatment.

	Before	After manipulation				
	Sp2020	A2021	A2022	A2023	A2024	A2025
Assessments:						
(A) Habitat and biodiversity assessment measures	x	x	x	x		
(B) Social survey of amenity values; manageability for emergency services	x	x				
(C) Decision Science workshop (Y4,5); develop education tools					x	x
Workshop for participants and interested parties						x

some of these species [21]. Understorey plant populations are likely to be impacted in some way by both mechanical removal and burning according to plant traits [22, 23], but the relative impacts of the different treatments in the urban landscapes we are working are not known. Finally, any disturbance is likely to promote weed growth. **Methods.** (i) **PhD project 1** (See F2) will complement tree health measures by quantifying soil biodiversity and function responses to FLR treatments. (ii) **Tree health** will be quantified using a combination of on-ground canopy assessments (e.g. 'crown density-foliage transparency (USDAF; 2011), 'crown condition' as used broadly for eucalypts [24]) while canopy health will be captured using high-resolution (from 3cm GSD) airborne multispectral and thermal imagery (11 spectral bands across the visible to infrared). Where trees are in decline, we will determine possible causes using established pathology techniques for root, stem and foliage pathogens as well look at issues such as salinity, pH changes, compaction and nutrient deficiencies and toxicities. (iii) **Vegetation and weed responses.** We will record cover and count abundance of all native and introduced plant species. **Team track record.** We have extensively published on our tree health assessments and vegetation analyses (e.g. [25]). We have developed a standard survey technique for this vegetation type through LP160100996, and ArborCarbon routinely uses airborne multi-spectral imagery to capture urban forest health for city councils (with a track record in Perth, Melbourne, Adelaide and Sydney) to provide information on vegetation structure, bare ground, area of vegetation, species classification, and coarse woody debris; the multi-spectral imagery will be available for Mandurah into the long-term.

(3) Fauna. Background. Controlled burns can negatively impact on small ground dwelling mammal populations due to removal of understorey that they utilise for cover (e.g. [26]), while mechanical fuel load reduction has also been shown to reduce abundance in some small mammals [27]. Hazard reduction therefore needs to be carefully planned with clear understanding of its impact on different fauna species and vegetation types [28]. Our analyses will quantify fauna responses to manipulation of vegetation structure. **Methods.** (i) **PhD project 2** (See F2) will address quenda responses to the FLR treatments. (ii) we will carry out **assessment of fauna habitat** for each site, using field assessments to identify the retention of large trees, intact grass trees, patches of dense understory, and remote sensing to map vegetation communities, vertical structure through 3D surface modelling, and presence of major dead wood that may contain hollows. (iii) use a wide range of survey methods to **quantify fauna activity** – camera trapping for medium-sized mammals (monitoring quenda activity), spotlighting for arboreal mammals (monitoring western ringtail possum activity), pitfall trapping for reptiles, and visual surveys for birds. We will compare species richness, activity indices and community composition between treatments and across timepoints. **Team track record.** Wildlife biology is a major strength at Murdoch, with many Wildlife Biology and Conservation students seeking suitable research projects. We have published similar broad surveys of fauna responses to environmental health (e.g. [25, 29-32]).

(B) In Y1 (before treatment) and Y2 (after treatment), we will assess SOCIAL VALUES:

(4) Community values. Background. The amenity values of urban bushland reserves (and therefore house prices, quality of life, and human health) are all inextricably linked with ecosystem vitality [33] – nobody wants to live next door to dead and dying vegetation [34]. Utilising a greater range of tools for implementing FLR, together with a Decision Making tool that will help determine the best approach to hazard reduction according to circumstances, will therefore directly contribute towards environmental and social outcomes. **Methods.** (i) Carry out a **community survey** (online/hard copy) sent out to Mandurah residents supported by focus group assessments on opinions about fire in urban environments (e.g. smoke, burning, impact on bushland amenity values), perceived fire risk, trust in local authorities to provide advice and implement hazard reduction, and barriers and motivators for taking action to mitigate such risk. (ii) conduct **focal group assessments** – with groups of residents walking through reserves before and after treatments to identify whether the treatments have addressed their fire risk concerns and address amenity assets. **Team track record.** We have a solid track record of similar research undertakings; e.g. with Mandurah, we have completed community surveys to assess responses to biodiversity values, gardening practices, and pet ownership (unpublished).

(C) In years 4/5, we will develop DECISION-SUPPORT AND EDUCATION TOOLS

(5) Structured Decision Making. Background. Capturing the biodiversity values as part of a decision science model will help to engender support for further hazard reduction assessment and action. **Methods.** In addition to flora and fauna responses, we will include calculations of the (i) **costs of control action** for alternative control methods (recording effort for control activity for each treatment; hours per hectare); (ii) **community values** – perceptions of fire risk reduction and amenity; and (iii) **emergency services values** – monetary value for alternative fire risk management methods and perceived future manageability of the treatment sites for emergency services personnel.

Team track record. We have carried out structured Decision Making as part of industry-integrated studies (e.g. [35, 36]).

(6) Develop extension and training. Background. Practical tools that residents can implement on their own are required. TECs and Threatened Species are not confined to public land, and therefore pose a challenge for private landholders who are required to reduce fuel loads on their properties. The southern end of Mandurah has a high number of TECs and Threatened Species and is comprised of rural-residential and rural blocks that need to be managed for bushfire risk. Should a resident unintentionally have a detrimental impact on a Threatened Species while reducing fuel loads, they could risk contravening legislation protecting these species. Further education and support for residents is therefore required to ensure any fuel removal is both effective and done in accordance with best practice. In addition, education and training on fuel load assessment and how to determine the best method of hazard reduction for their property will provide landholders with the ability to effectively manage fuel loads. This also has the potential to reduce community fear around bushfire risk. **Methods.** (i) **Targeted training for residents.** Developing resources and educational tools for fire risk management based on *needs analysis* and the barriers/motivators for fire risk management identified from the community survey. Tools that will be developed include: online self-assessments; directory of education resources; engaging community education workshops. (ii) **Develop the next generation of scientific leaders** through education of higher degree by research (HDR) students (Honours and PhD), including Structured Decision Making mentoring (supported by PI Barnes, modelled after the world-leading U.S. Fish and Wildlife Service program). (iii) **Tools.** Development of fuel arrangement guides and tools for residents. **Team track record.** We have track record of developing educational resources, both community-based and K-12 curriculum-linked through our previous ARC-LP with Mandurah and have had excellent feedback from teachers, community members and industry partners. We will work closely with Mandurah to identify the most relevant materials and valued approaches.

FEASIBILITY. We have a high quality, supportive research environment with facilities necessary to conduct the proposed study. | **Mandurah** spends a good proportion of its annual budget on actions that empower the community to play an active role in environmental protection and restoration. The city is genuinely committed to this research collaboration; for example, Mandurah and MU researchers have been Industry Partners on two previous ARC Linkage Projects with CI Hardy (LP0346931, LP0668195 also with CI Fleming), were financial contributors to the WA State Centre of Excellence in Climate Change, Woodland and Forest Health (with both CI Hardy and CI Fleming) and are collaborating on a current ARC Linkage project (LP160100441, CI Fleming and CI Hardy). | **Murdoch University** (administering organisation) is research-led that ranks in the top 100 Young Universities worldwide (THE 2019). Murdoch's extremely strong research environment is directly relevant to this project, bringing together outstanding ecologists, biological scientists, biotechnologists and education specialists to create the capacity to tackle environmental sustainability challenges now and into the future. The CIs work in the Research Centre for Environment and Conservation Sciences (ECS) under the Harry Butler Institute (HBI) <https://www.murdoch.edu.au/research/institutes-centres/harry-butler-institute>. This Centre produces robust science in disturbance ecology: environmental and biodiversity conservation in the presence of fire, climate change, pathogens and invasive species, habitat loss, salinisation, and the impacts of human activities on ecosystems. With research strengths (ERA 2018 rankings) in Environmental Science and Management (5), Ecology (4), and Zoology (5), the collaborative research environment provides a wealth of opportunities at the interface between disciplines. Of direct relevance for this project, we have internationally-recognised strengths in Forest Pathology, Fire Science, and Wildlife Biology, with large cohesive research programs in these fields that directly complement our translational research in Policy Development and Education for Sustainability. | **DBCA Science** also has extensive capacity and facilities in fire science. DBCA undertakes scientific research to inform fire management and biodiversity conservation on lands across the State to ensure the best available scientific information is used for integrated fire management to protect communities and natural values. For example, the Fire Risk Management project led by CI Miller (<https://www.bgpa.wa.gov.au/about-us/information/research/ecosystem-ecology/fire-risk-management>), which has been running since 2014, is assessing the impact of different fire and weed management activities on native bushland in urban areas and directly complements the proposed study. | **ArborCarbon** has substantial experience working with LGAs and other industry organisations to develop their capacity in vegetation assessment and analysis. Their high-level technological approach to forest pathology (unpublished data commercial in confidence) has resulted in their being appointed to the Western Australian Local Government Agency (WALGA) preferred supplier panel for Environmental Consultants. ArborCarbon's involvement will ensure this project has access to the latest innovative technologies for vegetation health and fuel load assessment.

BENEFIT. Managing urban bushland fire risk is fundamental for protection of property and lives, as well as for conservation objectives. **A range of alternative FLR approaches would increase the range of management choices for controlling bushfire risk around human lives and property.** By documenting the costs, hazard reduction, residual risk, effectiveness and impact of different FLR treatments, we will assist managers to determine the best option under different circumstances. This will assist land managers to better manage risks relating to unintentionally triggering State or Federal environmental legislation by detrimentally impacting on a threatened species. Such tools would also enable LGAs to demonstrate due diligence in planning to reduce risk to threatened species or threatened ecological communities when reducing fuel loads. **We will therefore enable LGAs to better deal with corporate risk and liability.** We will develop a model system for engaging local community action in bushfire risk mitigation in urban bushland that maintains tree health, habitat for fauna, and amenity values for residents. Increasing the range of tools that local residents can implement and engaging them with training will improve confidence in the effectiveness and impact of hazard mitigation measures. The applied nature of these data will therefore maximise economic, commercial, environmental and social benefit to Australia. **Structured Decision Making is explicitly consultative and designed to be inclusive of multiple values and will be a model that can be applied broadly across Australia.** We will also further develop the strategic research alliances between Murdoch University and the City of Mandurah, a partnership that has been growing over the last 16 years. Collaborative trans-disciplinary science has a number of benefits, in particular the development of productive partnerships that result in better evidence to support decisions. Working with ArborCarbon adds a small business to this research team. Importantly, ArborCarbon will be located on MU South Campus from January 2020. This proximity will facilitate and strengthen our collaboration. **Developing these collaboration linkages will provide excellent value.**

COMMUNICATION OF RESULTS. Murdoch and Mandurah researchers have worked in collaboration previously on three ARC LPs. The research and community outputs of this collaboration, as indicated in sections above, provides demonstrable evidence of freedom to operate to enable future benefits to end-users beyond the immediate research collaboration. We will disseminate and promote research outcomes of this project through scientific and general publications, while development of decision support tools will encourage uptake of results that should be more broadly designed to address resident's and the City's concerns. We will run a Symposium/Workshop on our findings in Year 5 for Mandurah residents, DBCA, DFES and other interested groups. Outcomes from this project will include: *Scientific:* quantify fuel load and arrangement, biodiversity responses, and social acceptance of alternative fire mitigation treatments; initiate long-term monitoring. | *Social:* Decision Making mentoring; increased community involvement in local fauna and natural resource conservation and greater engagement, confidence and support for bushfire management strategies; development of tools for local residents to implement hazard reduction in the absence of applying prescribed burns on private property. | *Management:* develop decision support tools, engage more urban residents in bushfire risk mitigation action; increase local skills; empower residents to take bushfire hazard mitigation action.

MANAGEMENT OF DATA. Field sites will be established for long term monitoring; data relevant to each plot will be retained by Murdoch University and the City of Mandurah. Data will be shared and managed by all research partners to allow broad dissemination. Data will also be stored on Dryad.

REFERENCES (* indicates publications of the CIs) | 1. Gregory, et al., *Structured Decision Making: a practical guide to environmental management choices*. 2012: John Wiley & Sons. | 2. Hammond, et al., *Smart choices: A practical guide to making better decisions*. 2015: Harvard Business Review Press. | 3. UN. 2018, The United Nations Population Division's World Urbanization Prospects. | 4. ABS. *Regional Population Growth, Australia, 2017-18*. Australian Bureau of Statistics, 32180 2019 page last updated 27 March 2019 30 July 2019]. | 5. Bond. 2005. *J Veg Sci* 16:261-266. | 6. Burrows. 2008. *For Ecol Man* 255:2394-2406. | 7. Underwood, et al. 2009. *Div Dist* 15:188-197. | 8. Ximenes, et al. 2017. *Aust For* 80:88-98. | 9. McCaw. 2013. *For Ecol Man* 294:217-224. | 10. Hughes & Fenwick. 2015, Climate Council of Australia Ltd.: Potts Point, NSW, Australia. | 11. Bureau of Meteorology. *Fire weather*. 2019; Available from: <http://www.bom.gov.au/state-of-the-climate/australias-changing-climate.shtml>. | 12. Cruz, et al. 2018. *Env Model Software* 105:54-63. | 13. Gould, et al. 2011. *For Ecol Man* 262:531-546. | *14. Fontaine, et al. 2012. *Int J Wildland Fire* 21:385-395. | 15. Gould, et al. 2007. *Fuel Dynamics and Fire Behaviour* 218: | 16. Cheney, et al. 2012. *For Ecol Man* 280:120-131. | 17. Sneeuwjagt. 1985, Department of Conservation and Land Management. | 18. Zylstra, et al. 2016. *PLoS One* 11:e0160715. | *19. Scott, et al. 2009. *Persoonia* 22:1-13. | 20. *Wentzel, et al. 2018. *Australasian Plant Pathology* 47:521-530. | *21. Archibald, et al., 2005. Millpress Science Publishers. | *22. Enright, et al. 2014. *J Ecol* 102:1572-1581. | *23. Enright, et al. 2011. *Plant Ecol* 212:2071-2083. | 24. Souter, et al. 2010. *Ecol Man Rest* 11:210-214. | *25. Anderson, et al. 2019. *Aust Mammal* In press: | 26. Lawes, et al. 2015. *PLoS One* 10:e0130626. | 27. Bull & Blumton, in *Pacific Northwest Research Station Research Note PNW-RN-539 March 1999*. 1999: United States Department of Agriculture Forest Service. | 28. Converse, et al. 2006. *Ecol Appl* 16:1717-1729. | *29. Moore, et al. 2014. *Aust Mammal* 36:35-44. | *30. Moore, et al. 2013. *Wildl Res* 40:358-366. | *31. Moore, et al. 2013. *Aust J Zool* 61:187-195. | *32. Wentzel, et al. 2019. *Aust Ecol* 44:265-275. | 33. Helliwell. 1967. *Arbor Ass J* 1:128-131. | 34. Tyrväinen, et al. 2003. *Urban Forestry & Urban Greening* 1:135-149. | 35. Tulloch, et al. 2015. *Frontiers in Ecology and the Environment* 13:91-99. | *36. Barnes, et al. 2019, PeerJ Preprints. |

C2. Medical Research

(Does this project contain content which requires a statement to demonstrate that it complies with the eligible research requirements set out in the ARC Medical Research Policy located on the ARC website?)

No

C3. Medical Research Statement

(If applicable, justify why this project complies with the eligible research requirements set out in the ARC Medical Research Policy located on the ARC website. Eligibility will be based solely on the information contained in this application. This is your only chance to provide justification, the ARC will not be writing to seek further clarification. (No more than 750 characters (approximately 100 words))

Part D - Personnel and ROPE (Prof Patricia Fleming)

D1. Personal Details

(To update personal details, click the 'Manage Personal Details' link below. Note this will open a new browser tab. When returning to the form ensure you 'Refresh' the page to capture the changes made to your profile.)

Participation Type

Chief Investigator

Title

Prof

First Name

Patricia

Family Name

Fleming

D4. Qualifications

(To update any qualifications, click on the 'Manage Qualifications' link below. Note this will open a new browser tab. When returning to the form ensure you 'Refresh' the page to capture the changes made to your profile.)

Conferral Date	AQF Level	Degree/Award Title	Discipline/Field	Awarding Organisation	Country of Award
31/12/2005	Masters Degree	Master of Science	Environmental Science	Murdoch University	Australia
30/04/1996	Doctoral Degree	Doctor of Philosophy	Neuroscience	The University of Western Australia	Australia
30/12/1990	Bachelor Honours Degree, Graduate Certificate, Graduate Diploma	Bachelor of Science (Honours)	Zoology	The University of Western Australia	Australia

D5. Research Opportunity and Performance Evidence (ROPE) - Current and previous appointment(s) / position(s) - during the past 10 years

(To update any details in this table, click on the 'Manage Employment Details' link below. Note this will open a new browser tab. When returning to the form ensure you 'Refresh' the page to capture the changes made to your profile. Refer to the Instructions to Applicants for more information.)

Description	Department	Contract Type	Employment Type	Start Date	End Date	Organisation
Professor	Environmental and Conservation Sciences	Permanent	Full Time	06/03/2019		Murdoch University
Associate Professor	School of Veterinary & Life Sciences	Permanent	Full Time	10/06/2013	05/03/2019	Murdoch University
Senior Lecturer	School of Veterinary & Biomedical Sciences	Permanent	Full Time	01/01/2010	09/06/2013	Murdoch University
Lecturer	School of Veterinary & Biomedical Sciences	Permanent	Full Time	01/07/2006	31/12/2009	Murdoch University

D6. Research Opportunity and Performance Evidence (ROPE) - Academic Interruptions

(You must read the ROPE Statement <http://www.arc.gov.au/arc-research-opportunity-and-performance-evidence-rope-statement> before filling out this section.)

Have you experienced an interruption that has impacted on your academic record?

Yes

From when

01/04/1996

To when

01/04/1999

FTE of academic interruption

1

Details

After completing my PhD, I travelled overseas for 3 years and worked in a diversity of non-science positions.

D7. Research Opportunity and Performance Evidence (ROPE) - Details of the participant's academic career and opportunities for research, evidence of research impact and contributions to the field, including those most relevant to this application

(Provide details of your academic career and opportunities, evidence of research impact and contributions to the field. (Upload a PDF of no more than five A4 pages))

Uploaded PDF file follows on next page.

Research Opportunity and Performance Evidence (ROPE)

AMOUNT OF TIME AS AN ACTIVE RESEARCHER I was awarded my PhD 23 years ago in 1996 and in that period I experienced a total of three years of academic interruptions (i.e. 20 years in research pursuit); I have also moved country three times over the last 23 years, requiring a new start each time I moved country. Since 2004, approximately 40% of my time has been officially allocated to research, and much of the remainder to teaching and administration, including supervision of research students.

RESEARCH OPPORTUNITIES: Postdoctoral research: After completing my PhD, I travelled overseas for 3 years and worked in a diversity of non-science positions. I had a strong ambition to work in Africa, and so set about to obtain funding and research permission to work in Zimbabwe. After 14 months, battling bureaucracy, I secured permission of the Office of the President and an association with the University of Zimbabwe (6 months) which allowed me to work in the country. I then applied for postdoctoral position at the University of Cape Town (1 year) and later at the University of Pretoria (3 years). During these years, I gained a huge amount of experience working with different species across a range of disciplines (ecology, physiology, behaviour) and faced substantial political and intellectual challenges. This time stretched my capacities and the experience and skills were immensely formative to my future career. Most importantly, my time in Africa sparked my commitment to make a substantial contribution, at home, for Australian wildlife. Everyone wants to work in Africa, but I recognised as an Australian, the importance of being accountable for conservation action to protect wildlife species on this continent.

When I returned to Australia, I worked in a non-research position for a year (Native Vegetation Protection; Government of Western Australia). This position provided insight into the challenges of trying to conserve habitat via legislation. At the same time, I was studying for my Masters in Environmental Management degree. The juxtaposition of implementing government regulations while studying was an important step in developing my current research approach. Working directly with community members (as applicants for vegetation clearing permits) provided an important reality check in terms of the applicability of scientific research for the broader audience. It cemented my desire to work in practical, applied research fields.

Current position and considerations: I was offered my current position at Murdoch late in 2004 (~15 years ago). I have successfully applied for three promotions since my appointment as Associate Lecturer, with an average of 3y between promotion applications (the minimum time allowed). My position since employment at Murdoch is nominally: 40% research, 40% teaching and 20% administration. Two-thirds of my teaching allocation is represented by supervising research students.

Research mentoring and research facilities available to me during my career:

Murdoch University (MU) is extremely supportive of research and provides excellent access to mentors, research students, world-class animal housing, and library facilities. MU arguably leads Western Australia academic institutions in wildlife biology research, with an array of undergraduate courses (Conservation & Wildlife Biology, Biological Sciences and Environmental Science), many postgraduate degrees, and a long-standing active core of research staff in this area. These courses have always ensured that there have been a large number of enthusiastic and well-equipped students looking for Honours, Masters and PhD projects. I have therefore been in a position to work with some excellent graduates. I have strong research collaborations with more than 11 Murdoch researchers across a range of disciplines.

University support: There is very strong research culture in Life Sciences at Murdoch University. The proposed research is strongly underpinned and supported by Murdoch's strategic focus on the environment under the **Harry Butler Institute** (HBI; one of the three Murdoch University research institutes). Under the HBI, the **University Research Centre for Environment and Biodiversity** provides robust science underpinning environmental and biodiversity conservation in the presence of climate change, invasive species, habitat loss, salinisation, disease, and the impacts of human activities on ecosystems. This Centre captures the efforts of 17 tenured researchers who work directly with 11 government departments, 12 local governments, five local research institutions (e.g. CSIRO, the WA Museum, WA Biodiversity Science Institution, WA Marine Science Institution, Australian Institute of Marine Science), over 15 community groups, and at least 25 industry bodies. We also collaborate broadly with researchers across 40 national and international universities. Our focus on identifying biodiversity processes and threats to understand biodiversity conservation issues, and work with community, industry and regulators to protect biodiversity and restore habitats through policy and governance of natural resources. Our work therefore spans basic biological understanding through to improved management practice for sustaining, conserving and restoring

ecosystems. With research strengths (ERA 2018 rankings) in Environmental Science and Management (5), Ecology (4), and Zoology (5), the collaborative research environment at Murdoch University provides a wealth of opportunities at the interface between disciplines. Of direct relevance for this project, we have internationally-recognised strengths in Plant Pathology and Wildlife Biology, with large cohesive research programs in these fields that complement our translational research in Policy Development and Education for Sustainability. **Facilities:** I have excellent dedicated laboratory space and a 4WD vehicle for the sole use by my research group, and access to other University vehicles. Murdoch’s Research Office provides assistance in grant submission and the administration of successful applications, and our administrative and finance teams provide excellent support. Our strong collegial network (locally, nationally, and internationally) enables opportunities to grow our research into novel areas, such as demonstrated by this proposal.

RESEARCH ACHIEVEMENTS AND CONTRIBUTIONS

Metrics of research output quality @13 December 2019. My 162 (Scopus) or 192 (Google Scholar) international peer-reviewed journal publications have been cited a total of 2,479 or 3,522 times. My field-weighted citation impact score (2015-8) is 1.16 (SciVal) and my ResearchGate score (39.82) is higher than 97.5% of RG members. My hla index (Harzing et al. 2014) is in the top of the range of benchmarked academics (Level D and E) in the Sciences or Life Sciences (Fig. 1).

Whole career 192 peer-reviewed publications[†] (first author on 31 of these and last author on 87) Papers in 62 journals h index: Scopus 23 [‡] Google Scholar 27 hla 0.65[†]	Over the last 5 years (2014-2019) 63 peer-reviewed publications[†] (first author on 10 of these and last author on 51) Papers in 39 journals h index: Scopus 9 [‡] Google Scholar 12 hla 1.1 [†]
Grant income \$ 10,568,418 PhD completions 17 (+7 current) Masters completions 3 (+ 2 current) Honours completions 47 (+1 current)	Grant income \$ 2,272,691 PhD completions 12 (+7 current) Masters completions 2 (+ 2 current) Honours completions 20 (+1 current)
Citation metrics are based on Scopus: [‡] Proportion of citations to my work with at least one author from outside Australia. No difference with or without excluding self-citations. [†] The hla (Harzing et al. 2014) ¹ is calculated from the average number of single-author-equivalent “impactful” articles that an academic has published per year, and represents the average annual increase in the individual h-index (Fig. 1).	<p>Fig. 1. My (TF) hla index relative to benchmarked Level D and E academics. Whiskers: mean ± SD; box: range.</p>

Prizes, honours and awards

- 2018 – Mike Bull Award for best student-led paper in Austral Ecology (Dawson et al. 2017).
- 2018 – Australian Petroleum Production and Exploration Association award for environmental excellence ‘Kimberley Bilby Initiative’.
- 2017 – Munson Award from the American Association of Zoo Veterinarians for the top pathology paper in either the Journal of Zoo and Wildlife Medicine or the Journal of Wildlife Diseases (Macgregor et al. 2017).
- 2015 – Murdoch University Vice-Chancellor’s Excellence in Research Award (Sustained Research Effort).
- 2006 – Murdoch University Vice-Chancellor’s Excellence in Research Award (Early Career Researcher).

Invited keynote and speaker addresses

- My students and I have presented at over 100 national and international conferences.
- 2017 – Invited presenter as part of the WA Minister’s Forum on Wild Dogs
- 2017 – Invited researcher as part of a workshop on the role of digging mammals in restoration (Canberra, Australia) – travel and accommodation were paid by the workshop organisers
- 2012 – Invited to the International Herpetology Conference (Vancouver, Canada) – travel, registration and accommodation were paid by the symposium organisers

¹ Harzing et al. 2014 hla: an individual annual h-index to accommodate disciplinary and career length differences. *Scientometrics* 99:811.

Other Invited speaker events: 2018 – WA Forest Science Forum; 2018 – Chittering Landcare tree decline workshop; 2018 – Dieback Information Group symposium; 2018 – Urban Bushland Council; 2018 – Western Australian Local Government Authority (WALGA) symposium; 2017 – Quokka Symposium (organised by the Rottnest Island Authority); 2016 – Guildford Association on impacts of *Eucalyptus rudis* decline on fauna; 2015 – Perth Science Festival; 2015 – Department of Biodiversity, Conservation and Attractions on fox baiting.

Research support income:

I have had marked success in establishing cross-disciplinary research collaborations and have contributed to grants totalling **\$4 million over the last 10 years**. Many of these grants have been successful because of our application of novel techniques and approaches to address common problems.

Years	Investigators	Title	Funding body (abbreviations†)	Total (\$)
2017–2019	Collins, Barnes, Fleming , Miller	Welfare Indicator Dashboard; a pilot study for the live export supply chain	MLA and Livecorp	721,460
2016–2019	Fleming , Adams, Kreplins, Bateman, Whiting, Stuart	Predation of marine turtle nests and hatchlings by the red fox (<i>Vulpes vulpes</i>); understanding predator behaviour at marine turtle rookeries	DBCA	111,896
2017–2019	Fleming , Hardy, Baudains	Backyard Bandicoots: engaging community in urban bushland conservation	ARC LP160100441	200,000
			City of Mandurah	75,000
2015–2017	Adams, Fleming , Murray, (CSIRO), van Klinken (CSIRO)	Reducing feral pig disease risks through the use of aerially deployed infrared sensors and habitat modelling	BBD RDF14-00044 DPIRD Biosecurity Research and Development Fund	558,300
2015–2017	Fleming , Adams, Baudains	Reducing impacts of wild canids on livestock production industries	BBD RDF14-00034 DPIRD Biosecurity Research and Development Fund	286,000
2014–2017	Dawson, Adams, Fleming	Disturbance ecology of the bilby (<i>Macrotis lagotis</i>) in the Canning Basin.	Buru Energy Ltd Industry sponsorship	22,500
2014–2015	Wickham, Fleming , Barnes, Miller, Collins	Development and Assessment of Livestock Welfare Indicators	W.LIV.3032 MLA	138,000
2013	Barnes, Collins, Fleming , Miller, Wickham	Heat load in sheep exported to Middle Eastern feedlots	W.LIV.3018 MLA	72,085
2011–2014	Fleming , Collins, Miller, Barnes, Stockman, Wickham	Developing qualitative behavioural assessment as an objective measure of pig welfare	APL 2011/1018.347 Postgrad Scholarship APL 2010/1000.382	120,000
				114,500
2011–2012	Miller, Stockman, Fleming , Collins, Barnes	Preparation of rangeland goats for live export	Meat & Livestock Australia (MLA – WLIV0159)	159,000
2011	Warren, Fleming , Holyoake, Robertson, Fleming	Platypus conservation: development of a framework to assess the health of wild platypus populations	The Winifred Violet Scott Estate	40,000
2009–2011	Adams, Fenwick, Fleming	Quantifying Feral Pig Abundance and Efficacy of Control Strategies in Southwest Western Australia	Water Corporation, BHP	80,000
2009–2013	Barnes, Miller, Stockman, Collins, Fleming	Strategies to reduce inanition in sheep	MLA	1,123,352
2009–2011	Fleming , Parsons	Novel applications of sensory based predatory cues to mitigate impact of wildlife encroachment on human habitats	Minerals and Energy Research Institute of WA (MERIWA)	213,000

† MLA: Meat & Livestock Aust; DPIRD: Dept. Primary Industries and Regional Development WA; DBCA: Department of Biodiversity, Conservation and Attractions (formerly Department of Parks and Wildlife); APL: Australian Pork Limited

Commercial outcomes and resulting benefits

My work has translated into practical, on-ground applications as well as scientific peer-reviewed publications:

- 1. Backyard bandicoots:** We have been working with the City of Mandurah since 2013, on a transdisciplinary project examining the role of bandicoots as contribution to healthy urban bushland. Quenda (our local bandicoot species) move mycorrhizal fungi between reserves with their scats, and we have shown that these fungi are important for maintaining tree health. The challenge has therefore been to determine whether we can use quenda scats as an inoculant for seedlings (ARC LP16010044 \$275,000). Work commenced under the WA State Government Centre of Excellence for Climate Change, Woodland & Forest Health (2008-2013; \$4.7 million).

2. Invasive species biology and control: 'Reducing impacts of wild canids on livestock production industries'

(\$286,000; Royalties for Regions Boosting Biosecurity, DPIRD) has already resulted in three papers published in 2018; at least four more are in various stages of writing or review. Amongst other studies, our paper describing the fate of dried meat baits deployed to control wild dogs will likely influence best practice for the industry, as our findings are informative but controversial. This work with Dr Malcolm Kennedy (DPIRD) has catalysed three projects funded through the Centre for Invasive Species Solutions (CISS) (~\$300,000 – DPIRD as administrating organisation). These projects will extend upon our wild dog research to establish monitoring protocols for kangaroos and wild dogs, identify the impacts of control on landscape productivity, and therefore impacts on livelihoods of farmers. This project will also develop linkages with researchers across Australia.

3. Development of animal welfare assessment tools: I led a programme of experiments developing and validating the novel application of qualitative behavioural assessment (QBA) in sheep and cattle (MLA; \$560,000). This basic proof of concept research was followed by funding secured to examine sheep under commercial transport (Australian Animal Welfare Strategy), pigs under different housing conditions (APL; \$234,000), cattle during castration (MLA), and as a measure in goats during habituation to handling (MLA; \$159,000). This welfare assessment work has been further developed through work on inanition in sheep (MLA; \$1,123,000) and thermal challenges for live export animals (MLA; \$72,000). We are currently working on a project developing welfare indicators for the live export industry (LiveCorp; \$721,000) and using our assessment methods to identify stress levels in cattle processed at the abattoir (Harvey Beef).

Identifiable benefits outside of academia

I have had considerable interest in my research from international media and my work has been picked up in the popular literature (e.g. websites, newspapers). Four of my studies are in the top 5% in terms of Altmetric scores, for example:



My 2013 manuscript '**Sexual selection on forelimb muscles of western grey kangaroos (Skippy was clearly a female)**', published in *Biological Journal of the Linnean Society* (Warburton et al. 2013), received a great deal of press through online blogs, science reports, radio and TV interviews:

- Write-ups: Northern Daily Leader, Libero 24x7, Ballarat Courier, Canberra Times, Age, The Times of India, The New Zealand Herald, Post, Deccan Chronicle, Zee news India, Burnie Advocat, Warnambool Standard, Bendigo Advertiser, ninemsn, SBS World News Australia, Yahoo News Australia, University World News, Sydney Morning Herald, Launceston Examiner, The West Australian, Adelaide Advertiser, Big News Network, Australasian Science, Australian Timescomuk, Science Network, The University of Waikato, Asian Scientist, PhysOrg, The Conversation, Smithsonian.com, editor. Smithsoniancom, Time: Science and Space, ABC Online, Australian Geographic
- Interviews: PAF ABC North West WA Karratha, Statewide Drive with Barry Nicholls (4 min 25 s), 720 ABC Perth (52 s), PWB: 702 ABC Sydney (8 min 55 s), PWB 3AW Melbourne (3 min 48 s), NW: TV Tokyo, Interview with Ian Connellan from Australian Geographic, 2UE The George and Paul Show Sydney (4 min 57 s)
- Radio news: 720 ABC Perth, 666 ABC Canberra Afternoons with Alex Sloan, 720 ABC Perth News (51 s), ABC Darwin News (40 s), ABC Broken Hill News (23 s)



My 2016 review on Australian mammal research effort and impact '**The good, the bad, and the ugly: which Australian terrestrial mammal species attract most research?**', published in *Mammal Review* (Fleming and Batemen 2016), is one of the highest-scoring outputs from this source in terms of its social outreach (#3 of 293; Altmetrics) and is in the 99th percentile with a 'High Attention Score compared to outputs of the same age'.



My 2014 review on digging mammals '**Is the loss of Australian digging mammals contributing to a deterioration in ecosystem function?**' published in *Mammal Review* (Fleming et al. 2014) – a topic that is study is topical and important in a changing climate faced by Australian fauna – drew a high level of media attention: Writeups: PhysOrg.com, ScienceNetwork WA, National Australasian Science, Scientific American, ABC Catalyst, Science Alert, The Conversation, Austrian Tribune, Kopalnia Wiedxy, The Guardian, Wiley's News Round-Up, Harvey-Waroona Reporter, Southern Gazette Community Newspaper Group, Animals Australia, ABC Science Online, University World News, Big News Network; Radio interviews for Science Network, ABC Radio National.

I produce papers of global significance; many are significant beyond biological and environmental sciences. The geographic spread of citations to my work demonstrates a strong international acceptance of my research: 73% of

D8. Research Opportunity and Performance Evidence (ROPE) - Currently held ARC projects

(This information is auto-populated from the applicants RMS profile and will include any active project which has not yet had a Final Report approved and the project file closed by the ARC. You will not be able to submit an application to the ARC that involves a researcher who has an overdue Final Report on an ARC-funded project. If there are any concerns with the information recorded here, contact Your organisation's Research Office.)

Identifier	Investigators	Admin Organisation	Project Title	Funding	End Date	Final Report Due Date	Final Report Status
LP160100441	Prof Patricia Fleming ; Prof Giles Hardy ; Dr Catherine Baudains ; Mr Brett Brenchley	Murdoch University	Backyard Bandicoots: Engaging community in urban bushland conservation	\$200,000	30/06/2020	30/06/2021	Draft

D9. Project/Role relinquishment or application withdrawal

(If you exceed the Linkage Program limits on projects and/or applications and have applied under the Industrial Transformation Research Hubs, Industrial Transformation Training Centres, Special Research Initiatives, Learned Academies Special projects, Supporting Responses to Commonwealth Science Council Priorities or any other Linkage Program scheme, list the application you wish to withdraw, or the existing project (or role) that that you wish to relinquish should this application be successful (see sections 6.35 to 6.39 of the grant guidelines). Failing to provide this information will jeopardise the eligibility of your applications. Provide project/application ID(s) separated by a comma.)

D10. Eligibility - Role of Partner Investigator

(Please indicate which of the Partner Investigator role options from section 6.29 of the grant guidelines apply to your role on this project. Select all options that apply.)

D11. Eligibility - Will the participant be residing predominately in Australia for the duration of the project activity period?

((This is a 'Yes' or 'No' question. Indicate whether the participant will be residing predominantly in Australia for the project activity period. If the participant is applying as a CI and they answer 'No' to this question you will be prompted to contact the Research Office to check the participant's eligibility. If the participant is a Foreign National, they must reside legally in Australia. Eligibility will be based solely on the information contained in this application.))

D12. Eligibility - Is the participant currently undertaking a Higher Degree by Research which will be conferred after the grant commencement date?

((This is a 'Yes' or 'No' question. If the participant is applying as a CI and they answer 'Yes' to this question they will be prompted to contact the Research Office and Part D will not validate. Eligibility will be based solely on the information contained in this application.))

D13. Eligibility - Employment Details as at grant commencement date of project

(This question will be used to determine your eligibility. Your eligibility will be based solely on the information contained in this application. Confirm your employment status at all organisations that you will be associated with as at the Grant Commencement Date. Enter the relevant appointment type and Full-Time Equivalent (FTE) for each organisation.)

Org name	Is this an Eligible Organisation?	Please choose your appointment type for this organisation.	Please enter your FTE for this Organisation
Murdoch University	Yes	Employee	1

D14. Eligibility - Further Details Regarding Partner Investigator Status - Does the participant hold a remunerated appointment at an Eligible Organisation as at the grant commencement date for this project?

(At A2 Partner Investigator has been selected as the role type, but it appears that the participant meets the criteria of a Chief Investigator.

NOTE: this question is mandatory ONLY FOR PIs WHO:

- at D11 confirmed that they will reside predominantly in Australia for the project activity period of the proposed Project; AND
- at D12 confirmed that they are not currently undertaking a Higher Degree by Research which will be conferred after the grant commencement date; AND
- at D13 indicated that they would hold either:
 - an appointment at an Eligible Organisation equal or greater than 0.2 FTE; OR
 - an honorary academic appointment at an Eligible Organisation

You do not need to answer these questions if it was indicated in question D11 that the participant will be living predominantly overseas OR if they have indicated in question D12 that the participant will be undertaking a Higher Degree by Research.)

Do you hold a remunerated appointment at an Eligible Organisation?

Justification of PI status

D15. Eligibility - Relevant Organisation for this application as at the grant commencement date for this project

(Enter the Organisation that is relevant to the participant's inclusion on this application, and that they will be associated with as at the grant commencement date. The 'relevant organisation' is the primary organisation that will be supporting the participant's involvement in this project if it is funded. Note that the Organisation must be listed in D13 for this question to validate.)

Relevant Organisation

D16. What is the participant's time commitment to this project?

(Enter the participant's time commitment to this project as a Full-Time Equivalent (FTE). Note that a FTE of 1.0 represents a full-time commitment (i.e. 5 days per week).)

D17. Research Opportunity and Performance Evidence (ROPE) - Research Outputs

(Research context: Provide clear information that explains the relative importance of different research outputs and expectations in the participant's discipline/s. The information should help assessors understand the context of the participant's academic research achievements but not repeat information already provided in this application. It is

helpful to include the importance/esteem of specific journals in the participant's field; specific indicators of recognition within the participant's field such as first authorship/citations, or the significance of non-traditional research outputs. If this question is not relevant to a participant, for example a PI with non-academic background, the participant should include a short explanatory statement as to why this question is not applicable. (No more than 3,750 characters, approximately 500 words))

MY PUBLICATION STRATEGY.

I work directly with industry partners on research questions that directly address conservation or welfare issues. This work can yield results that are specific to the particular issue being addressed, but also has had broader international implications. For example, my research in animal production has aimed to validate and implement world-standard objective measures of animal welfare. My conservation-directed studies have identified critical resources for wildlife species that are fundamental to how we manage these animals.

I therefore publish across a diverse range of discipline areas. I have always aimed to publish my work in high profile journals, while keeping in mind relevance to our research field. For example, I have 9 papers in journals that are ranked in the top 10 for Animal Science and Zoology (Scimago SJR). I also strongly encourage students to publish their research and play a primary role in getting data analysed (often re-analysed if required), manuscripts written up, and through the review process to publication. I believe that it is our responsibility as university educators to encourage and assist students through this learning process.

I have published a total of 160 papers and three book chapters, of which I am first author (lead investigator) on 31 of these (19%) and last (senior) author on 76 (48%). My publication rate has increased over time, and in the last 5 years, I have published 63 peer-reviewed publications; I am first author on 10 of these (17%) and last (senior) author on 51 (81%).

I have published 12 substantive review articles to synthesise over a decade of primary data collection by my laboratory within a global context, involving significant collation of primary data, meta-analyses of effect sizes and synthesis with published data. These include topics relevant to our proposal: the role of CWR digging mammals on ecosystems and the impacts of tourism on animal behavioural (escape) responses.

I have five papers with over 100 citations and my i10 index for the last five years (since 2014) is 58. I have four papers that are in the top 5% of all Altmetric records in terms of social impact scores. Two of my papers have won awards (Dawson et al. 2017 [8] Mike Bull Award Austral Ecology; Macgregor et al. 2017 [6] Munson Award from the American Association of Zoo Veterinarians), one that was recognised as Behavioral Ecology Editor's choice (May et al 2016) and four papers have made the front page of journals.

I have published in a number of high-ranking journals for my fields of behavioural ecology, zoology and wildlife biology including:

[number of papers]Scimago JR rank
of 401 journals in Animal Science and Zoology
•Behavioral Ecology [2 papers]1.871 6/401
•Behavioral Ecology and Sociobiology [3 papers]1.32316/401
•Journal of Zoology [14 papers]1.077 37/401

of 306 journals in Management, Monitoring, Policy and Law
•Wildlife Research [8 papers] 0.87667/306

of 612 journals in Ecology, Evolution, Behavior and Systematics
•Functional Ecology [5 papers]2.86826/612
•Biological Conservation[2 papers]2.397 38/612
•Mammal Review [2 papers]2.393 39/612

of 243 journals in Biochemistry, Genetics and Molecular Biology (Miscellaneous)
•Biological Reviews[1 paper]4.90014/243

of 187 journals in Physiology
•Physiological and Biochemical Zoology [5 papers]0.90493/187

D18. Research Opportunity and Performance Evidence (ROPE) – Research Outputs Listing including Ten Career-Best Research Outputs

(List the research outputs marking those that are most relevant to this application categorised under the following headings: Ten career-best research outputs; Authored books; Edited books; Book chapters; Referred Journal articles; Fully refereed conference proceedings; Additional research outputs (including non-traditional research outputs). CVs and theses should not be included in this list. The participant's ten career-best research outputs should not be repeated under subsequent headings. (No more than 100 research outputs).)

Research Outputs Listing

Generated research output document follows on the next page

Ten Career-Best Research Outputs

- [1] * Fleming, P.A., Anderson, H., Prendergast, A.S., Bretz, M.R. & Valentine, L.E. et al. 2014, 'Is the loss of Australian digging mammals contributing to a deterioration in ecosystem function?', *Mammal Review*, vol. 44, no. 2, pp. 94-108, LP0668195 (2006-2008) (Refereed Journal Article)
- [2] * Valentine, L.E., Fisher, R., Wilson, B.A., Sonneman, T. & Stock, W.D. et al. 2014, 'Time since fire influences food resources for an endangered species, Carnaby's cockatoo, in a fire-prone landscape', *Biological Conservation*, vol. 175, pp. 1-9, LP0668195 (2006-2008) (Refereed Journal Article)
- [3] * Gillian L. Bryant, Halina T. Kobryn, Giles E. StJ. Hardy & Patricia A. Fleming 2017, 'Habitat islands in a sea of urbanisation', *Urban Forestry & Urban Greening*, vol. 28, pp. 131-137, doi:10.1016/j.ufug.2017.10.016 (Refereed Journal Article)
- [4] * Valentine, L.E., Anderson, H., Hardy, G.E.S. & Fleming, P.A. 2012, 'Foraging activity by the southern brown bandicoot (*Isodon obesulus*) as a mechanism for soil turnover', *Australian Journal of Zoology*, vol. 60, no. 6, pp. 419-423, LP0668195 (2006-2008) (Refereed Journal Article)
- [5] * Craig, M.D., Hobbs, R.J., Grigg, A.H., Garkaklis, M.J. & Grant, C.D. et al. 2010, 'Do thinning and burning sites revegetated after bauxite mining improve habitat for terrestrial vertebrates?', *Restoration Ecology*, vol. 18, no. 3, pp. 300-310 (Refereed Journal Article)
- [6] * Valentine, L.E., Bretz, M., Ruthrof, K.X., Fisher, R. & Hardy, G.E.S.J. et al. 2017, 'Scratching beneath the surface: Bandicoot bioturbation contributes to ecosystem processes', *Austral Ecology*, vol. 42, no. 3, pp. 265-276, LP160100441 (2016-2018) (Refereed Journal Article)
- [7] * 'Microbat responses to forest decline', doi:10.1111/aec.12671, LP0668195 (2006-2008) (Refereed Journal Article)
- [8] * Jacobus J. Wentzel, Michael D. Craig, Paul A. Barber, Giles E. StJ Hardy & Patricia A. Fleming 2018, 'Microbat responses to forest decline', *Austral Ecology*, doi:10.1111/aec.12671, LP0668195 (2006-2008) (Refereed Journal Article)
- [9] * Leonie E. Valentine, Katinka X. Ruthrof, Rebecca Fisher, Giles E. St. J. Hardy & Richard J. Hobbs et al. 2018, 'Bioturbation by bandicoots facilitates seedling growth by altering soil properties', *Functional Ecology*, doi:10.1111/1365-2435.13179, LP160100441 (2016-2018) (Refereed Journal Article)
- [10] * Natasha E. Tay, Anna J. M. Hopkins, Katinka X. Ruthrof, Treena Burgess & Giles E. StJ. Hardy et al. 2018, 'The tripartite relationship between a bioturbator, mycorrhizal fungi, and a key Mediterranean forest tree', *Austral Ecology*, vol. 43, no. 7, pp. 742-751, doi:10.1111/aec.12598 (Refereed Journal Article)

Authored Books

- [1] Bateman, P.W. & Fleming, P.A. 2015, 'Invertebrates', *Escaping from Predators: An Integrative View of Escape Decisions*, pp. 177-196
- [2] Fleming, P.A. & Bateman, P.W. 2015, 'Fish and amphibians', *Escaping from Predators: An Integrative View of Escape Decisions*, pp. 152-176

Refereed Journal Articles

- [1] Ashleigh K. Wolfe, Patricia A. Fleming & Philip W. Bateman 2018, 'Impacts of translocation on a large urban-adapted venomous snake', *Wildlife Research*, vol. 45, no. 4, pp. 316, doi:10.1071/wr17166
- [2] Patricia A. Fleming & Philip W. Bateman 2018, 'Novel predation opportunities in anthropogenic landscapes', *Animal Behaviour*, vol. 138, pp. 145-155, doi:10.1016/j.anbehav.2018.02.011
- [3] * Ashleigh K Wolfe, Philip W Bateman & Patricia A Fleming 2017, 'Does urbanization influence the diet of a large snake?', *Current Zoology*, vol. 64, no. 3, pp. 311-318, doi:10.1093/cz/zox039
- [4] J. L. Forbes-Harper, H. M. Crawford, S. J. Dundas, N. M. Warburton & P. J. Adams et al. 2017, 'Diet and bite force in red foxes: ontogenetic and sex differences in an invasive carnivore', *Journal of Zoology*, doi:10.1111/jzo.12463
- [5] Fleming, P.A. & Bateman, P.W. 2017, 'Scavenging Opportunities Modulate Escape Responses over a Small Geographic Scale', *Ethology*, vol. 123, no. 3, pp. 205-212
- [6] Macgregor, J.W., Holyoake, C.S., Munks, S.A., Connolly, J.H. & Robertson, I.D. et al. 2017, 'Investigation into individual health and exposure to infectious agents of platypuses (*Ornithorhynchus anatinus*) in two river catchments in northwest Tasmania', *Journal of Wildlife Diseases*, vol. 53, no. 2, pp. 258-271

- [7] Forbes-Harper, J.L., Crawford, H.M., Dundas, S.J., Warburton, N.M. & Adams, P.J. et al. 2017, 'Diet and bite force in red foxes: Ontogenetic and sex differences in an invasive carnivore', *Journal of Zoology*
- [8] Worrell, T., Admiraal, R., Bateman, P.W. & Fleming, P.A. 2017, 'Are tourism and conservation compatible for 'island tame' species?', *Animal Conservation*, vol. 20, no. 2, pp. 155-163
- [9] Macgregor, J.W., Holyoake, C.S., Connolly, J.H., Robertson, I.D. & Fleming, P.A. et al. 2017, 'A need for dynamic hematology and serum biochemistry reference tools: Novel use of sine wave functions to produce seasonally varying reference curves in platypuses (*Ornithorhynchus anatinus*)', *Journal of Wildlife Diseases*, vol. 53, no. 2, pp. 235-247
- [10] * Stuart J. Dawson, Peter J. Adams, Katherine E. Moseby, Kris I. Waddington & Halina T. Kobryn et al. 2017, 'Peak hour in the bush: linear anthropogenic clearings funnel predator and prey species', *Austral Ecology*, doi:10.1111/aec.12553
- [11] Philip W. Bateman & Patricia A. Fleming 2017, 'Are negative effects of tourist activities on wildlife over-reported? A review of assessment methods and empirical results', *Biological Conservation*, vol. 211, pp. 10–19, doi:10.1016/j.biocon.2017.05.003
- [12] * Dundas, S.J., Hardy, G.E.S.J. & Fleming, P.A. 2016, 'The plant pathogen *Phytophthora cinnamomi* influences habitat use by the obligate nectarivore honey possum (*Tarsipes rostratus*)', *Australian Journal of Zoology*, vol. 64, no. 2, pp. 122-131
- [13] Fleming, P.A. & Bateman, P.W. 2016, 'The good, the bad, and the ugly: which Australian terrestrial mammal species attract most research?', *Mammal Review*, vol. 46, no. 4, pp. 241-254
- [14] May, T.M., Page, M.J. & Fleming, P.A. 2016, 'Predicting survivors: Animal temperament and translocation', *Behavioral Ecology*, vol. 27, no. 4, pp. 969-977
- [15] Fleming, P.A., Dundas, S.J., Lau, Y.Y.W. & Pluske, J.R. 2016, 'Predation by red foxes (*Vulpes vulpes*) at an outdoor piggery', *Animals*, vol. 6, no. 10
- [16] * Moore, T.L., Ruthrof, K.X., Craig, M.D., Valentine, L.E. & Hardy, G.E.S.J. et al. 2016, 'Living (and reproducing) on the edge: Reproductive phenology is impacted by rainfall and canopy decline in a Mediterranean eucalypt', *Australian Journal of Botany*, vol. 64, no. 2, pp. 129-141
- [17] Bishop, C.C., Fleming, P.A., Barnes, A.L., Collins, T. & Miller, D.W. 2016, 'Immunisation against gonadotrophin-releasing hormone (GnRH) reduces agonistic behaviours in male rangeland goats', *Animal Production Science*, vol. 56, no. 11, pp. 1882-1887
- [18] * Dawson, S.J., Crawford, H.M., Huston, R.M., Adams, P.J. & Fleming, P.A. 2016, 'How to catch red foxes red handed: Identifying predation of freshwater turtles and nests', *Wildlife Research*, vol. 43, no. 8, pp. 615-622
- [19] Patricia Fleming, Shannon Dundas, Yvonne Lau & John Pluske 2016, 'Predation by Red Foxes (*Vulpes vulpes*) at an Outdoor Piggery', *Animals*, vol. 6, no. 10, pp. 60, doi:10.3390/ani6100060
- [20] Patricia A. Fleming & Philip W. Bateman 2016, 'The good, the bad, and the ugly: which Australian terrestrial mammal species attract most research?', *Mam Rev*, vol. 46, no. 4, pp. 241–254, doi:10.1111/mam.12066
- [21] Taya Clarke, John R. Pluske & Patricia A. Fleming 2016, 'Are observer ratings influenced by prescription? A comparison of Free Choice Profiling and Fixed List methods of Qualitative Behavioural Assessment', *Applied Animal Behaviour Science*, vol. 177, pp. 77–83, doi:10.1016/j.applanim.2016.01.022
- [22] P. W. Bateman, P. A. Fleming & A. K. Wolfe 2016, 'A different kind of ecological modelling: the use of clay model organisms to explore predator-prey interactions in vertebrates', *Journal of Zoology*, doi:10.1111/jzo.12415
- [23] * Poole, H.L., Mukaromah, L., Kobryn, H.T. & Fleming, P.A. 2014, 'Spatial analysis of limiting resources on an island: Diet and shelter use reveal sites of conservation importance for the Rottne Island quokka', *Wildlife Research*, vol. 41, no. 6, pp. 510-521
- [24] Moore, T.L., Craig, M.D., Valentine, L.E., Hardy, G.E.S.J. & Fleming, P.A. 2014, 'Signs of wildlife activity and Eucalyptus wandoo condition', *Australian Mammalogy*, vol. 36, no. 2, pp. 146-153
- [25] Macgregor, J.W., Holyoake, C., Fleming, P.A., Robertson, I.D. & Connolly, J.H. et al. 2014, 'Investigation into the characteristics, triggers and mechanism of apnoea and bradycardia in the anaesthetized platypus (*Ornithorhynchus anatinus*)', *Conservation Physiology*, vol. 2, no. 1
- [26] Dundas, S.J., Adams, P.J. & Fleming, P.A. 2014, 'First in, first served: Uptake of 1080 poison fox baits in south-west Western Australia', *Wildlife Research*, vol. 41, no. 2, pp. 117-126
- [27] * Dawson, S.J., Adams, P.J., Huston, R.M. & Fleming, P.A. 2014, 'Environmental factors influence nest excavation by foxes', *Journal*

- [28] * Moore, T.L., Valentine, L.E., Craig, M.D., Hardy, G.E.S.J. & Fleming, P.A. 2014, 'Does woodland condition influence the diversity and abundance of small mammal communities?', *Australian Mammalogy*, vol. 36, no. 1, pp. 35-44
- [29] Bateman, P.W. & Fleming, P.A. 2014, 'Does human pedestrian behaviour influence risk assessment in a successful mammal urban adapter?', *Journal of Zoology*, vol. 294, no. 2, pp. 93-98
- [30] Napier, K.R., Mather, S.H., McWhorter, T.J. & Fleming, P.A. 2014, 'Do bird species richness and community structure vary with mistletoe flowering and fruiting in Western Australia?', *Emu*, vol. 114, no. 1, pp. 13-22
- [31] Bateman, P.W., Fleming, P.A., Jones, B.C. & Rothermel, B.B. 2014, 'Defensive responses of gopher tortoises (*Gopherus polyphemus*) are influenced by risk assessment and level of habituation to humans', *Behaviour*, vol. 151, no. 9, pp. 1267-1280
- [32] S. J. Dawson, P. J. Adams, R. M. Huston & P. A. Fleming 2014, 'Environmental factors influence nest excavation by foxes', *Journal of Zoology*, vol. 294, no. 2, pp. 104-113, doi:10.1111/jzo.12158
- [33] P. W. Bateman & P. A. Fleming 2014, 'Does human pedestrian behaviour influence risk assessment in a successful mammal urban adapter?', *Journal of Zoology*, vol. 294, no. 2, pp. 93-98, doi:10.1111/jzo.12156
- [34] Fleming, P.A., Valentine, L.E. & Bateman, P.W. 2013, 'Telling tails: Selective pressures acting on investment in lizard tails', *Physiological and Biochemical Zoology*, vol. 86, no. 6, pp. 645-658
- [35] Warburton, N.M., Bateman, P.W. & Fleming, P.A. 2013, 'Sexual selection on forelimb muscles of western grey kangaroos (*Skipper* was clearly a female)', *Biological Journal of the Linnean Society*, vol. 109, no. 4, pp. 923-931
- [36] * Moore, T.L., Valentine, L.E., Craig, M.D., Hardy, G.E.S.J. & Fleming, P.A. 2013, 'Is the reptile community affected by Eucalyptus wandoo tree condition?', *Wildlife Research*, vol. 40, no. 5, pp. 358-366
- [37] Purchase, C., Napier, K.R., Nicolson, S.W., McWhorter, T.J. & Fleming, P.A. 2013, 'Gastrointestinal and renal responses to variable water intake in whitebellied sunbirds and New Holland honeyeaters', *Journal of Experimental Biology*, vol. 216, no. 9, pp. 1537-1545, DP0665730 (2006-2008)
- [38] * Dundas, S.J., Fleming, P.A. & Hardy, G.E.S.J. 2013, 'Flower visitation by honey possums (*Tarsipes rostratus*) in a coastal banksia heathland infested with the plant pathogen *Phytophthora cinnamomi*', *Australian Mammalogy*, vol. 35, no. 2, pp. 166-174
- [39] Dybing, N.A., Fleming, P.A. & Adams, P.J. 2013, 'Environmental conditions predict helminth prevalence in red foxes in Western Australia', *International Journal for Parasitology: Parasites and Wildlife*, vol. 2, no. 1, pp. 165-172
- [40] * Moore, T.L., Valentine, L.E., Craig, M.D., Hardy, G.E.S. & Fleming, P.A. 2013, 'Do woodland birds prefer to forage in healthy Eucalyptus wandoo trees?', *Australian Journal of Zoology*, vol. 61, no. 3, pp. 187-195
- [41] Bateman, P.W. & Fleming, P.A. 2012, 'Big city life: Carnivores in urban environments', *Journal of Zoology*, vol. 287, no. 1, pp. 1-23
- [42] * Bryant, G.L., Dundas, S.J. & Fleming, P.A. 2012, 'Tree hollows are of conservation importance for a Near-Threatened python species', *Journal of Zoology*, vol. 286, no. 1, pp. 81-92
- [43] * Craig, M.D., Hardy, G.E.S.J., Fontaine, J.B., Garkakalis, M.J. & Grigg, A.H. et al. 2012, 'Identifying unidirectional and dynamic habitat filters to faunal recolonisation in restored mine-pits', *Journal of Applied Ecology*, vol. 49, no. 4, pp. 919-928
- [44] Bryant, G.L., Fleming, P.A., Twomey, L. & Warren, K.A. 2012, 'Factors affecting hematology and plasma biochemistry in the south-west Carpet Python (*Morelia spilota imbricata*)', *Journal of Wildlife Diseases*, vol. 48, no. 2, pp. 282-294
- [45] Bryant, G.L., De Tores, P.J., Warren, K.A. & Fleming, P.A. 2012, 'Does body size influence thermal biology and diet of a python (*Morelia spilota imbricata*)?', *Austral Ecology*, vol. 37, no. 5, pp. 583-591
- [46] * Craig, M.D., Benkovic, A.M., Grigg, A.H., Hardy, G.E.S.J. & Fleming, P.A. et al. 2011, 'How many mature microhabitats does a slow-recolonising reptile require? Implications for restoration of bauxite minesites in south-western Australia', *Australian Journal of Zoology*, vol. 59, no. 1, pp. 9-17
- [47] Bateman, P.W. & Fleming, P.A. 2011, 'Frequency of tail loss reflects variation in predation levels, predator efficiency, and the behaviour of three populations of brown anoles', *Biological Journal of the Linnean Society*, vol. 103, no. 3, pp. 648-656
- [48] Kaewmongkol, G., Kaewmongkol, S., Burmej, H., Bennett, M.D. & Fleming, P.A. et al. 2011, 'Diversity of Bartonella species detected in arthropod vectors from animals in Australia', *Comparative Immunology, Microbiology and Infectious Diseases*, vol. 34, no. 5, pp. 411-417

- [49] Kaewmongkol, G., Kaewmongkol, S., Owen, H., Fleming, P.A. & Adams, P.J. et al. 2011, 'Candidatus Bartonella antechini: A novel Bartonella species detected in fleas and ticks from the yellow-footed antechinus (*Antechinus flavipes*), an Australian marsupial', *Veterinary Microbiology*, vol. 149, no. 3-4, pp. 517-521
- [50] * Craig, M.D., Grigg, A.H., Garkaklis, M.J., Hobbs, R.J. & Grant, C.D. et al. 2009, 'Does habitat structure influence capture probabilities? A study of reptiles in a eucalypt forest', *Wildlife Research*, vol. 36, no. 6, pp. 509-515
- [51] * Andrew Grigg, Patricia Fleming, Giles Hardy, Michael Craig, Christine Davis, 2008, 'A funnel trap for capture of small arboreal reptiles', *Amphibia-Reptilia*, vol. 29, no. 3, pp. 413-423

Part D - Personnel and ROPE (Prof Giles Hardy)

D1. Personal Details

(To update personal details, click the 'Manage Personal Details' link below. Note this will open a new browser tab. When returning to the form ensure you 'Refresh' the page to capture the changes made to your profile.)

Participation Type

Chief Investigator

Title

Prof

First Name

Giles

Family Name

Hardy

D4. Qualifications

(To update any qualifications, click on the 'Manage Qualifications' link below. Note this will open a new browser tab. When returning to the form ensure you 'Refresh' the page to capture the changes made to your profile.)

Conferral Date	AQF Level	Degree/Award Title	Discipline/Field	Awarding Organisation	Country of Award
26/04/1990	Doctoral Degree	Doctor of Philosophy	Plant Pathology	University of Western Australia	Australia

D5. Research Opportunity and Performance Evidence (ROPE) - Current and previous appointment(s) / position(s) - during the past 10 years

(To update any details in this table, click on the 'Manage Employment Details' link below. Note this will open a new browser tab. When returning to the form ensure you 'Refresh' the page to capture the changes made to your profile. Refer to the Instructions to Applicants for more information.)

Description	Department	Contract Type	Employment Type	Start Date	End Date	Organisation
Professor	School of Veterinary and Life Sciences	Permanent	Full Time	01/01/2009		Murdoch University
Professor Forest Pathology	Environmental and Conservation Sciences	Permanent	Full Time	01/01/2009		Murdoch University

D6. Research Opportunity and Performance Evidence (ROPE) - Academic Interruptions

(You must read the ROPE Statement <http://www.arc.gov.au/arc-research-opportunity-and-performance-evidence-robe-statement> before filling out this section.)

Have you experienced an interruption that has impacted on your academic record?

No

D7. Research Opportunity and Performance Evidence (ROPE) - Details of the participant's academic career and opportunities for research, evidence of research impact and contributions to the field, including those most relevant to this application

(Provide details of your academic career and opportunities, evidence of research impact and contributions to the field. (Upload a PDF of no more than five A4 pages))

Uploaded PDF file follows on next page.

D7. Research Opportunity and Performance Evidence (ROPE) - Details of the participant's academic career and opportunities for research, evidence of research impact and contributions to the field, including those most relevant to this application

Provide details of your academic career and opportunities, evidence of research impact and contributions to the field. (Upload a PDF of no more than five A4 pages)

(This question must be answered)

AMOUNT OF TIME AS AN ACTIVE RESEARCHER I was awarded my PhD in September 1989 from the University of Western Australia. I have had no academic interruptions.

RESEARCH OPPORTUNITIES: Postdoctoral Research: After completing my PhD, I worked as research scientist for Bunnings Tree Farms on a CSIRO project screening ectomycorrhizal fungi (EMF) from across southern Australia for their potential to enhance *Eucalyptus globulus* growth in plantation forestry. I also developed a robust automated inoculation program for production nurseries to ensure seedlings were mycorrhizal at establishment, as well as establishing a range of field trials to monitor the efficacy of the mycorrhizal program across soil types and rainfall regions. I then joined Murdoch University funded by Alcoa of Australia in January 1992 as a Lecturer on a 50:50 research:teaching position. The purpose of the Alcoa position was two-fold. Firstly, to conduct research on *Phytophthora cinnamomi* in the jarrah forest to help understand its biology, ecology and pathology and to develop ways to reduce its spread and impact during mining and restoration. Secondly, to establish a Plant Pathology program to train undergraduate and postgraduate students in forest pathology. During this time, I was successful in obtaining three ARC Industry Collaborative Grants. In January 1998, I was offered a permanent research:teaching position at Murdoch University as a Senior Lecturer (1998-2004), Associate Professor 2005-2009, and since 2010 as a Professor.

Current position and considerations: Since joining Murdoch University as full-time academic in 1998, I have mainly been nominally 40% research, 40% teaching and 20% administration, except for (1) 10 months in 2009 when I was the 'acting' Research Institute Director of Sustainable Ecosystems which was 80% administration, and (2) between March 2014 and January 2019 when I was Associate Dean of Research for the School of Veterinary and Life Sciences. Both of these activities impacted on my research activities, especially the latter.

RESEARCH MENTORING AND RESEARCH FACILITIES AVAILABLE TO ME DURING MY CAREER:

Murdoch University (MU) is extremely supportive of research and provides excellent access to mentors, research students, world-class animal housing, and library facilities. MU arguably leads Western Australia academic institutions in forestry and natural ecosystem related research, with an array of undergraduate courses (Conservation & Wildlife Biology, Biological Sciences and Environmental Science), many postgraduate degrees, and a long-standing active core of research staff in this area. I have therefore been in a position to work with some excellent graduates. I have strong research collaborations with more than 11 Murdoch researchers across a range of disciplines.

University support: There is very strong research culture in Life Sciences at Murdoch University. The proposed research is strongly underpinned and supported by MU's strategic focus on further building research capacity in **The Research Centre for Environment and Biodiversity (CEB)**, which is a recognised area of growth for Research at Murdoch within the **Harry Butler Institute (HBI)** (one of the three Murdoch University research institutes). Research in CEB spans basic biological understanding through to improved management practice for sustaining, conserving and restoring ecosystems. CEB captures the efforts of 17 tenured researchers who work directly with 11 government departments, 12 local governments, five local research institutions (CSIRO, the WA Museum, WA Biodiversity Science Institution, WA Marine Science Institution, Australian Institute of Marine Science), over 15 community groups, and at least 25 industry bodies. We collaborate with researchers across 40 national and international universities (New Zealand, Portugal, Indonesia, China, Thailand, S Africa, France, The Netherlands, Canada, Denmark, USA). Our focus on identifying biodiversity processes and threats to understand biodiversity conservation issues, and work

with community, industry and regulators to protect biodiversity and restore habitats through policy and governance of natural resources. Our work therefore spans basic biological understanding through to improved management practice for sustaining, conserving and restoring ecosystems. With research strengths (ERA 2018 rankings) in Environmental Science and Management (5), Ecology (4), and Zoology (5), the collaborative research environment at Murdoch University provides a wealth of opportunities at the interface between disciplines. **Facilities:** I have a molecular laboratory, and two laboratories dedicated to forest pathology and mycorrhizal fungi, with a 4WD vehicle for the sole use by my research group, and access to other University vehicles. In addition, I have communication equipment (dGPS, hand-held GPS, EPIRBS) available to the current proposal. MU's Research Office helps in grant submission and the administration of successful applications, and our administrative and finance teams provide excellent support. Our strong collegial network (locally, nationally, and internationally) enables opportunities to grow our research into novel areas, such as demonstrated by this proposal.

RESEARCH ACHIEVEMENTS AND CONTRIBUTIONS

Research support income:

I have been very successful in establishing cross-disciplinary research collaborations and have contributed to over 100 research projects valued at over \$22.6m cash and \$13.1m in-kind since 1994. Including 26 ARC grants (including SPIRT and ARC Collaborative). The majority of the ARC grants have been Linkage Projects (or earlier versions) and the majority (22) of these I have been the lead CI.

Leadership/management:

2014- Jan 2019: Associate Dean Research School of Veterinary and Life Sciences (MU).

2009: for 10 months Acting Director Research Institute Director of Sustainable Ecosystems (MU).

2002-current: Director of Centre of Phytophthora Science and Management (MU).

2008-2014: Director for the State and industry funded State Centre of Excellence for Climate Change, Woodland and Forest Health (MU).

2002-current: I am the Coordinator of IUFRO 7.02.09 – Phytophthora Diseases of Forest Trees.

Student supervision:

I have trained 57 PhD, 5 Masters and 62 Honours Students to completion. Currently, I am supervising 13 PhD students.

Prizes, honours and awards

2018 – Runner up of Western Australian 'Golden Gekko' Award for Environmental Excellence.

2015 – Awarded Fellow of the Australasian Plant Pathology Society.

2014 – Murdoch University Vice-Chancellor's Excellence in Research Award (Distinguished and Sustained Research Award)

2005 – Murdoch University Vice-Chancellor's Excellence in Research Award (Outstanding Research Development).

Service to scientific community:

Between 2013-2015, I was on the ARC College of Experts. I regularly review papers (approx. 1 fortnightly) for approximately 23 journals. I regularly assess grants for the ARC across all schemes.

Invitations to speak at conferences:

Since 2009, I have been a 'keynote' and 'invited' speaker at 9 and 22 conferences, respectively. In addition, I talk regularly at a range of symposia. Examples, include Dieback Information Group (annually for last 21 years),

I also do regular radio/TV interviews such as 720 ABC Perth, Today Tonight Perth, Statewide Drive, Country Hour.

Consultancies:

I have undertaken numerous research consultancies in Libya, Laos, Vietnam and Indonesia, and with industry (e.g. mining –Alcoa, Tronox, Boddington Gold); Forestry- WAPRES, Elders, Horizon Power, ArborCarbon, Specterra, and Government (e.g. DPaW, Department of Sustainability, Environment, Water, Population and Communities, NSW Environmental Trust).

Community engagement:

I run 10-15 seminars and workshops annually on (a) tree health and management, and (b) Phytophthora dieback and management to local community, National Regional Management, school groups and various government and non-government agencies. In 2019, I have run 25 workshops and field forays on the above. These are critical for helping generate interest in the research, but also for attracting support for research consultancies and ARC Linkage projects.

Collaboration:

I have numerous active collaborations with researchers and students in Australia, Asia and South Africa, and I have published with 386 authors from 28 countries. The Web of Sciences database indicates I publish in 23 subject areas: Plant Sciences (38%), Mycology (14%), Agronomy (12%), Biotechnology (10.5%), Soil Science (8%), and Forestry (6%), indicating my international profile and broad discipline base. My research is recognised internationally; only 36% of citations are from documents originating in Australia, the remaining 64% come from 73 countries on all continents with the top ten being USA, South Africa, China, the Netherlands, Canada, Brazil, UK, France, Spain and New Zealand.

Member on expert panels:

(1) Advisory Panel Member for 'Increasing Sustainability of European Forests: Modelling for security against invasive pests and pathogens under climate change (2012-2015); (2) Research Expert on WA Dieback Consultative Council and WA Dieback Response Group both Ministerial appointments between 2005-2015; (3) 2016-current, one of two international experts on 'Expert Advisory Panel on Phytothreats' for the United Kingdom, to protect forests, woodlands and heathlands from Phytophthora; (4) 2018-current, only international expert of the Scientific Advisory Panel for Kauri Dieback in New Zealand; (5) 2019-2024 member of Project Steering Group for New South Wales Environmental Trust on 'Eucalyptus Dieback Research Program'.

Thesis examinations:

Since 2004 I have examined 29 PhD, 56 Honours and 2 Masters theses.

KEY RESEARCH THEMES

I am interested in how biotic and abiotic diseases impact on ecosystem health and function, spanning urban, forest, woodland, mine site restoration and plantation forestry. This has involved working with animal ecologists, ecohydrologists, restoration ecologists, fire ecologists, entomologists, plant ecologists, ecophysiologicalists, meteorologists, fungal geneticists, mycologists, plant pathologists and microbiologists.

Disturbance ecology: The WA State Government Centre of Excellence for Climate Change, Woodland & Forest Health (for which I was lead CI/Director) was a transdisciplinary research program involving a large team of researchers across a wide range of disciplines: wildlife biology, plant pathology, education, policy development, agencies and universities. The CoE was a result of successful ARC Linkage Grants including LP0346931, LP0668195, and an LP run out of The University of Western Australia. The CoE developed research collaborations that have persisted post-funding. We have been implementing experiments, running the field/laboratory trials, and writing/completion of publications over the last 5+ years. This work has led on to successful collaborations with community and local government; for example, we are currently working on a very productive ARC Linkage project with the City of Mandurah (LP160100441) and a previous LP120200581 (Cape to Cape Catchments Group, Margaret River; Alcoa of Australia; Department of

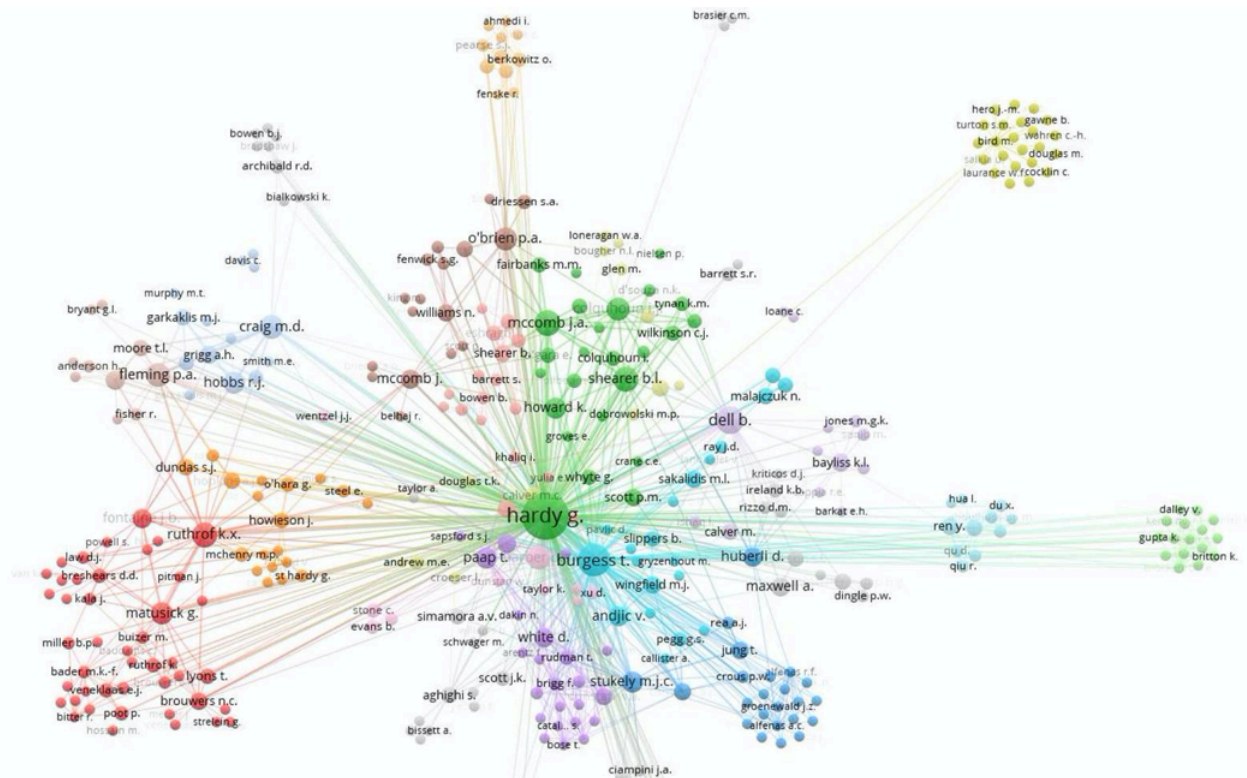
Environment and Conservation). This work led to a ABC Catalyst Program showing the impacts of climate change on eucalypt forests and woodlands and tree declines elsewhere worldwide.

Phytophthora biology, ecology, pathology, taxonomy and control: I was founding director of the Centre for Phytophthora Science and Management. This Centre has been very successful in attracting funding including 10 ARC Linkages as well as support from a range of industry partners (e.g. Dept. of Biodiversity, Conservation and Attractions DBCA – partners on the present proposal, Alcoa of Australia, Iluka, Tronox, and Minerals and Energy Research Institute of WA). Our work has increased our understanding about the biology, pathology and control of *Phytophthora* species in natural ecosystems, rehabilitated mines and horticulture. Much of this work has been applied and resulted in on-ground applications. My research group has helped reduce the spread of *P. cinnamomi* between infested and disease-free plant communities. We have contributed greatly to the existing knowledge on how, when, and at what rates to apply the fungicide and priming agent phosphite to natural plant communities; this fungicide is used worldwide to treat natural ecosystems as a result. In Western Australia, phosphite is now widely used by many 'Friends of Groups' to treat *P. cinnamomi* infested areas in bushland. My group has also developed successful 'proof of concept' eradication and containment methods of *P. cinnamomi* in native plant communities in Western Australia and Tasmania (Dunstan et al 2009). Eradication and containment is now being used operationally by the Dept of Environment and Conservation in threatened plant communities in Cape Arid and the Fitzgerald River National Parks. More recently, as a result of ARC LP0776740, we showed success of a herbicide and fallow approach without the use of fumigants or fungicides, resulting in eradication of the pathogen from a site in approximately 3 years. Based on these findings, we have now successfully shown in LP13010057 that we can eradicate *P. cinnamomi* from haul roads on Alcoa of Australia's mine site. This will potentially save Alcoa approximately \$500 m over the next 30-40 years of mining. The results of this work were recognised through a 'runner up' award in the Dept. of Mines and Industry Regulation and Safety 'Golden Gekko' Award for Environmental Excellence. The mineral sands company, Tronox (previously Tiwest) (through a research consultancy) is now implementing the fallow approach to eradicate *Phytophthora* from an area that could not otherwise be mined. Finally, the Main Roads Department is now trialling (3 x 1ha sites) the fallow approach on infested gravels sourced from the gravel forest. If successful, Main Roads will no longer have to source 'dieback-free' gravels from healthy forest sites. These represent tangible outcomes as a result of ARC funding, and significant economic, environmental and social impacts. Recently, I have placed an emphasis on determining how phosphite induces plant defence at a biochemical and molecular level (LP0776252). The Centre for Phytophthora Science and Management has national and international recognition for its research and communication on *Phytophthora* diseases, especially in natural ecosystems and forests in particular. In addition, we have contributed at a Policy Level, for example with the National Threat Abatement Plan, which the CPSM wrote and managed via a consultancy. My laboratory has also made significant contributions into the description of new *Phytophthora* species in Australia, and is the only group to have made major contributions in this area. Many of these *Phytophthora* species are associated with declining trees and it is likely that future work will show they are contributing to incite these declines.

More recently, I have started to look closely at how plant diseases impact on forest and woodland ecosystem function and health and my research activities have extended into projects that examine the impact of plant disease on fauna and on water (LP0455309 and LP0454140). I also work on other diseases of trees in plantations and natural ecosystems (e.g. LP0346931, LP0668195, LP0349226 and DP0666498). In many instances, one or more *Phytophthora* species are associated with these tree declines as primary or secondary pathogens of fine roots, lateral roots or as canker pathogens. In 2008, I was the primary instigator of a successful bid for a State Centre of Excellence on Climate Change and Woodland and Forest Health of which I was the Director. This multi-disciplinary Centre collaborated with six overseas Universities, four national Universities and six government agencies, with 26 research scientists involved. It had projects from remote sensing, climate modelling, eco-physiology, hydrology, entomology, plant pathology, restoration ecology and policy. I have started to use 'Smartphones' and Citizen Science to (a) communicate with and 'up skill' key stakeholders including the general community, and (b) inform our research by using the community to gather information. This has been in the form of the 'Marri App' available on both Android and iPhone interfaces. Using the app, we have trained different groups and individuals to treat trees and follow progress of those treatments. Therefore, my research has provided tangible impacts for end users and the

environment. Our collaborations continue as a result of this work. For example, Professor David Breshears (Uni of Arizona), a highly cited scientist (Scopus 'h' index of 53, and 17,016 citations; Goggle Scholar, 'h' of 63 and 24.690 citations) is a Sir Walter Murdoch Distinguished Professorial Fellow at Murdoch. He was keen to work with us based on our research, and his interests in global change and forest ecology.

How my research has led to a significant change or advance of knowledge, and how my achievements will contribute to this application: I work across a range of disciplines and collaborate with researchers from a wide range of backgrounds and interests in order to address the questions I am interested in. I am a great believer in collaboration, as indicated by the 386 authors I have published with (Scopus) (Figure 1).



The current application will conduct research on fire, tree health, plant pathogens, plant diversity and abundance, soil microflora with an emphasis on mycorrhizal fungi, remote sensing, fauna and interactions of fire with all of the above. I have published across all of these areas, so bring a multi-disciplinary approach to the proposal. In addition, I have had extensive experience working with numerous industry partners across a range of projects, together with interacting with broad stakeholder groups. Therefore, I am in a good position to help disseminate our research findings effectively, and in a timely manner.

D8. Research Opportunity and Performance Evidence (ROPE) - Currently held ARC projects

(This information is auto-populated from the applicants RMS profile and will include any active project which has not yet had a Final Report approved and the project file closed by the ARC. You will not be able to submit an application to the ARC that involves a researcher who has an overdue Final Report on an ARC-funded project. If there are any concerns with the information recorded here, contact Your organisation's Research Office.)

Identifier	Investigators	Admin Organisation	Project Title	Funding	End Date	Final Report Due Date	Final Report Status
LP140100690	Prof Giles Hardy ; Dr Graham O'Hara ; Prof John Howieson ; Em/Prof Jennifer McComb ; Ms Joy Wickenden	Murdoch University	Transition from phosphate mining to an economically, environmentally and socially viable agricultural industry on Christmas Island	\$341,291	30/05/2019	30/05/2020	Draft
LP150100936	Dr Paul Rymer ; Prof Giles Hardy ; Prof David Tissue ; Dr Margaret Byrne ; Dr Nora Devoe	Western Sydney University	Do hotter and drier regions harbour adaptive variation for climate change?	\$281,506	11/01/2020	11/01/2021	Draft
LP160100441	Prof Patricia Fleming ; Prof Giles Hardy ; Dr Catherine Baudains ; Mr Brett Brenchley	Murdoch University	Backyard Bandicoots: Engaging community in urban bushland conservation	\$200,000	30/06/2020	30/06/2021	Draft

D9. Project/Role relinquishment or application withdrawal

(If you exceed the Linkage Program limits on projects and/or applications and have applied under the Industrial Transformation Research Hubs, Industrial Transformation Training Centres, Special Research Initiatives, Learned Academies Special projects, Supporting Responses to Commonwealth Science Council Priorities or any other Linkage Program scheme, list the application you wish to withdraw, or the existing project (or role) that that you wish to relinquish should this application be successful (see sections 6.35 to 6.39 of the grant guidelines). Failing to provide this information will jeopardise the eligibility of your applications. Provide project/application ID(s) separated by a comma.)

--

D10. Eligibility - Role of Partner Investigator

(Please indicate which of the Partner Investigator role options from section 6.29 of the grant guidelines apply to your role on this project. Select all options that apply.)

--

D11. Eligibility - Will the participant be residing predominately in Australia for the duration of the project activity period?

((This is a 'Yes' or 'No' question. Indicate whether the participant will be residing predominantly in Australia for the project activity period. If the participant is applying as a CI and they answer 'No' to this question you will be prompted to contact the Research Office to check the participant's eligibility. If the participant is a Foreign National, they must reside legally in Australia. Eligibility will be based solely on the information contained in this application.))

Yes

D12. Eligibility - Is the participant currently undertaking a Higher Degree by Research which will be conferred after the grant commencement date?

((This is a 'Yes' or 'No' question. If the participant is applying as a CI and they answer 'Yes' to this question they will be prompted to contact the Research Office and Part D will not validate. Eligibility will be based solely on the information contained in this application.))

No

D13. Eligibility - Employment Details as at grant commencement date of project

(This question will be used to determine your eligibility. Your eligibility will be based solely on the information contained in this application. Confirm your employment status at all organisations that you will be associated with as at the Grant Commencement Date. Enter the relevant appointment type and Full-Time Equivalent (FTE) for each organisation.)

Org name	Is this an Eligible Organisation?	Please choose your appointment type for this organisation.	Please enter your FTE for this Organisation
Murdoch University	Yes	Employee	1

D14. Eligibility - Further Details Regarding Partner Investigator Status - Does the participant hold a remunerated appointment at an Eligible Organisation as at the grant commencement date for this project?

(At A2 Partner Investigator has been selected as the role type, but it appears that the participant meets the criteria of a Chief Investigator.

NOTE: this question is mandatory ONLY FOR PIs WHO:

- at D11 confirmed that they will reside predominantly in Australia for the project activity period of the proposed Project; AND
- at D12 confirmed that they are not currently undertaking a Higher Degree by Research which will be conferred after the grant commencement date; AND
- at D13 indicated that they would hold either:
 - an appointment at an Eligible Organisation equal or greater than 0.2 FTE; OR
 - an honorary academic appointment at an Eligible Organisation

You do not need to answer these questions if it was indicated in question D11 that the participant will be living predominantly overseas OR if they have indicated in question D12 that the participant will be undertaking a Higher Degree by Research.)

Do you hold a remunerated appointment at an Eligible Organisation?

Justification of PI status

D15. Eligibility - Relevant Organisation for this application as at the grant commencement date for this project

(Enter the Organisation that is relevant to the participant's inclusion on this application, and that they will be associated with as at the grant commencement date. The 'relevant organisation' is the primary organisation that will be supporting the participant's involvement in this project if it is funded. Note that the Organisation must be listed in

Relevant Organisation

Murdoch University

D16. What is the participant's time commitment to this project?

(Enter the participant's time commitment to this project as a Full-Time Equivalent (FTE). Note that a FTE of 1.0 represents a full-time commitment (i.e. 5 days per week).)

0.2

D17. Research Opportunity and Performance Evidence (ROPE) - Research Outputs

(Research context: Provide clear information that explains the relative importance of different research outputs and expectations in the participant's discipline/s. The information should help assessors understand the context of the participant's academic research achievements but not repeat information already provided in this application. It is helpful to include the importance/esteem of specific journals in the participant's field; specific indicators of recognition within the participant's field such as first authorship/citations, or the significance of non-traditional research outputs. If this question is not relevant to a participant, for example a PI with non-academic background, the participant should include a short explanatory statement as to why this question is not applicable. (No more than 3,750 characters, approximately 500 words))

METRICS OF RESEARCH QUALITY @DECEMBER 2019:

My 293 (Scopus) international peer-reviewed journal publications have been cited a total of 5,895 (Scopus) or 7,987 (Google Scholar) times. My Scopus 'h' index is 42 and Google Scholar is 49. My field weighted citation impact score (2009-18) is 1.59 (SciVal) from 171 publications, with an average of 18.6 citations/publication. My ResearchGate score (44.8) is higher than 97.5% of ResearchGate members. I have published with 386 authors, 38% of these are international (Scopus). Of my publications, 20.5% are in top 10% most cited worldwide (Scopus).

RESEARCH OVERVIEW

My overall aim is to address industry related questions with the objective of giving applied outcomes as quickly as possible. For example, my work on *Phytophthora* has led to widespread use of phosphite by agencies, private individuals and friends of groups to stop the spread and impact of the pathogen. My work on eradication, has changed our understanding of the biology and ecology of the pathogen, allowing us to develop effective approaches to eradicate the pathogen from a site. Industry and government agencies are now implementing the strategies developed. Our work on tree declines is now driving managers to look at thinning and fire, and restoration options to manage the severity and incidence of declines.

As an academic my emphasis is on training graduate students in research, and providing support to postdocs, consequently the majority of my publications are as last or corresponding author. I have published across a diverse range of topics across more than 94 peer reviewed journals of these 57 are Q1 journals (Scimago). Based on Scopus I have 45, 13, 7, 8 and 1 papers cited more than 25, 50, 75, 100 or 150 times. I have supervised 60 PhD students to completion and am currently supervising 10 PhD students. Over the last 20 years I have worked with 37 postdoc fellows or different projects.

I have published in a number of high-ranking journals for my fields of Forestry, Ecology, Plant Science

Journal	SRJ	Ranking	No of papers
Out of 138 Journals in Forest			
Forest Ecology and Management	1.43	6/138	8
Urban Forestry and Greening	0.954	16/138	2
Forest Pathology	0.564	39/138	13
Of 351 Journals in Ecology			
Fungal Diversity	7.501	2/351	2
Global Change Biology	3.458	6/351	2
Plants	1.361	39/351	2
Austral Ecology	0.764	104/351	7

Out of 440 Journals in Plant Science			
Fungal Diversity	7.501	1/440	2
Persoonia	3.155	12/440	11
IMA Fungus	1.912	21/440	3
Plant Pathology	1.091	64/440	24
Fungal Biology	1.048	71/440	12
Australasian Plant Pathology	0.566	147/440	50

D18. Research Opportunity and Performance Evidence (ROPE) – Research Outputs Listing including Ten Career-Best Research Outputs

(List the research outputs marking those that are most relevant to this application categorised under the following headings: Ten career-best research outputs; Authored books; Edited books; Book chapters; Referred Journal articles; Fully refereed conference proceedings; Additional research outputs (including non-traditional research outputs). CVs and theses should not be included in this list. The participant's ten career-best research outputs should not be repeated under subsequent headings. (No more than 100 research outputs).)

Research Outputs Listing

Generated research output document follows on the next page

Ten Career-Best Research Outputs

- [1] * Fleming, P.A., Anderson, H., Prendergast, A.S., Bretz, M.R. & Valentine, L.E. et al. 2014, 'Is the loss of Australian digging mammals contributing to a deterioration in ecosystem function?', *Mammal Review*, vol. 44, no. 2, pp. 94-108 (Refereed Journal Article)
- [2] * Matusick, G., Ruthrof, K.X., Brouwers, N.C., Dell, B. & Hardy, G.S.J. 2013, 'Sudden forest canopy collapse corresponding with extreme drought and heat in a Mediterranean-type eucalypt forest in southwestern Australia', *European Journal of Forest Research*, vol. 132, no. 3, pp. 497-510 (Refereed Journal Article)
- [3] * Brouwers, N., Matusick, G., Ruthrof, K., Lyons, T. & Hardy, G. 2013, 'Landscape-scale assessment of tree crown dieback following extreme drought and heat in a Mediterranean eucalypt forest ecosystem', *Landscape Ecology*, vol. 28, no. 1, pp. 69-80 (Refereed Journal Article)
- [4] * Laurance, W.F., Dell, B., Turton, S.M., Lawes, M.J. & Hutley, L.B. et al. 2013, 'Corrigendum to The ten Australian ecosystems most vulnerable to tipping points [Biol. Conserv. 144 (2011) 1472-1480]', *Biological Conservation*, vol. 159 (Refereed Journal Article)
- [5] * Brouwers, N.C., Mercer, J., Lyons, T., Poot, P. & Veneklaas, E. et al. 2013, 'Climate and landscape drivers of tree decline in a Mediterranean ecoregion', *Ecology and Evolution*, vol. 3, no. 1, pp. 67-79 (Refereed Journal Article)
- [6] * Ruthrof, K.X., Fontaine, J.B., Matusick, G., Breshears, D.D. & Law, D.J. et al. 2016, 'How drought-induced forest die-off alters microclimate and increases fuel loadings and fire potentials', *International Journal of Wildland Fire*, vol. 25, no. 8, pp. 819-830 (Refereed Journal Article)
- [7] * Valentine, L.E., Bretz, M., Ruthrof, K.X., Fisher, R. & Hardy, G.E.S.J. et al. 2017, 'Scratching beneath the surface: Bandicoot bioturbation contributes to ecosystem processes', *Austral Ecology*, vol. 42, no. 3, pp. 265-276, LP160100441 (2016-2018) (Refereed Journal Article)
- [8] * Craig, M.D., Hobbs, R.J., Grigg, A.H., Garkaklis, M.J. & Grant, C.D. et al. 2010, 'Do thinning and burning sites revegetated after bauxite mining improve habitat for terrestrial vertebrates?', *Restoration Ecology*, vol. 18, no. 3, pp. 300-310, LP0455309 (2005-2008), LP0882687 (2009-2014) (Refereed Journal Article)
- [9] * Sapsford, S.J., Paap, T., Hardy, G.E.S.J. & Burgess, T.I. 2017, 'The "chicken or the egg": which comes first, forest tree decline or loss of mycorrhizae?', *Plant Ecology*, vol. 218, no. 9, pp. 1093-1106, LP120200581 (2013-2016) (Refereed Journal Article)
- [10] * Natasha E. Tay, Anna J. M. Hopkins, Katinka X. Ruthrof, Treena Burgess & Giles E. StJ. Hardy et al. 2018, 'The tripartite relationship between a bioturbator, mycorrhizal fungi, and a key Mediterranean forest tree', *Austral Ecology*, vol. 43, no. 7, pp. 742-751, doi:10.1111/aec.12598, LP160100441 (2016-2018) (Refereed Journal Article)

Refereed Journal Articles

- [1] * Lewis L. Walden, Joseph B. Fontaine, Katinka X. Ruthrof, George Matusick & Richard J. Harper et al. 2019, 'Carbon consequences of drought differ in forests that resprout', *Global Change Biology*, vol. 25, no. 5, pp. 1653-1664, doi:10.1111/gcb.14589
- [2] * Shannon J. Dundas, Anna J. M. Hopkins, Katinka X. Ruthrof, Natasha E. Tay & Treena I. Burgess et al. 2018, 'Digging mammals contribute to rhizosphere fungal community composition and seedling growth', *Biodiversity and Conservation*, vol. 27, no. 12, pp. 3071-3086, doi:10.1007/s10531-018-1575-1
- [3] * Leonie E. Valentine, Katinka X. Ruthrof, Rebecca Fisher, Giles E. St. J. Hardy & Richard J. Hobbs et al. 2018, 'Bioturbation by bandicoots facilitates seedling growth by altering soil properties', *Functional Ecology*, vol. 32, no. 9, pp. 2138-2148, doi:10.1111/1365-2435.13179, LP160100441 (2016-2018)
- [4] * Gillian L. Bryant, Halina T. Kobryn, Giles E. StJ. Hardy & Patricia A. Fleming 2017, 'Habitat islands in a sea of urbanisation', *Urban Forestry & Urban Greening*, vol. 28, pp. 131-137, doi:10.1016/j.ufug.2017.10.016, LP160100441 (2016-2018)
- [5] * Paap, T., Burgess, T.I., Calver, M., McComb, J.A. & Shearer, B.L. et al. 2017, 'A thirteen-year study on the impact of a severe canker disease of *Corymbia calophylla*, a keystone tree in Mediterranean-type forests', *Forest Pathology*, vol. 47, no. 1, LP120200581 (2012-2014)
- [6] * Burgess, T.I., Scott, J.K., McDougall, K.L., Stukely, M.J.C. & Crane, C. et al. 2017, 'Current and projected global distribution of *Phytophthora cinnamomi*, one of the world's worst plant pathogens', *Global Change Biology*, vol. 23, no. 4, pp. 1661-1674
- [7] Burgess, T.I., White, D., McDougall, K.M., Garnas, J. & Dunstan, W.A. et al. 2017, 'Distribution and diversity of *Phytophthora* across Australia', *Pacific Conservation Biology*, vol. 23, no. 2, pp. 150-162
- [8] * Paap, T., Brouwers, N.C., Burgess, T.I. & Hardy, G.E.S.J. 2017, 'Importance of climate, anthropogenic disturbance and pathogens (*Quambalaria coeyrecup* and *Phytophthora* spp.) on marri (*Corymbia calophylla*) tree health in southwest Western Australia', *Annals of*

- [9] * Matusick, G., Ruthrof, K.X., Fontaine, J.B. & Hardy, G.E.S.J. 2016, 'Eucalyptus forest shows low structural resistance and resilience to climate change-type drought', *Journal of Vegetation Science*, vol. 27, no. 3, pp. 493-503
- [10] * Matusick, G., Ruthrof, K.X., Pitman, J. & Hardy, G.E.S.J. 2016, 'Feeling the cold in a warming climate: differential effects of low temperatures on co-occurring eucalypts', *Australian Journal of Botany*, vol. 64, no. 5, pp. 456-466
- [11] * Moore, T.L., Ruthrof, K.X., Craig, M.D., Valentine, L.E. & Hardy, G.E.S.J. et al. 2016, 'Living (and reproducing) on the edge: Reproductive phenology is impacted by rainfall and canopy decline in a Mediterranean eucalypt', *Australian Journal of Botany*, vol. 64, no. 2, pp. 129-141
- [12] * Ruthrof, K.X., Bader, M.K.-F., Matusick, G., Jakob, S. & Hardy, G.E.S.J. 2016, 'Promoting seedling physiological performance and early establishment in degraded Mediterranean-type ecosystems', *New Forests*, vol. 47, no. 3, pp. 357-376
- [13] * Andrew, M.E., Ruthrof, K.X., Matusick, G. & Hardy, G.E.St.J. 2016, 'Spatial configuration of drought disturbance and forest gap creation across environmental gradients', *PLoS ONE*, vol. 11, no. 6
- [14] * Whyte, G., Howard, K., Hardy, G. & Burgess, T.I. 2016, 'The Tree Decline Recovery Seesaw; a conceptual model of the decline and recovery of drought stressed plantation trees', *Forest Ecology and Management*, vol. 370, pp. 102-113, LP0349190 (2004-2007)
- [15] * Ruthrof, K.X., Matusick, G. & Hardy, G.E.S.J. 2015, 'Early differential responses of co-dominant canopy species to sudden and severe drought in a mediterranean-climate type forest', *Forests*, vol. 6, no. 6, pp. 2082-2091
- [16] * Craig, M.D., Stokes, V.L., Stj Hardy, G.E. & Hobbs, R.J. 2015, 'Edge effects across boundaries between natural and restored jarrah (*Eucalyptus marginata*) forests in south-western Australia', *Austral Ecology*, vol. 40, no. 2, pp. 186-197, LP0882687 (2009-2014), LP0455309 (2005-2008)
- [17] * Brouwers, N.C., Van Dongen, R., Matusick, G., Coops, N.C. & Strelein, G. et al. 2015, 'Inferring drought and heat sensitivity across a Mediterranean forest region in southwest Western Australia: A comparison of approaches', *Forestry*, vol. 88, no. 4, pp. 454-464
- [18] * Scott, P.M., Barber, P.A. & Hardy, G.E.S.J. 2015, 'Novel phosphite and nutrient application to control *Phytophthora cinnamomi* disease', *Australasian Plant Pathology*, vol. 44, no. 4, pp. 431-436, LP120200581 (2013-2016)
- [19] * Seaton, S., Matusick, G., Ruthrof, K.X. & Hardy, G.E.S.J. 2015, 'Outbreak of *Phoracantha semipunctata* in response to severe drought in a mediterranean Eucalyptus forest', *Forests*, vol. 6, no. 11, pp. 3868-3881
- [20] * Evans, B., Lyons, T.J., Barber, P.A., Stone, C. & Hardy, G. 2014, 'Dieback classification modelling using high-resolution digital multispectral imagery and in situ assessments of crown condition', *Remote Sensing Letters*, vol. 3, no. 6, pp. 541-550, LP0668195 (2007-2010)
- [21] * Craig, M.D., Grigg, A.H., Hobbs, R.J. & Hardy, G.E.S.J. 2014, 'Does coarse woody debris density and volume influence the terrestrial vertebrate community in restored bauxite mines?', *Forest Ecology and Management*, vol. 318, pp. 142-150, LP0882687 (2009-2014), LP0455309 (2005-2008)
- [22] * Moore, T.L., Valentine, L.E., Craig, M.D., Hardy, G.E.S.J. & Fleming, P.A. 2014, 'Does woodland condition influence the diversity and abundance of small mammal communities?', *Australian Mammalogy*, vol. 36, no. 1, pp. 35-44
- [23] * Crone, M., McComb, J.A., O'Brien, P.A. & Hardy, G.E.S.J. 2014, 'Host removal as a potential control method for *Phytophthora cinnamomi* on severely impacted black gravel sites in the jarrah forest', *Forest Pathology*, vol. 44, no. 2, pp. 154-159, LP0776740 (2008-2011)
- [24] * Moore, T.L., Craig, M.D., Valentine, L.E., Hardy, G.E.S.J. & Fleming, P.A. 2014, 'Signs of wildlife activity and Eucalyptus wandoo condition', *Australian Mammalogy*, vol. 36, no. 2, pp. 146-153
- [25] * Bader, M.K.-F., Ehrenberger, W., Bitter, R., Stevens, J. & Miller, B.P. et al. 2014, 'Spatio-temporal water dynamics in mature *Banksia menziesii* trees during drought', *Physiologia Plantarum*, vol. 152, no. 2, pp. 301-315
- [26] * Moore, N., Barrett, S., Howard, K., Craig, M.D. & Bowen, B. et al. 2014, 'Time since fire and average fire interval are the best predictors of *Phytophthora cinnamomi* activity in heathlands of south-western Australia', *Australian Journal of Botany*, vol. 62, no. 7, pp. 587-593
- [27] * Matusick, G., Ruthrof, K.X., Brouwers, N.C. & Hardy, G.S.J. 2014, 'Topography influences the distribution of autumn frost damage on trees in a Mediterranean-type Eucalyptus forest', *Trees - Structure and Function*, vol. 28, no. 5, pp. 1449-1462
- [28] * Barber, P.A., Paap, T., Burgess, T.I., Dunstan, W. & Hardy, G. 2013, 'A diverse range of *Phytophthora* species are associated with

dying urban trees', *Urban Forestry and Urban Greening*, vol. 12, no. 4, pp. 569-575

[29] * Crone, M., McComb, J.A., O'Brien, P.A. & Hardy, G.E.S.J. 2013, 'Annual and herbaceous perennial native Australian plant species are symptomless hosts of *Phytophthora cinnamomi* in the *Eucalyptus marginata* (jarrah) forest of Western Australia', *Plant Pathology*, vol. 62, no. 5, pp. 1057-1062, LP0776740 (2008-2011)

[30] * Crone, M., McComb, J.A., O'Brien, P.A. & Hardy, G.E.S.J. 2013, 'Assessment of Australian native annual/herbaceous perennial plant species as asymptomatic or symptomatic hosts of *Phytophthora cinnamomi* under controlled conditions', *Forest Pathology*, vol. 43, no. 3, pp. 245-251, LP0776740 (2008-2011)

[31] * Moore, T.L., Valentine, L.E., Craig, M.D., Hardy, G.E.S. & Fleming, P.A. 2013, 'Do woodland birds prefer to forage in healthy *Eucalyptus wandoo* trees?', *Australian Journal of Zoology*, vol. 61, no. 3, pp. 187-195

[32] * Brouwers, N., Moore, S., Lyons, T., Hardy, G. & Chopard, J. et al. 2013, 'Fostering collaborations towards integrative research development', *Forests*, vol. 4, no. 2, pp. 329-342

[33] * Moore, T.L., Valentine, L.E., Craig, M.D., Hardy, G.E.S.J. & Fleming, P.A. 2013, 'Is the reptile community affected by *Eucalyptus wandoo* tree condition?', *Wildlife Research*, vol. 40, no. 5, pp. 358-366

[34] * Ruthrof, K.X., Fontaine, J.B., Buizer, M., Matusick, G. & McHenry, M.P. et al. 2013, 'Linking restoration outcomes with mechanism: The role of site preparation, fertilisation and revegetation timing relative to soil density and water content', *Plant Ecology*, vol. 214, no. 8, pp. 987-998, LP0668195 (2007-2010)

[35] * Jung, T., Colquhoun, I.J. & Hardy, G.E.J. 2013, 'New insights into the survival strategy of the invasive soilborne pathogen *Phytophthora cinnamomi* in different natural ecosystems in Western Australia', *Forest Pathology*, vol. 43, no. 4, pp. 266-288, LP0668195 (2008-2011)

[36] * Scott, P.M., Dell, B., Shearer, B.L., Barber, P.A. & Hardy, G.E.S.J. 2013, 'Phosphite and nutrient applications as explorative tools to identify possible factors associated with *Eucalyptus gomphocephala* decline in South-Western Australia', *Australasian Plant Pathology*, vol. 42, no. 6, pp. 701-711, LP0668195 (2007-2010)

[37] * Lambers, H., Ahmedi, I., Berkowitz, O., Dunne, C. & Finnegan, P.M. et al. 2013, 'Phosphorus nutrition of phosphorus-sensitive Australian native plants: Threats to plant communities in a global biodiversity hotspot', *Conservation Physiology*, vol. 1, no. 1, LP0776252 (2008-2013)

[38] * Scott, P.M., Shearer, B.L., Barber, P.A. & Hardy, G.E.S.J. 2013, 'Relationships between the crown health, fine root and ectomycorrhizae density of declining *Eucalyptus gomphocephala*', *Australasian Plant Pathology*, vol. 42, no. 2, pp. 121-131, LP0668195 (2007-2010)

[39] * Ishaq, L., Barber, P.A., Hardy, G.E.S.J., Calver, M. & Dell, B. 2013, 'Seedling mycorrhizal type and soil chemistry are related to canopy condition of *Eucalyptus gomphocephala*', *Mycorrhiza*, vol. 23, no. 5, pp. 359-371, LP0668195 (2007-2010)

[40] * Crone, M., McComb, J.A., O'Brien, P.A. & Hardy, G.E.J. 2013, 'Survival of *Phytophthora cinnamomi* as oospores, Stromata, And thick-walled chlamydospores in roots of symptomatic and asymptomatic annual and herbaceous perennial plant species', *Fungal Biology*, vol. 117, no. 2, pp. 112-123, LP0776740 (2008-2011)

[41] * Evans, B., Lyons, T., Barber, P., Stone, C. & Hardy, G. 2012, 'Enhancing a eucalypt crown condition indicator driven by high spatial and spectral resolution remote sensing imagery', *Journal of Applied Remote Sensing*, vol. 6, no. 1

[42] * Valentine, L.E., Anderson, H., Hardy, G.E.S. & Fleming, P.A. 2012, 'Foraging activity by the southern brown bandicoot (*Isodon obesulus*) as a mechanism for soil turnover', *Australian Journal of Zoology*, vol. 60, no. 6, pp. 419-423, LP0668195 (2006-2008)

[43] Crous, P.W., Summerell, B.A., Shivas, R.G., Burgess, T.I. & Decock, C.A. et al. 2012, 'Fungal planet description sheets: 107-127', *Persoonia: Molecular Phylogeny and Evolution of Fungi*, vol. 28, pp. 138-182

[44] Crous, P.W., Shivas, R.G., Wingfield, M.J., Summerell, B.A. & Rossman, A.Y. et al. 2012, 'Fungal Planet description sheets: 128-153', *Persoonia: Molecular Phylogeny and Evolution of Fungi*, vol. 29, pp. 146-201, LP0349190 (2004-2007)

[45] * Craig, M.D., Hardy, G.E.S.J., Fontaine, J.B., Garkakalis, M.J. & Grigg, A.H. et al. 2012, 'Identifying unidirectional and dynamic habitat filters to faunal recolonisation in restored mine-pits', *Journal of Applied Ecology*, vol. 49, no. 4, pp. 919-928, LP0882687 (2009-2014), LP0455309 (2005-2008)

[46] * Scott, P.M., Jung, T., Shearer, B.L., Barber, P.A. & Calver, M. et al. 2012, 'Pathogenicity of *Phytophthora multivora* to *Eucalyptus gomphocephala* and *Eucalyptus marginata*', *Forest Pathology*, vol. 42, no. 4, pp. 289-298, LP0668195 (2007-2010)

[47] Aghighi, S., Hardy, G.E.S.J., Scott, J.K. & Burgess, T.I. 2012, '*Phytophthora bilorbang* sp. nov., a new species associated with the

decline of *Rubus anglocandicans* (European blackberry) in Western Australia', *European Journal of Plant Pathology*, vol. 133, no. 4, pp. 841-855

[48] * Ruthrof, K.X., Douglas, T.K., Calver, M.C., Craig, M.D. & Dell, B. et al. 2012, 'The efficacy of soil ameliorants to improve early establishment in trees and shrubs in degraded *Eucalyptus gomphocephala* woodlands', *Pacific Conservation Biology*, vol. 12, no. 4, pp. 310-318, LP0668195 (2007-2010)

[49] Eshraghi, L., Aryamanesh, N., Anderson, J.P., Shearer, B. & McComb, J.A. et al. 2011, 'A quantitative PCR assay for accurate in planta quantification of the necrotrophic pathogen *Phytophthora cinnamomi*', *European Journal of Plant Pathology*, vol. 131, no. 3, pp. 419-430, LP0776252 (2008-2013)

[50] Sakalidis, M.L., Hardy, G.E.St.J. & Burgess, T.I. 2011, 'Class III endophytes, clandestine movement amongst hosts and habitats and their potential for disease; a focus on *Neofusicoccum australe*', *Australasian Plant Pathology*, vol. 40, no. 5, pp. 510-521

[51] Sakalidis, M.L., Hardy, G.E.S.J. & Burgess, T.I. 2011, 'Endophytes as potential pathogens of the baobab species *Adansonia gregorii*: A focus on the Botryosphaeriaceae', *Fungal Ecology*, vol. 4, no. 1, pp. 1-14

[52] Crous, P.W., Groenewald, J.Z., Shivas, R.G., Edwards, J. & Seifert, K.A. et al. 2011, 'Fungal planet description sheets: 69-91', *Persoonia: Molecular Phylogeny and Evolution of Fungi*, vol. 26, pp. 108-156

[53] * Craig, M.D., Benkovic, A.M., Grigg, A.H., Hardy, G.E.S.J. & Fleming, P.A. et al. 2011, 'How many mature microhabitats does a slow-recolonising reptile require? Implications for restoration of bauxite minesites in south-western Australia', *Australian Journal of Zoology*, vol. 59, no. 1, pp. 9-17, LP0455309 (2005-2008), LP0882687 (2009-2014)

[54] * Archibald, R.D., Craig, M.D., Bialkowski, K., Howe, C. & Burgess, T.I. et al. 2011, 'Managing small remnants of native forest to increase biodiversity within plantation landscapes in the south west of Western Australia', *Forest Ecology and Management*, vol. 261, no. 7, pp. 1254-1264, LP0346931 (2004-2007)

[55] * Jung, T., Stukely, M.J.C., Hardy, G.E.St.J., White, D. & Paap, T. et al. 2011, 'Multiple new *Phytophthora* species from ITS clade 6 associated with natural ecosystems in Australia: Evolutionary and ecological implications', *Persoonia: Molecular Phylogeny and Evolution of Fungi*, vol. 26, pp. 13-39

[56] Agostini, C., Agudelo, P.A., Bâ, K., Barber, P.A. & Bisol, P.M. et al. 2011, 'Permanent Genetic Resources added to Molecular Ecology Resources Database 1 October 2010-30 November 2010', *Molecular Ecology Resources*, vol. 11, no. 2, pp. 418-421

[57] Eshraghi, L., Anderson, J., Aryamanesh, N., Shearer, B. & McComb, J. et al. 2011, 'Phosphite primed defence responses and enhanced expression of defence genes in *Arabidopsis thaliana* infected with *Phytophthora cinnamomi*', *Plant Pathology*, vol. 60, no. 6, pp. 1086-1095, LP0776252 (2008-2013)

[58] Pilbeam, R.A., Howard, K., Shearer, B.L. & Hardy, G.E.S.J. 2011, 'Phosphite stimulated histological responses of *Eucalyptus marginata* to infection by *Phytophthora cinnamomi*', *Trees - Structure and Function*, vol. 25, no. 6, pp. 1121-1131

[59] * Laurance, W.F., Dell, B., Turton, S.M., Lawes, M.J. & Hutley, L.B. et al. 2011, 'The 10 Australian ecosystems most vulnerable to tipping points', *Biological Conservation*, vol. 144, no. 5, pp. 1472-1480

[60] Rea, A.J., Burgess, T.I., Hardy, G.E.S.J., Stukely, M.J.C. & Jung, T. 2011, 'Two novel and potentially endemic species of *Phytophthora* associated with episodic dieback of Kwongan vegetation in the south-west of Western Australia', *Plant Pathology*, vol. 60, no. 6, pp. 1055-1068

[61] Sakalidis, M.L., Hardy, G.E.S.J. & Burgess, T.I. 2011, 'Use of the Genealogical Sorting Index (GSI) to delineate species boundaries in the *Neofusicoccum parvum*-*Neofusicoccum ribis* species complex', *Molecular Phylogenetics and Evolution*, vol. 60, no. 3, pp. 333-344

[62] Dunstan, W.A., Rudman, T., Shearer, B.L., Moore, N.A. & Paap, T. et al. 2010, 'Containment and spot eradication of a highly destructive, invasive plant pathogen (*Phytophthora cinnamomi*) in natural ecosystems', *Biological Invasions*, vol. 12, no. 4, pp. 913-925, LP0776740 (2008-2011), LP0227820 (2003-2006)

[63] * Rea, A.J., Jung, T., Burgess, T.I., Stukely, M.J.C. & Hardy, G.E.St.J. 2010, '*Phytophthora elongata* sp. nov., a novel pathogen from the *Eucalyptus marginata* forest of Western Australia', *Australasian Plant Pathology*, vol. 39, no. 6, pp. 477-491

[64] * Ruthrof, K.X., Douglas, T.K., Calver, M.C., Barber, P.A. & Dell, B. et al. 2010, 'Restoration treatments improve seedling establishment in a degraded Mediterranean-type *Eucalyptus* ecosystem', *Australian Journal of Botany*, vol. 58, no. 8, pp. 646-655, LP0668195 (2007-2010), LP0346931 (2004-2007)

[65] * Archibald, R.D., Bradshaw, J., Bowen, B.J., Close, D.C. & McCaw, L. et al. 2010, 'Understorey thinning and burning trials are needed in conservation reserves: The case of Tuart (*Eucalyptus gomphocephala* D.C.)', *Ecological Management and Restora-*

tion, vol. 11, no. 2, pp. 108-112, LP0668195 (2007-2010), LP0346931 (2004-2007)

- [66] * Taylor, K., Barber, P.A., St J. Hardy, G.E. & Burgess, T.I. 2009, 'Botryosphaeriaceae from tuart (*Eucalyptus gomphocephala*) woodland, including descriptions of four new species', *Mycological Research*, vol. 113, no. 3, pp. 337-353, LP0668195 (2007-2010)
- [67] * Craig, M.D., Grigg, A.H., Garkaklis, M.J., Hobbs, R.J. & Grant, C.D. et al. 2009, 'Does habitat structure influence capture probabilities? A study of reptiles in a eucalypt forest', *Wildlife Research*, vol. 36, no. 6, pp. 509-515, LP0455309 (2005-2008), LP0882687 (2009-2014)
- [68] McCarren, K.L., McComb, J.A., Shearer, B.L. & Hardy, G.E.St.J. 2009, 'Phosphite impact on the in vitro production and viability of selfed oospores by *Phytophthora cinnamomi*', *Forest Pathology*, vol. 39, no. 2, pp. 124-132
- [69] * Scott, P.M., Burgess, T.I., Barber, P.A., Shearer, B.L. & Stukely, M.J.C. et al. 2009, '*Phytophthora multivora* sp. nov., a new species recovered from declining *Eucalyptus*, *Banksia*, *Agonis* and other plant species in Western Australia', *Persoonia: Molecular Phylogeny and Evolution of Fungi*, vol. 22, pp. 1-13, LP0668195 (2007-2010)
- [70] Burgess, T.I., Webster, J.L., Ciampini, J.A., White, D. & Hardy, G.E.S. et al. 2009, 'Re-evaluation of *phytophthora* species isolated during 30 years of vegetation health surveys in Western Australia using molecular techniques', *Plant Disease*, vol. 93, no. 3, pp. 215-223
- [71] Glen, M., Bougher, N.L., Colquhoun, I.J., Vlahos, S. & Loneragan, W.A. et al. 2008, 'Ectomycorrhizal fungal communities of rehabilitated bauxite mines and adjacent, natural jarrah forest in Western Australia', *Forest Ecology and Management*, vol. 255, no. 1, pp. 214-225, C00002212 (2000-2002)
- [72] Jackson, S.L., Maxwell, A., Burgess, T.I., Hardy, G.E.St.J. & Dell, B. 2008, 'Incidence and new records of *Mycosphaerella* species within a *Eucalyptus globulus* plantation in Western Australia', *Forest Ecology and Management*, vol. 255, no. 12, pp. 3931-3937, C00002214 (2000-2002)
- [73] * Paap, T., Burgess, T.I., McComb, J.A., Shearer, B.L. & St J. Hardy, G.E. 2008, '*Quambalaria* species, including *Q. coyrecup* sp. nov., implicated in canker and shoot blight diseases causing decline of *Corymbia* species in the southwest of Western Australia', *Mycological Research*, vol. 112, no. 1, pp. 57-69
- [74] Dobrowolski, M.P., Shearer, B.L., Colquhoun, I.J., O'Brien, P.A. & Hardy, G.E.St.J. 2008, 'Selection for decreased sensitivity to phosphite in *Phytophthora cinnamomi* with prolonged use of fungicide', *Plant Pathology*, vol. 57, no. 5, pp. 928-936, C00002224 (2000-2002)
- [75] McDougall, K.L., Hardy, G.E.St.J. & Hobbs, R.J. 2007, 'Comparison of colonisation by *Phytophthora cinnamomi* in detached stem tissue of *Eucalyptus marginata* in relation to site disease status', *Australasian Plant Pathology*, vol. 36, no. 5, pp. 498-500, C19804805 (1998-2001)
- [76] * Swinburn, M.L., Fleming, P.A., Craig, M.D., Grigg, A.H. & Garkaklis, M.J. et al. 2007, 'The importance of naked grasstrees (*Xanthorrhoea preissii*) as habitat for mardo (*Antechinus flavipes leucogaster*) during post-fire recovery', *Wildlife Research*, vol. 34, no. 8, pp. 640-651
- [77] Burgess, T.I., Barber, P.A. & Hardy, G.E.St.J. 2005, '*Botryosphaeria* spp. associated with eucalypts in Western Australia, including the description of *Fusicoccum macroclavatum* sp. nov.', *Australasian Plant Pathology*, vol. 34, no. 4, pp. 557-567, DP0343600 (2003-2007)
- [78] Taylor, A., Hardy, G.E.St.J., Wood, P. & Burgess, T. 2005, 'Identification and pathogenicity of *Botryosphaeria* species associated with grapevine decline in Western Australia', *Australasian Plant Pathology*, vol. 34, no. 2, pp. 187-195
- [79] McDougall, K.L., Hardy, G.E.St.J. & Hobbs, R.J. 2002, 'Distribution of *Phytophthora cinnamomi* in the northern jarrah (*Eucalyptus marginata*) forest of Western Australia in relation to dieback age and topography', *Australian Journal of Botany*, vol. 50, no. 1, pp. 107-114, C19804805 (1998-2001)
- [80] McDougall, K.L., Hobbs, R.J. & Hardy, G.E.St.J. 2002, 'Vegetation of *Phytophthora cinnamomi*-infested and adjoining uninfested sites in the northern jarrah (*Eucalyptus marginata*) forest of Western Australia', *Australian Journal of Botany*, vol. 50, no. 3, pp. 277-288, C19804805 (1998-2001)
- [81] Wilkinson, C.J., Holmes, J.M., Tynan, K.M., Colquhoun, I.J. & McComb, J.A. et al. 2001, 'Ability of phosphite applied in a glasshouse trial to control *Phytophthora cinnamomi* in five plant species native to Western Australia', *Australasian Plant Pathology*, vol. 30, no. 4, pp. 343-351, C29700340 (1997-1999), C00002224 (2000-2002)
- [82] Hardy, G.E.St.J., Barrett, S. & Shearer, B.L. 2001, 'The future of phosphite as a fungicide to control the soilborne plant pathogen *Phytophthora cinnamomi* in natural ecosystems', *Australasian Plant Pathology*, vol. 30, no. 2, pp. 133-139, C29700340 (1997-1999), C00002224 (2000-2002)

- [83] Wilkinson, C.J., Shearer, B.L., Jackson, T.J. & Hardy, G.E.St.J. 2001, 'Variation in sensitivity of Western Australian isolates of *Phytophthora cinnamomi* to phosphite in vitro', *Plant Pathology*, vol. 50, no. 1, pp. 83-89, C29700340 (1997-1999), C0002224 (2000-2002)
- [84] Jackson, T.J., Burgess, T., Colquhoun, I. & Hardy, G.E.St.J. 2000, 'Action of the fungicide phosphite on *Eucalyptus marginata* inoculated with *Phytophthora cinnamomi*', *Plant Pathology*, vol. 49, no. 1, pp. 147-154, C29700340 (1997-1999)
- [85] El-Tarabily, K.A., Soliman, M.H., Nassar, A.H., Al-Hassani, H.A. & Sivasithamparam, K. et al. 2000, 'Biological control of *Sclerotinia minor* using a chitinolytic bacterium and actinomycetes', *Plant Pathology*, vol. 49, no. 5, pp. 573-583
- [86] Colquhoun, I.J. & Hardy, G.E.St.J. 2000, 'Managing the risks of phytophthora root and collar rot during bauxite mining in the *Eucalyptus marginata* (jarrah) forest of Western Australia', *Plant Disease*, vol. 84, no. 2, pp. 116-127, C29700340 (1997-1999), C2953011 (1995-1997)
- [87] * Thomson, B.D., Grove, T.S., Malajczuk, N. & StJ Hardy, G.E. 1996, 'The effect of soil pH on the ability of ectomycorrhizal fungi to increase the growth of *Eucalyptus globulus* Labill.', *Plant and Soil*, vol. 178, no. 2, pp. 209-214
- [88] * Thomson, B.D., StJ Hardy, G.E., Malajczuk, N. & Grove, T.S. 1996, 'The survival and development of inoculant ectomycorrhizal fungi on roots of outplanted *Eucalyptus globulus* Labill.', *Plant and Soil*, vol. 178, no. 2, pp. 247-253
- [89] * THOMSON, B.D., GROVE, T.S., MALAJCZUK, N. & HARDY, G.E.S.J. 1994, 'The effectiveness of ectomycorrhizal fungi in increasing the growth of *Eucalyptus globulus* Labill. in relation to root colonization and hyphal development in soil', *New Phytologist*, vol. 126, no. 3, pp. 517-524
- [90] * Thomson, B.D., Malajczuk, N., Grove, T.S. & Hardy, G.E.St.J. 1993, 'Improving the colonization capacity and effectiveness of ectomycorrhizal fungal cultures by association with a host plant and re-isolation', *Mycological Research*, vol. 97, no. 7, pp. 839-844

Part D - Personnel and ROPE (Mrs Bonnie Beal Richardson)

D1. Personal Details

(To update personal details, click the 'Manage Personal Details' link below. Note this will open a new browser tab. When returning to the form ensure you 'Refresh' the page to capture the changes made to your profile.)

Participation Type

Partner Investigator

Title

Mrs

First Name

Bonnie

Family Name

Beal Richardson

D4. Qualifications

(To update any qualifications, click on the 'Manage Qualifications' link below. Note this will open a new browser tab. When returning to the form ensure you 'Refresh' the page to capture the changes made to your profile.)

Conferral Date	AQF Level	Degree/Award Title	Discipline/Field	Awarding Organisation	Country of Award
18/02/2015	Bachelor Degree	Bachelor	Sustainability	Murdoch University	Australia

D5. Research Opportunity and Performance Evidence (ROPE) - Current and previous appointment(s) / position(s) - during the past 10 years

(To update any details in this table, click on the 'Manage Employment Details' link below. Note this will open a new browser tab. When returning to the form ensure you 'Refresh' the page to capture the changes made to your profile. Refer to the Instructions to Applicants for more information.)

Description	Department	Contract Type	Employment Type	Start Date	End Date	Organisation
Senior Environmental Education Officer	Environmental Services	Permanent	Full Time	19/12/2016		CITY OF MANDURAH
Sustainability Officer	Environmental Services	Permanent	Full Time	31/01/2013	18/12/2016	CITY OF MANDURAH
Project Officer	Climate Change Services	Permanent	Full Time	30/04/2011	31/01/2013	CITY OF MANDURAH
Administration Officer / Projects Assistant	EcoServices	Permanent	Full Time	09/01/2009	30/04/2011	CITY OF MANDURAH

D6. Research Opportunity and Performance Evidence (ROPE) - Academic Interruptions

(You must read the ROPE Statement <http://www.arc.gov.au/arc-research-opportunity-and-performance-evidence-rope-statement> before filling out this section.)

Have you experienced an interruption that has impacted on your academic record?

No

D7. Research Opportunity and Performance Evidence (ROPE) - Details of the participant's academic career and opportunities for research, evidence of research impact and contributions to the field, including those most relevant to this application

(Provide details of your academic career and opportunities, evidence of research impact and contributions to the field. (Upload a PDF of no more than five A4 pages))

Uploaded PDF file follows on next page.

Research Opportunity and Performance Evidence (ROPE)

AMOUNT OF TIME AS AN ACTIVE RESEARCHER I was awarded my Bachelor in Sustainability with a Minor in Issues in Global Development in 2015. I commenced working in the environmental education and community engagement field in 2009 and during this time I have experienced no academic interruptions. Over the past eleven years, I have cultivated a broad set of skills that are transferable to the social, environmental and economic contexts. These include the design of multiple community and environmental education programs, partnership development, delivery of community events, community engagement and consultation, and strategic thinking. I specialise in the utilisation of social science approaches to enhance the effectiveness of community programs, and work with the community to develop their own capacity to deliver environmental and community programs.

RESEARCH OPPORTUNITIES:

In my current role as the Senior Environmental Education Officer at the City of Mandurah, I am responsible for setting the strategic direction for community sustainability education and engagement in the City of Mandurah. My role is heavily focused on engaging the community in actions to protect our local environment, with specific focus on empowering people to rediscover their innate strengths, skills and passions, and leveraging these to develop and deliver community projects. In doing so, I am privileged to witness local communities realise their full potential.

Working in local government in a community-facing role has provided me with a thorough understanding of how to translate scientific information into practical application and communicating complex information in a way that is easily understandable for the broader community. Examples of this include my work on *LP16010044 – ‘Backyard Bandicoots: engaging community in urban bushland conservation’*, which has required me to advocate for the practical implementation of research findings, ensuring a best-practice approach to the management of the City’s urban bushland. I have also worked to engage other local governments through the Backyard Bandicoots project by showcasing the benefits of our partnership and encouraging other organisations to pursue their own research partnerships.

I strive to stay up-to-date with changes in my industry, and am trained in a number of different approaches in community engagement. These include community-based social marketing, International Association for Public Participation (IAP2) engagement techniques and values-based communication. In 2011, I designed and implemented the Community Household Electricity Reduction Pilot (CHERP) Project. This project was the first of its kind in WA and was awarded with a Highly Commended in the 2012 Keep Australia Beautiful Awards. In 2018, I coordinated the successful delivery of a community engagement campaign to assess and build community support for the National Heritage Listing of Yalgorup National Park.

Research mentoring and research facilities available to me during my career:

The City of Mandurah is extremely supportive of research engagement and working with Murdoch University researchers has been part of my role since 2016. As a result, one of the most important aspects of my role is the creation and development of strong relationships with research institutions, government and community. I have supported the development and delivery of a number of research partnerships including:

- Backyard Bandicoots (LP16010044), a partnership with Murdoch University that aims to engage the local community in environmental protection through citizen science,
- Mandurah Dolphin Research, a partnership with Murdoch University which monitors the health of our resident dolphin population, and
- Environmental Education Research Partnership, a PhD research project which aims to assess the effectiveness of three of the City’s approaches to environmental education.

I work closely with experts in my field, and I am a member of the WA Chapter of the Australian Association of Environmental Education, the peak body for environmental education in Australia. In 2018, in collaboration with the WA Chapter, I was successful in attracting the 2020 Australian Association of Environmental Education Biennial Conference and Research Symposium to Mandurah.

RESEARCH ACHIEVEMENTS AND CONTRIBUTIONS

Prizes, honours and awards

2019 – Finalist, Western Australian Young Achiever Awards.

2018 – Semi-Finalist, Western Australian Young Achiever Awards.

2013 – Vice Chancellor's Award for Academic Excellence, Murdoch University.

2012 – Highly Commended, Keep Australia Beautiful Awards. Awarded to the City of Mandurah for the Community Household Electricity Reduction Pilot (CHERP) Program.

Invited keynote and speaker addresses

I regularly present on research findings and community engagement on behalf of the City of Mandurah, including invited oral presentations such as:

- Beal Richardson, B. 2019. Designing environmental programs that support people (and people want to support). Nature City Seminar 2019 supported by Perth Natural Resource Management (NRM).
- Beal Richardson, B. 2018. Backyard Bandicoots: Partnering to Engage Community. Wild City 2018 organised by Murdoch University.
- Baudains, C. and Beal Richardson, B. 2017. Backyard Bandicoots – residents assisting with wildlife conservation. Western Australian Local Government Authority (WALGA) Natural Area Management Network Citizen Science Forum organised by WALGA.

Scientific Service and Public Engagement

My role as **Senior Environmental Education Officer with the City of Mandurah** (Dec 2016 – Current), involves substantial demonstration of excellent written and verbal communication skills for public engagement. I have personally been responsible for:

- Developing Council Reports
- Presenting reports/requests to Council and the City's Executive Leadership team
- Representing the City of Mandurah at industry-relevant events
- Facilitating community workshops
- Providing clear instruction to staff and volunteers
- Conducting community surveys
- Data collection, interpretation and analysis
- Developing project branding and marketing strategies, including social and traditional media promotion

All these mediums are vital for active engagement of community with environmental activities.

I have also been directly involved in overseeing the design, implementation and evaluation of school and community programs which actively engage the public. Examples include:

- The City's annual Kids Teaching Kids Conference – a program designed to develop research, leadership and presentation skills and engage students in self-directed learning,
- Embrace a Space – a program that provides a framework for the community to activate and care for local spaces of their choosing for the benefit of the whole community,
- Climate Change and Sustainability School Tours – these tours are tailored to meet the requirements of the Year 12 ATAR Geography curriculum and provide students with the ability to connect their classroom learning with real-life examples,
- Establishment of the Mandurah Environmental Volunteer Alliance – a regular networking event for local environmental volunteers, and
- Yalgorup Bioblitz – a day-long community flora and fauna survey that provides local people with the opportunity to learn what is special about their local environment. Over 130 community members participated in 10 different surveys throughout the course of the event. Participants identified 60 species of plant, 57 species of bird (including both shorebirds and bushland birds), 4 species of frogs, hundreds of invertebrates and 2 species of possum (including the Critically Endangered Western Ringtail Possum). The event was hugely successful in educating local people about their local environment, and was run by a volunteer Steering Committee with support from City of Mandurah staff.

Identifiable benefits outside of academia

I regularly provide support to my peers from other local governments and non-government organisations in regard to setting up effective research partnerships that translate to real-world outcomes, and on effective community engagement strategies. In 2018, I initiated the effort to attract the 2020 Australian Association of Environmental Education Biennial Conference and Research Symposium to Mandurah. My aim as the Conference Chair of this conference is to change the way practitioner's approach education for sustainability by ensuring we design truly effective, best-practice, outcomes-focussed programs. With the association's network, this conference has the potential to influence the field of environmental education both nationally and internationally.

How my research has led to a significant change or advance of knowledge, and how my achievements will contribute to this application:

My work is the interface between people and environment. I am passionate about finding effective solutions to social and environmental issues, and believe understanding human values and the way they impact behaviour is critical to successful program design. I design and deliver programs that connect people with nature and strengthen local sense of place to enhance overall wellbeing. Such programs include the City's Embrace a Space program and the Mandurah Environmental Volunteer Alliance.

For the past three years, I have been heavily focused on creating and enhancing community capacity through the incubation of community-led action and initiatives, and supporting local community groups and volunteers to design and deliver effective community programs. My work has directly encouraged active public participation and engagement, leading to significant change for our local environment and our community. Community projects I have supported include:

- Osprey WA – a group focussed on using citizen science to effectively monitor local osprey populations
- Lakelands Community Gardens – supporting the community to develop a community garden in Lakelands
- Coastal Waste Warriors – a local initiative focussed on cleaning up local waterways. This groups has removed over 1,200 kg of rubbish in 12 months and regularly attracts over 100 people to their events.
- Seabin Project – the second installation of seabins in Australia, delivered in partnership with Peel Preservation Group

I am skilled in systems thinking and strategic planning. My tendency to look at the bigger picture to help understand complex, systemic interactions ensures collaboration is my natural way of operating. For example, I am currently overseeing the development of a sustainable tourism assessment tool for the City of Mandurah in conjunction with the City's Manager Economic Development and Murdoch University. This tool will provide a strategic framework for sustainable tourism in the City of Mandurah, and will draw on social, environmental and cultural factors to provide a tool that will enable the City to be in the driving seat when it comes to attracting tourism opportunities, and ensuring these opportunities are aligned with the City's vision.

D8. Research Opportunity and Performance Evidence (ROPE) - Currently held ARC projects

(This information is auto-populated from the applicants RMS profile and will include any active project which has not yet had a Final Report approved and the project file closed by the ARC. You will not be able to submit an application to the ARC that involves a researcher who has an overdue Final Report on an ARC-funded project. If there are any concerns with the information recorded here, contact Your organisation's Research Office.)

D9. Project/Role relinquishment or application withdrawal

(If you exceed the Linkage Program limits on projects and/or applications and have applied under the Industrial Transformation Research Hubs, Industrial Transformation Training Centres, Special Research Initiatives, Learned Academies Special projects, Supporting Responses to Commonwealth Science Council Priorities or any other Linkage Program scheme, list the application you wish to withdraw, or the existing project (or role) that that you wish to relinquish should this application be successful (see sections 6.35 to 6.39 of the grant guidelines). Failing to provide this information will jeopardise the eligibility of your applications. Provide project/application ID(s) separated by a comma.)

D10. Eligibility - Role of Partner Investigator

(Please indicate which of the Partner Investigator role options from section 6.29 of the grant guidelines apply to your role on this project. Select all options that apply.)

D11. Eligibility - Will the participant be residing predominately in Australia for the duration of the project activity period?

((This is a 'Yes' or 'No' question. Indicate whether the participant will be residing predominantly in Australia for the project activity period. If the participant is applying as a CI and they answer 'No' to this question you will be prompted to contact the Research Office to check the participant's eligibility. If the participant is a Foreign National, they must reside legally in Australia. Eligibility will be based solely on the information contained in this application.))

D12. Eligibility - Is the participant currently undertaking a Higher Degree by Research which will be conferred after the grant commencement date?

((This is a 'Yes' or 'No' question. If the participant is applying as a CI and they answer 'Yes' to this question they will be prompted to contact the Research Office and Part D will not validate. Eligibility will be based solely on the information contained in this application.))

D13. Eligibility - Employment Details as at grant commencement date of project

(This question will be used to determine your eligibility. Your eligibility will be based solely on the information contained in this application. Confirm your employment status at all organisations that you will be associated with as at the Grant Commencement Date. Enter the relevant appointment type and Full-Time Equivalent (FTE) for each organisation.)

Org name	Is this an Eligible Organisation?	Please choose your appointment type for this organisation.	Please enter your FTE for this Organisation
CITY OF MANDURAH		Employee	1.0

D14. Eligibility - Further Details Regarding Partner Investigator Status - Does the participant hold a

remunerated appointment at an Eligible Organisation as at the grant commencement date for this project?

(At A2 Partner Investigator has been selected as the role type, but it appears that the participant meets the criteria of a Chief Investigator.

NOTE: this question is mandatory ONLY FOR PIs WHO:

- at D11 confirmed that they will reside predominantly in Australia for the project activity period of the proposed Project; AND*
- at D12 confirmed that they are not currently undertaking a Higher Degree by Research which will be conferred after the grant commencement date; AND*
- at D13 indicated that they would hold either:*
 - an appointment at an Eligible Organisation equal or greater than 0.2 FTE; OR*
 - an honorary academic appointment at an Eligible Organisation*

You do not need to answer these questions if it was indicated in question D11 that the participant will be living predominantly overseas OR if they have indicated in question D12 that the participant will be undertaking a Higher Degree by Research.)

Do you hold a remunerated appointment at an Eligible Organisation?

Justification of PI status

D15. Eligibility - Relevant Organisation for this application as at the grant commencement date for this project

(Enter the Organisation that is relevant to the participant's inclusion on this application, and that they will be associated with as at the grant commencement date. The 'relevant organisation' is the primary organisation that will be supporting the participant's involvement in this project if it is funded. Note that the Organisation must be listed in D13 for this question to validate.)

Relevant Organisation

D16. What is the participant's time commitment to this project?

(Enter the participant's time commitment to this project as a Full-Time Equivalent (FTE). Note that a FTE of 1.0 represents a full-time commitment (i.e. 5 days per week).)

D17. Research Opportunity and Performance Evidence (ROPE) - Research Outputs

(Research context: Provide clear information that explains the relative importance of different research outputs and expectations in the participant's discipline/s. The information should help assessors understand the context of the participant's academic research achievements but not repeat information already provided in this application. It is helpful to include the importance/esteem of specific journals in the participant's field; specific indicators of recognition within the participant's field such as first authorship/citations, or the significance of non-traditional research outputs. If this question is not relevant to a participant, for example a PI with non-academic background, the participant should include a short explanatory statement as to why this question is not applicable. (No more than 3,750 characters, approximately 500 words))

D18. Research Opportunity and Performance Evidence (ROPE) – Research Outputs Listing including Ten Career-Best Research Outputs

(List the research outputs marking those that are most relevant to this application categorised under the following headings: Ten career-best research outputs; Authored books; Edited books; Book chapters; Referred Journal articles; Fully refereed conference proceedings; Additional research outputs (including non-traditional research outputs). CVs and theses should not be included in this list. The participant's ten career-best research outputs should not be repeated under subsequent headings. (No more than 100 research outputs).)

Research Outputs Listing

No research outputs provided

Part D - Personnel and ROPE (Dr Ben Miller)

D1. Personal Details

(To update personal details, click the 'Manage Personal Details' link below. Note this will open a new browser tab. When returning to the form ensure you 'Refresh' the page to capture the changes made to your profile.)

Participation Type

Partner Investigator

Title

Dr

First Name

Ben

Family Name

Miller

D4. Qualifications

(To update any qualifications, click on the 'Manage Qualifications' link below. Note this will open a new browser tab. When returning to the form ensure you 'Refresh' the page to capture the changes made to your profile.)

Conferral Date	AQF Level	Degree/Award Title	Discipline/Field	Awarding Organisation	Country of Award
18/11/2004	Doctoral Degree	PhD	Plant Ecology	The University of Melbourne	Australia
06/01/1992	Bachelor Honours Degree, Graduate Certificate, Graduate Diploma	BSc Hons	Botany and Physical Geography	The University of Melbourne	Australia

D5. Research Opportunity and Performance Evidence (ROPE) - Current and previous appointment(s) / position(s) - during the past 10 years

(To update any details in this table, click on the 'Manage Employment Details' link below. Note this will open a new browser tab. When returning to the form ensure you 'Refresh' the page to capture the changes made to your profile. Refer to the Instructions to Applicants for more information.)

Description	Department	Contract Type	Employment Type	Start Date	End Date	Organisation
Principal Research Scientist	Department of Biodiversity Conservation and Attractions	Permanent	Full Time	01/07/2018		Department of Biodiversity Conservation and Attractions
Director, Science	Kings Park Science	Permanent	Full Time	01/07/2015	30/06/2018	BOTANIC GARDENS & PARKS AUTHORITY
Senior Research Scientist (Fire Ecologist)	Science	Contract	Full Time	17/08/2013	30/06/2015	BOTANIC GARDENS & PARKS AUTHORITY

Senior Research Scientist (Restoration Ecologist)	Science	Contract	Full Time	07/06/2010	16/08/2013	WA Botanic Gardens and Parks Authority
Research Scientist (Rare Flora Ecologist)	Science	Contract	Full Time	06/06/2007	06/06/2010	WA Botanic Gardens and Parks Authority

D6. Research Opportunity and Performance Evidence (ROPE) - Academic Interruptions

(You must read the ROPE Statement <http://www.arc.gov.au/arc-research-opportunity-and-performance-evidence-rope-statement> before filling out this section.)

Have you experienced an interruption that has impacted on your academic record?

No

D7. Research Opportunity and Performance Evidence (ROPE) - Details of the participant's academic career and opportunities for research, evidence of research impact and contributions to the field, including those most relevant to this application

(Provide details of your academic career and opportunities, evidence of research impact and contributions to the field. (Upload a PDF of no more than five A4 pages))

Uploaded PDF file follows on next page.

B. Miller

D7 Details of academic career and opportunities for research, evidence of research impact and contributions to the field, including those most relevant to this application

AMOUNT OF TIME AS AN ACTIVE RESEARCHER

I was awarded my PhD 15 years ago in 2004, and have worked full time as a research scientist, with no major academic interruptions since.

I have been in industry (State Government) since 2007. In my current role of Principal Research Scientist and Fire Science program leader, I spend about 50% of my time in research, 30% in post-graduate teaching, 10% (Science) program management and administration and 10% corporate (agency) administration.

This new position (since July 2018) resulted from a departmental merger and restructure. In the three years prior to that, my role as Director, Science at BGPA was much more heavily focussed on administration with about 20% research, 25% teaching, 30% program management and 25% corporate administration.

RESEARCH OPPORTUNITIES

Over the past twelve years I have been employed by the Botanic Gardens and Parks Authority (BGPA), and since July 2018 their merger, within the Department of Biodiversity Conservation and Attractions (DBCA). Research facilities and mentoring available to me over this time have generally been very good. I commenced at BGPA with a 3-year conservation research project, and subsequently my roles have involved either initiating long-term research programs (most to then be taken up by others), providing advice for conservation or management programs, or science management. Many of the programs I initiated are now reaching completion and publication stage.

My three years 2015-2018 as BGPA Director, Science, was particularly heavily focussed on administration and bureaucratic process. This is an inherent aspect of the role, but, as a distraction from research, it was compounded by others factors: relationship breakdown with the previous Director resulting in continuous turmoil across many projects; a 12 months employment freeze that prevented backfill of my previous role as Fire Ecologist, leaving me responsible for the management of both positions; and, in the last 18 months, reviews, working groups strategy and administration associated with the subsequent BGPA DBCA departmental merger. My Director position became redundant in the merge, effective July 2018, and I now have a more research-focussed role in fire ecology and developing a Fire Science program within the new Department.

Taking on the role of Director, I also inherited two ARC PI roles from the previous director who chose to drop these when he moved to a University – and hence had a CI status with a tighter cap on numbers. These projects resulted in no academic products for me.

The research mentoring and research facilities that have been available to you during my career have been good.

RESEARCH ACHIEVEMENTS AND CONTRIBUTIONS

Since 2009

- The research team at Kings Park Science, which I led (2015-18) and contributed to, was recognised for its research excellence and innovation and the excellence of its engagement with industry and the community through receipt of four prestigious awards in 2016 and 2017. Two of these, the State Government's Golden Gecko award for environmental excellence, and the West Australian/Australian Institute of Management's green business Pinnacle award, were for a single project – a book describing research and management for restoration of Perth's Banksia Woodlands, to which I contributed a chapter. I was also part of the research team that received the 2017 Australian Mining Exploration Council's environment award. Lastly our team won a 2016 WA innovator of the year award in partnership with UWA.
- I was invited to give a keynote at the 2016 Mine Closure Conference – on 'Ecological research needed to manage risk and meet rising standards in mining rehabilitation.'
- I worked directly with thirteen industry, government, community and research partners to obtain >\$9 million research funding at Kings Park Science.
- I co-led a successful 2016 bid for funds, and chaired an international workshop on standardising seed traits for functional ecology and conservation purposes with a resulting research agenda setting paper published in 2018, and a handbook in preparation.
- With a small team, I developed a Framework for establishment of risk-based Completion Criteria for post-mining rehabilitation and monitoring for WA – for the state EPA and mining departments (DMIRS, DWER), published in 2018.
- I developed a comprehensive Conservation Strategy for Arriyadh Province in Saudi Arabia in four major reports (total 250 pp), which is being implemented through the provincial planning authority, and was asked to advise on the development of that nation's new Department of Environment, which is also following part of the strategy I developed.
- I was Board member/Director for the Western Australian Biodiversity Science Institute (WABSI) for two years, have been a member of the Botanic Gardens and Parks Authority corporate executive team for five years, and have just joined the WA Threatened Ecological Community Scientific Committee, which advises the Minister on TEC listings and related matters. I also sit on the DBCA's Fire Research Engagement Committee, the WA Inter-government bushfire research committee, and the DBCA Science Management team.
- I am Program Leader for an 18-month old Fire Science program within WA's conservation and land management department (DBCA) which aims to consolidate, focus and develop research into fire ecology and fire management outcomes for all of Western Australia, and to assist conservation estate managers to interpret and utilise research findings. This Linkage application address key priorities of the program: my role in the Department and on its science – management committees will ensure that the project's findings achieve rapid management impact.

D8. Research Opportunity and Performance Evidence (ROPE) - Currently held ARC projects

(This information is auto-populated from the applicants RMS profile and will include any active project which has not yet had a Final Report approved and the project file closed by the ARC. You will not be able to submit an application to the ARC that involves a researcher who has an overdue Final Report on an ARC-funded project. If there are any concerns with the information recorded here, contact Your organisation's Research Office.)

Identifier	Investigators	Admin Organisation	Project Title	Funding	End Date	Final Report Due Date	Final Report Status
LP140100736	A/Prof Erik Veneklaas ; Dr Gavan McGrath ; Dr Nik Callow ; Dr Alan Aitken ; Dr Ben Miller ; Mr Andrew Malcolm ; Dr Jason Stevens	The University of Western Australia	Managing ecosystem change requires the integration of above and belowground hydrological processes at relevant scales.	\$300,000	30/04/2019	30/04/2020	Draft
LP150101111	Prof Andrew Whiteley ; Prof Kingsley Dixon ; Mr Paul Storer ; Dr Ben Miller	The University of Western Australia	Mine-site rehabilitation through novel plant and microbe interactions	\$355,000	30/09/2021	30/09/2022	Draft
LP160100996	Prof Neal Enright ; Dr Joseph Fontaine ; Dr Ben Miller	Murdoch University	Optimising fire management for a resilient future	\$455,000	22/01/2022	22/01/2023	Draft
LP180100741	Dr Mark Ooi ; Prof David Keith ; A/Prof William Cornwell ; Dr Mitchell Lyons ; Dr Miriam Munoz-Rojas ; Dr Tony Auld ; Dr Ben Miller ; Dr Katinka Ruthrof ; Dr JOSE A. GONZALEZ-PEREZ ; Mr Andrew Denham ; Mr Berin Mackenzie ; Dr Jennifer Cochrane ; Dr Colin Yates	The University of New South Wales	Beyond fire frequency: understanding fire season for ecosystem management	\$453,000	30/06/2023	30/06/2024	Draft

D9. Project/Role relinquishment or application withdrawal

(If you exceed the Linkage Program limits on projects and/or applications and have applied under the Industrial Transformation Research Hubs, Industrial Transformation Training Centres, Special Research Initiatives, Learned Academies Special projects, Supporting Responses to Commonwealth Science Council Priorities or any other Linkage Program scheme, list the application you wish to withdraw, or the existing project (or role) that that you wish to relinquish should this application be successful (see sections 6.35 to 6.39 of the grant guidelines). Failing to provide this information will jeopardise the eligibility of your applications. Provide project/application ID(s) separated by a comma.)

--

D10. Eligibility - Role of Partner Investigator

(Please indicate which of the Partner Investigator role options from section 6.29 of the grant guidelines apply to your role on this project. Select all options that apply.)

Take significant intellectual responsibility for the planning and conduct of the project and for any strategic decisions required in its pursuit and the communication of results.

D11. Eligibility - Will the participant be residing predominately in Australia for the duration of the project activity period?

((This is a 'Yes' or 'No' question. Indicate whether the participant will be residing predominantly in Australia for the project activity period. If the participant is applying as a CI and they answer 'No' to this question you will be prompted to contact the Research Office to check the participant's eligibility. If the participant is a Foreign National, they must reside legally in Australia. Eligibility will be based solely on the information contained in this application.))

Yes

D12. Eligibility - Is the participant currently undertaking a Higher Degree by Research which will be conferred after the grant commencement date?

((This is a 'Yes' or 'No' question. If the participant is applying as a CI and they answer 'Yes' to this question they will be prompted to contact the Research Office and Part D will not validate. Eligibility will be based solely on the information contained in this application.))

No

D13. Eligibility - Employment Details as at grant commencement date of project

(This question will be used to determine your eligibility. Your eligibility will be based solely on the information contained in this application. Confirm your employment status at all organisations that you will be associated with as at the Grant Commencement Date. Enter the relevant appointment type and Full-Time Equivalent (FTE) for each organisation.)

Org name	Is this an Eligible Organisation?	Please choose your appointment type for this organisation.	Please enter your FTE for this Organisation
DEPARTMENT OF BIODIVERSITY CONSERVATION AND ATTRACTIONS		Employee	1

D14. Eligibility - Further Details Regarding Partner Investigator Status - Does the participant hold a remunerated appointment at an Eligible Organisation as at the grant commencement date for this project?

(At A2 Partner Investigator has been selected as the role type, but it appears that the participant meets the criteria of a Chief Investigator.

NOTE: this question is mandatory ONLY FOR PIs WHO:

- at D11 confirmed that they will reside predominantly in Australia for the project activity period of the proposed Project; AND
- at D12 confirmed that they are not currently undertaking a Higher Degree by Research which will be conferred after the grant commencement date; AND
- at D13 indicated that they would hold either:
 - an appointment at an Eligible Organisation equal or greater than 0.2 FTE; OR
 - an honorary academic appointment at an Eligible Organisation

You do not need to answer these questions if it was indicated in question D11 that the participant will be living predominantly overseas OR if they have indicated in question D12 that the participant will be undertaking a Higher Degree by Research.)

Do you hold a remunerated appointment at an Eligible Organisation?

Justification of PI status

D15. Eligibility - Relevant Organisation for this application as at the grant commencement date for this project

(Enter the Organisation that is relevant to the participant's inclusion on this application, and that they will be associated with as at the grant commencement date. The 'relevant organisation' is the primary organisation that will be supporting the participant's involvement in this project if it is funded. Note that the Organisation must be listed in D13 for this question to validate.)

Relevant Organisation

DEPARTMENT OF BIODIVERSITY CONSERVATION AND ATTRACTIONS

D16. What is the participant's time commitment to this project?

(Enter the participant's time commitment to this project as a Full-Time Equivalent (FTE). Note that a FTE of 1.0 represents a full-time commitment (i.e. 5 days per week).)

0.1

D17. Research Opportunity and Performance Evidence (ROPE) - Research Outputs

(Research context: Provide clear information that explains the relative importance of different research outputs and expectations in the participant's discipline/s. The information should help assessors understand the context of the participant's academic research achievements but not repeat information already provided in this application. It is helpful to include the importance/esteem of specific journals in the participant's field; specific indicators of recognition within the participant's field such as first authorship/citations, or the significance of non-traditional research outputs. If this question is not relevant to a participant, for example a PI with non-academic background, the participant should include a short explanatory statement as to why this question is not applicable. (No more than 3,750 characters, approximately 500 words))

I have published a total of 60 publications, which have been cited a total of 1,596 times (Scopus). My h index is 22 (Scopus) or 25 (Google Scholar).

I aim to publish in the most appropriate, high impact journals to disseminate my science as broadly as possible. I directly collaborate on these publications with students and a broad range of industry and academic partners. As examples, the following publications demonstrate this research strategy:

1. Just published in prestigious journal TREE, a new framework for understanding effects of fire season on plant responses, co led by a PhD student I supervise and myself.
2. A well cited for its age, led by myself on research priorities for ecosystem restoration [54 citations since Dec 2016]
3. 1-year old paper – in a prestigious high-impact Nature published journal, 'went viral' – 99th percentile Altmetric (834), including with articles published in 58 news outlets [15 citations]
4. A highly cited 1-year old paper from a workshop on seed biology research priorities that I co-organised and chaired. [20 citations since 2018]
5. A highly cited review, now a key reference on spatial analysis techniques across ecology and other diverse fields. [361 citations]
6. This older paper continues to be regularly cited as a guide and test of methods in estimating species richness from vegetation samples. [186 citations]
7. An early paper analysing seed dispersal using (then) novel molecular techniques. The surprisingly high rate of dispersal of seeds over long distances reported is important for understanding responses to both local disturbance, and global change. [166 citations]
8. Breeding biology and seed production study from disturbed, fire-prone shrublands. [161 citations]
9. A book chapter led by myself in 3rd edition of key reference on Australian Vegetation. I was invited by the

editor David Keith to contribute this chapter on Fire in Australian Vegetation for the book Australian Vegetation. [9 citations]

10. The youngest of my 10 most cited papers. An important contribution to understanding the interactions between plant traits, fire interval and management, climate change and community responses. [86 citations]

D18. Research Opportunity and Performance Evidence (ROPE) – Research Outputs Listing including Ten Career-Best Research Outputs

(List the research outputs marking those that are most relevant to this application categorised under the following headings: Ten career-best research outputs; Authored books; Edited books; Book chapters; Referred Journal articles; Fully refereed conference proceedings; Additional research outputs (including non-traditional research outputs). CVs and theses should not be included in this list. The participant's ten career-best research outputs should not be repeated under subsequent headings. (No more than 100 research outputs).)

Research Outputs Listing

Generated research output document follows on the next page

Ten Career-Best Research Outputs

- [1] * Russell G. Miller, Ryan Tangney, Neal J. Enright, Joseph B. Fontaine & David J. Merritt et al. 2019, 'Mechanisms of Fire Seasonality Effects on Plant Populations', *Trends in Ecology & Evolution*, vol. 34, no. 12, pp. 1104–1117, doi:10.1016/j.tree.2019.07.009 (Refereed Journal Article)
- [2] * Ben P. Miller, Elizabeth A. Sinclair, Myles H. M. Menz, Carole P. Elliott & Eric Bunn et al. 2016, 'A framework for the practical science necessary to restore sustainable, resilient, and biodiverse ecosystems', *Restoration Ecology*, vol. 25, no. 4, pp. 605–617, doi:10.1111/rec.12475 (Refereed Journal Article)
- [3] * Katinka X. Ruthrof, David D. Breshears, Joseph B. Fontaine, Ray H. Froend & George Matusick et al. 2018, 'Subcontinental heat wave triggers terrestrial and marine, multi-taxa responses', *Scientific Reports*, vol. 8, no. 1, doi:10.1038/s41598-018-31236-5 (Refereed Journal Article)
- [4] Arne Saatkamp, Anne Cochrane, Lucy Commander, Lydia K. Guja & Borja Jimenez-Alfaro et al. 2018, 'A research agenda for seed-trait functional ecology', *New Phytologist*, vol. 221, no. 4, pp. 1764–1775, doi:10.1111/nph.15502 (Refereed Journal Article)
- [5] Perry, G.L.W., Miller, B.P. & Enright, N.J. 2006, 'A comparison of methods for the statistical analysis of spatial point patterns in plant ecology', *Plant Ecology*, vol. 187, no. 1, pp. 59-82 (Refereed Journal Article)
- [6] Chiarucci, A., Enright, N.J., Perry, G.L.W., Miller, B.P. & Lamont, B.B. 2003, 'Performance of nonparametric species richness estimators in a high diversity plant community', *Diversity and Distributions*, vol. 9, no. 4, pp. 283-295 (Refereed Journal Article)
- [7] He, T., Krauss, S.L., Lamont, B.B., Miller, B.P. & Enright, N.J. 2004, 'Long-distance seed dispersal in a metapopulation of *Banksia hookeriana* inferred from a population allocation analysis of amplified fragment length polymorphism data', *Molecular Ecology*, vol. 13, no. 5, pp. 1099-1109 (Refereed Journal Article)
- [8] * Lamont, B.B., He, T., Enright, N.J., Krauss, S.L. & Miller, B.P. 2003, 'Anthropogenic disturbance promotes hybridization between *Banksia* species by altering their biology', *Journal of Evolutionary Biology*, vol. 16, no. 4, pp. 551-557 (Refereed Journal Article)
- [9] * Miller, B. P., Murphy, B. P. 2017, 'Fire and Australian Vegetation' in Keith, D. A. (ed.), *Australian Vegetation*, pp. 113-134 (Book Chapter)
- [10] * Enright, N.J., Fontaine, J.B., Lamont, B.B., Miller, B.P. & Westcott, V.C. 2014, 'Resistance and resilience to changing climate and fire regime depend on plant functional traits', *Journal of Ecology*, vol. 102, no. 6, pp. 1572-1581 (Refereed Journal Article)

Book Chapters

- [1] * Miller BP, Stevens JC, Rokich DP. Defining targets and deriving criteria for restoration success. In: Stevens JC, Rokich DP, Newton VJ, Barrett RL, Dixon K, editors. *Banksia woodlands: A restoration guide for the Swan Coastal Plain*. Perth WA: UWA press; 2016. p. 61-79.
- [2] * Miller, B. P., Dixon, K. W. 2014, 'Plants and fire in Kwongan vegetation' in Lambers, H. (ed.), *Plant Life on the Sandplains in Southwest Australia, a Global Biodiversity Hotspot*
- [3] * Enright, N. J., Keith, D. A., Clarke, M. F., Miller, B. P. 2012, 'Fire regimes in Australian sclerophyllous shrubby ecosystems: heathlands, heathy woodlands and mallee woodlands' in Bradstock, R. A., Gill, A. M. & Williams, R. J. (eds.), *Flammable Australia: Fire Regimes, Biodiversity and Ecosystems in a Changing World*, pp. 215-234

Refereed Journal Articles

- [1] Carole P. Elliott, Wolfgang Lewandrowski, Ben P. Miller, Matthew Barrett & Shane R. Turner 2019, 'Identifying germination opportunities for threatened plant species in episodic ecosystems by linking germination profiles with historic rainfall events', *Australian Journal of Botany*, vol. 67, no. 3, pp. 256, doi:10.1071/bt18215
- [2] Ben P. Miller, David R. Symons & Matthew D. Barrett 2019, 'Persistence of rare species depends on rare events: demography, fire response and phenology of two plant species endemic to a semiarid Banded Iron Formation range', *Australian Journal of Botany*, vol. 67, no. 3, pp. 268, doi:10.1071/bt18214
- [3] Jessica C. Huss, Oliver Spaeker, Notburga Gierlinger, David J. Merritt & Ben P. Miller et al. 2018, 'Temperature-induced self-sealing capability of *Banksia* follicles', *Journal of The Royal Society Interface*, vol. 15, no. 143, pp. 20180190, doi:10.1098/rsif.2018.0190
- [4] Huss, J. C., Schoeppler, V., Merritt, D. J., Best, C., Maire, E. et al. 2018, 'Climate-Dependent Heat-Triggered Opening Mechanism of *Banksia* Seed Pods', *Advanced Science*

- [5] * Ryan Tangney, David J. Merritt, Joseph B. Fontaine & Ben P. Miller 2018, 'Seed moisture content as a primary trait regulating the lethal temperature thresholds of seeds', *Journal of Ecology*, doi:10.1111/1365-2745.13095
- [6] Commander, L. E., Golos, P. J., Miller, B. P., Merritt, D. J. 2017, 'Seed germination traits of desert perennials', *Plant Ecology*, vol. 218, no. 9, pp. 1077-1091
- [7] Merino-Martín, L., Commander, L., Mao, Z., Stevens, J. C., Miller, B. P. et al. 2017, 'Overcoming topsoil deficits in restoration of semiarid lands: Designing hydrologically favourable soil covers for seedling emergence', *Ecological Engineering*, vol. 105, pp. 102-117
- [8] Perry, G. L. W., Miller, B. P., Lamont, B. B., Enright, N. J. 2017, 'Community-level spatial structure supports a model of stochastic geometry in species-rich shrublands', *Oikos*, vol. 126, no. 6, pp. 833-842
- [9] Nancy Shackelford, Ben P. Miller & Todd E. Erickson 2017, 'Restoration of Open-Cut Mining in Semi-Arid Systems: A Synthesis of Long-Term Monitoring Data and Implications for Management', *Land Degradation & Development*, vol. 29, no. 4, pp. 994-1004, doi:10.1002/ldr.2746
- [10] * Challis, A., Stevens, J.C., McGrath, G. & Miller, B.P. 2016, 'Plant and environmental factors associated with drought-induced mortality in two facultative phreatophytic trees', *Plant and Soil*, vol. 404, no. 1-2, pp. 157-172
- [11] * Westcott, V.C., Enright, N.J., Miller, B.P., Fontaine, J.B. & Lade, J.C. et al. 2014, 'Biomass and litter accumulation patterns in species-rich shrublands for fire hazard assessment', *International Journal of Wildland Fire*, vol. 23, no. 6, pp. 860-871
- [12] * Bader, M.K.-F., Ehrenberger, W., Bitter, R., Stevens, J. & Miller, B.P. et al. 2014, 'Spatio-temporal water dynamics in mature *Banksia menziesii* trees during drought', *Physiologia Plantarum*, vol. 152, no. 2, pp. 301-315
- [13] Enright, N.J., Miller, B.P., Perry, G.L.W., Goldblum, D. & Jaffré, T. 2014, 'Stress-tolerator leaf traits determine population dynamics in the endangered New Caledonian conifer *Araucaria muelleri*', *Austral Ecology*, vol. 39, no. 1, pp. 60-71
- [14] Paul, S.K., Dixon, K.W. & Miller, B.P. 2014, 'The persistence and germination of fern spores in fire-prone, semi-arid environments', *Australian Journal of Botany*, vol. 62, no. 6, pp. 518-527
- [15] Perry, G.L.W., Enright, N.J., Miller, B.P. & Lamont, B.B. 2013, 'Do plant functional traits determine spatial pattern? A test on species-rich shrublands, Western Australia', *Journal of Vegetation Science*, vol. 24, no. 3, pp. 441-452
- [16] George L. W. Perry, Ben P. Miller, Neal J. Enright & Byron B. Lamont 2013, 'Stochastic geometry best explains spatial associations among species pairs and plant functional types in species-rich shrublands', *Oikos*, vol. 123, no. 1, pp. 99-110, doi:10.1111/j.1600-0706.2013.00400.x
- [17] * Fontaine, J.B., Westcott, V.C., Enright, N.J., Lade, J.C. & Miller, B.P. 2012, 'Fire behaviour in south-western Australian shrublands: Evaluating the influence of fuel age and fire weather', *International Journal of Wildland Fire*, vol. 21, no. 4, pp. 385-395
- [18] * Enright, N.J., Fontaine, J.B., Westcott, V.C., Lade, J.C. & Miller, B.P. 2011, 'Fire interval effects on persistence of resprouter species in Mediterranean-type shrublands', *Plant Ecology*, vol. 212, no. 12, pp. 2071-2083
- [19] Esther, A., Groeneveld, J., Enright, N.J., Miller, B.P. & Lamont, B.B. et al. 2011, 'Low-dimensional trade-offs fail to explain richness and structure in species-rich plant communities', *Theoretical Ecology*, vol. 4, no. 4, pp. 495-511
- [20] Miller, B.P., Perry, G.L.W., Enright, N.J. & Lamont, B.B. 2010, 'Contrasting spatial pattern and pattern-forming processes in natural vs. restored shrublands', *Journal of Applied Ecology*, vol. 47, no. 3, pp. 701-709
- [21] Perry, G.L., Groeneveld, J. & Miller, B.P. 2010, 'Development, application and place of neutral theory in ecology and biogeography', *Geography Compass*, vol. 4, no. 8, pp. 904-918
- [22] Esther, A., Groeneveld, J., Enright, N.J., Miller, B.P. & Lamont, B.B. et al. 2010, 'Sensitivity of plant functional types to climate change: Classification tree analysis of a simulation model', *Journal of Vegetation Science*, vol. 21, no. 3, pp. 447-461
- [23] He, T., Lamont, B.B., Krauss, S.L., Enright, N.J. & Miller, B.P. et al. 2009, 'Ants cannot account for interpopulation dispersal of the arillate pea *Daviesia triflora*', *New Phytologist*, vol. 181, no. 3, pp. 725-733
- [24] Herath, D.N., Lamont, B.B., Enright, N.J. & Miller, B.P. 2009, 'Comparison of post-mine rehabilitated and natural shrubland communities in Southwestern Australia', *Restoration Ecology*, vol. 17, no. 5, pp. 577-585
- [25] Krauss, S.L., He, T., Barrett, L.G., Lamont, B.B. & Enright, N.J. et al. 2009, 'Contrasting impacts of pollen and seed dispersal on spatial genetic structure in the bird-pollinated *Banksia hookeriana*', *Heredity*, vol. 102, no. 3, pp. 274-285

- [26] Perry, G.L.W., Enright, N.J., Miller, B.P., Lamont, B.B. & Etienne, R.S. 2009, 'Dispersal, edaphic fidelity and speciation in species-rich Western Australian shrublands: Evaluating a neutral model of biodiversity', *Oikos*, vol. 118, no. 9, pp. 1349-1362
- [27] * Herath, D.N., Lamont, B.B., Enright, N.J. & Miller, B.P. 2009, 'Impact of fire on plant-species persistence in post-mine restored and natural shrubland communities in southwestern Australia', *Biological Conservation*, vol. 142, no. 10, pp. 2175-2180
- [28] He, T., Lamont, B.B., Krauss, S.L., Enright, N.J. & Miller, B.P. 2009, 'Long-distance dispersal of seeds in the fire-tolerant shrub *Banksia attenuata*', *Ecography*, vol. 32, no. 4, pp. 571-580
- [29] Perry, G.L.W., Enright, N.J., Miller, B.P. & Lamont, B.B. 2009, 'Nearest-neighbour interactions in species-rich shrublands: The roles of abundance, spatial patterns and resources', *Oikos*, vol. 118, no. 2, pp. 161-174
- [30] Esther, A., Groeneveld, J., Enright, N.J., Miller, B.P. & Lamont, B.B. et al. 2008, 'Assessing the importance of seed immigration on coexistence of plant functional types in a species-rich ecosystem', *Ecological Modelling*, vol. 213, no. 3-4, pp. 402-416
- [31] He, T., Lamont, B.B., Krauss, S.L., Enright, N.J. & Miller, B.P. 2008, 'Covariation between intraspecific genetic diversity and species diversity within a plant functional group', *Journal of Ecology*, vol. 96, no. 5, pp. 956-961
- [32] Perry, G.L.W., Enright, N.J., Miller, B.P. & Lamont, B.B. 2008, 'Spatial patterns in species-rich sclerophyll shrublands of southwestern Australia', *Journal of Vegetation Science*, vol. 19, no. 5, pp. 705-716
- [33] * Miller, B.P., Walshe, T., Enright, N.J. & Lamont, B.B. 2007, 'Error in the inference of fire history from grasstrees', *Austral Ecology*, vol. 32, no. 8, pp. 908-916
- [34] Enright, N.J. & Miller, B.P. 2007, 'Livestock grazing impacts on desert vegetation, Khirthar National Park, Pakistan', *Rangeland Ecology and Management*, vol. 60, no. 6, pp. 680-684
- [35] Miller, B.P., Enright, N.J. & Lamont, B.B. 2007, 'Record error and range contraction, real and imagined, in the restricted shrub *Banksia hookeriana* in south-western Australia', *Diversity and Distributions*, vol. 13, no. 4, pp. 406-417
- [36] Enright, N.J., Mosner, E., Miller, B.P., Johnson, N. & Lamont, B.B. 2007, 'Soil vs. canopy seed storage and plant species coexistence in species-rich Australian shrublands', *Ecology*, vol. 88, no. 9, pp. 2292-2304
- [37] * Enright, N.J., Lamont, B.B. & Miller, B.P. 2006, 'Anomalies in grasstree fire history reconstructions for south-western Australian vegetation: Reply from Enright N. J., Lamont B. B. and Miller B. P.', *Austral Ecology*, vol. 31, no. 6, pp. 792-793
- [38] Krauss, S.L., He, T., Lamont, B.B., Miller, B.P. & Enright, N.J. 2006, 'Late Quaternary climate change and spatial genetic structure in the shrub *Banksia hookeriana*', *Molecular Ecology*, vol. 15, no. 4, pp. 1125-1137
- [39] * Enright, N.J., Lamont, B.B. & Miller, B.P. 2005, 'Anomalies in grasstree fire history reconstructions for south-western Australian vegetation', *Austral Ecology*, vol. 30, no. 6, pp. 668-673
- [40] Enright, N.J., Miller, B.P. & Akhter, R. 2005, 'Desert vegetation and vegetation-environment relationships in Kirthar National Park, Sindh, Pakistan', *Journal of Arid Environments*, vol. 61, no. 3, pp. 397-418
- [41] * Comino, E., Miller, B.P. & Enright, N.J. 2004, 'Soil seedbanks in natural and restored box-ironbark forests at Stawell Gold Mine, Victoria', *Pacific Conservation Biology*, vol. 10, no. 1, pp. 9-20
- [42] Enright, N.J., Miller, B.P. & Perry, G.L.W. 2003, 'Demography of the long-lived conifer *Agathis ovata* in maquis and rainforest, New Caledonia', *Journal of Vegetation Science*, vol. 14, no. 5, pp. 625-636
- [43] Enright, N., He, T., Krauss, S.L., Lamont, B.B. & Miller, B.P. 2003, 'Genetic variation and biogeographic history in the restricted southwestern Australian Shrub, *Banksia Hookeriana*', *Physical Geography*, vol. 24, no. 5, pp. 358-377
- [44] Brown, J., Enright, N.J. & Miller, B.P. 2003, 'Seed production and germination in two rare and three common co-occurring *Acacia* species from south-east Australia', *Austral Ecology*, vol. 28, no. 3, pp. 271-280
- [45] Rigg, L.S., Enright, N.J., Perry, G.L.W. & Miller, B.P. 2002, 'The role of cloud combing and shading by isolated trees in the succession from maquis to rain forest in New Caledonia', *Biotropica*, vol. 34, no. 2, pp. 199-210
- [46] * ENRIGHT, N.J., MILLER, B.P. & CRAWFORD, A. 1994, 'Environmental correlates of vegetation patterns and species richness in the northern Grampians, Victoria', *Australian Journal of Ecology*, vol. 19, no. 2, pp. 159-168

Part D - Personnel and ROPE (Dr Megan Barnes)

D1. Personal Details

(To update personal details, click the 'Manage Personal Details' link below. Note this will open a new browser tab. When returning to the form ensure you 'Refresh' the page to capture the changes made to your profile.)

Participation Type

Partner Investigator

Title

Dr

First Name

Megan

Family Name

Barnes

D4. Qualifications

(To update any qualifications, click on the 'Manage Qualifications' link below. Note this will open a new browser tab. When returning to the form ensure you 'Refresh' the page to capture the changes made to your profile.)

Conferral Date	AQF Level	Degree/Award Title	Discipline/Field	Awarding Organisation	Country of Award
06/12/2013	Doctoral Degree	PhD	Conservation Science	University of Queensland	Australia
01/06/2007	Bachelor Honours Degree, Graduate Certificate, Graduate Diploma	BSc (Hons)	Behavioural Ecology	James Cook University	Australia
12/12/2005	Bachelor Degree	BSc	Zoology and Marine Science	James Cook University	Australia

D5. Research Opportunity and Performance Evidence (ROPE) - Current and previous appointment(s) / position(s) - during the past 10 years

(To update any details in this table, click on the 'Manage Employment Details' link below. Note this will open a new browser tab. When returning to the form ensure you 'Refresh' the page to capture the changes made to your profile. Refer to the Instructions to Applicants for more information.)

Description	Department	Contract Type	Employment Type	Start Date	End Date	Organisation
Decision Support Scientist	Biodiversity and Conservation Science	Contract	Full Time	15/05/2019		DEPARTMENT OF BIODIVERSITY CONSERVATION AND ATTRACTIONS
Postdoctoral Research Fellow	School of Biology	Contract	Full Time	19/11/2018	15/05/2019	The University of Queensland
Postdoctoral Fellow	School of Natural Resources and Environmental Management	Contract	Full Time	01/01/2016	30/07/2018	University of Hawaii at Manoa, USA

NERP Emerging Priorities Postdoctoral Research Fellow	Centre for Biodiversity and Conservation Science	Contract	Full Time	01/05/2014	15/01/2016	The University of Queensland
Consultant to the Global Environment Facility		Contract	Part Time	01/11/2013	01/05/2015	International Union for Conservation of Nature
Postdoctoral Researcher	Centre for Excellence in Environmental Decisions	Contract	Part Time	01/10/2013	30/04/2014	The University of Queensland

D6. Research Opportunity and Performance Evidence (ROPE) - Academic Interruptions

(You must read the ROPE Statement <http://www.arc.gov.au/arc-research-opportunity-and-performance-evidence-robe-statement> before filling out this section.)

Have you experienced an interruption that has impacted on your academic record?

Yes

From when

31/07/2018

To when

15/11/2018

FTE of academic interruption

1.0

Details

I moved internationally from Hawaii to Melbourne for my partner's job. Subsequently, I was not employed in research for a 3.5 months period.

From when

02/01/2016

To when

01/10/2013

FTE of academic interruption

0.4

Details

Subsequent to submitting my PhD, I worked part time (0.6) for 8 months before accepting a post-doc as a NESF

D7. Research Opportunity and Performance Evidence (ROPE) - Details of the participant's academic career and opportunities for research, evidence of research impact and contributions to the field, including those most relevant to this application

(Provide details of your academic career and opportunities, evidence of research impact and contributions to the field. (Upload a PDF of no more than five A4 pages))

Uploaded PDF file follows on next page.

Research Opportunity and Performance Evidence (ROPE)

AMOUNT OF TIME AS AN ACTIVE RESEARCHER I was awarded my PhD 6 years ago in 2013. Since then, I experienced a total of 6 months of academic interruptions (i.e. 5 years in research pursuit); I have also moved country twice, requiring a new start each time I moved, and cross-continent once. Since completing my PhD, 60% of my time has been devoted to research, 5% to teaching, and 25% to project management and stakeholder engagement.

RESEARCH OPPORTUNITIES: Postdoctoral research: In the past 4 years I worked as a postdoctoral research fellow at two institutions; the University of Queensland (UQ) and the University of Hawaii.

I was awarded a PhD (Conservation Science) from the ARC Centre for Excellence in Environmental Decisions (CEED) at the University of Queensland in December 2013. My thesis investigated for the first time whether global protected areas (PAs) are effectively managed, and what drivers (e.g. species ecology, threats, PA design, or socio-economic conditions) predict biodiversity outcomes, supervised by Dr. Marc Hockings, Dr. Nigel Dudley and Prof. Hugh Possingham. Outputs of my thesis were published in 3 publications in *Nature Communications* (IF = 11.85), *Diversity and Distributions* (IF = 4.83), and *New York Annals of the Society* (IF 4.04). My research led to revised PA monitoring strategies in Canada, identified information gaps in Queensland PA management, and developed novel evaluation tools using citizen science data. During my PhD, I was invited to join the International Union for the Conservation of Nature (IUCN) World Commission on PAs, and IUCN Species Survival Commissions. I took a lead role in a Working Group on PA effectiveness, which held 6 international meetings over 4 years. The Working Group afforded me unparalleled opportunities to collaborate with leading global conservation policy actors, including Dr. Thomas Brooks (IUCN Head of Science), Dr. Stephen Woodley (IUCN Biodiversity and Protected Areas Taskforce Chair), Dr. Kathy McKinnon (WCPA Chair), and Alan Fox (CEO of the World Bank Evaluation Office). I leveraged GEF grants totaling >\$270,000 as co-chief investigator – unprecedented for a PhD student, and subsequent to submitting worked for several months to collaboratively deliver an evaluation of GEF PA systems that informed investment priorities for the GEF (~\$6 billion dollars in funds). I was also invited to join a Working Group on Marine Protected Area effectiveness by Dr. Helen Fox (2014-7), which enabled me to forge lasting collaborations with the World Wildlife Fund, Conservation International, The Nature Conservancy and the Luke Hoffman Institute. A product of this Working Group was a paper in the journal *Nature* (IF =38.15), which I co-authored. During my PhD, I founded the first Australian chapter of the Society for Conservation Biology (SCB) in Oceania and served as president for 3 years, concurrently serving as a member of the Oceania section board. I also co-supervised one Honours student to completion.

I was awarded a prestigious National Environmental Research Program (NERP) postdoctoral fellowship (2014-6) at UQ (65% research, 20% service, and 15% project management). I developed a novel application of decision science for national monitoring, building an optimisation tool to select monitoring programs that are cost-effective, highly informative, and representative. I also developed a method to rapidly assess monitoring costs as part of this research. I conducted my fellowship under Prof. Hugh Possingham (ARC Laureate Fellow) and Dr. Eve McDonald Madden, working directly with Peter Lyon at the Australian Department of the Environment (DoTE). DoTE. In this role I was invited to participate in developing a national monitoring strategy by Peter Lyon. As a NERP and CEED scholar, I was part of a highly collaborative network at UQ. I collaborated with leading Australian researchers at UQ, developed international collaborations through travel grants via CEED and my research forged relationships with all federal, state and territory environment agencies. I co-developed an ambitious research program now fully funded under the National Environmental Science Program (\$171,000, CI: Prof. Hugh Possingham). During this time I spent 6 months abroad working with researchers in USA, UK, and Canada, which benefited me by expanding my exposure to global protected management systems, and networks I require for international policy influence, but caused some delay in outputs. I invested in growing the now thriving SCB-UQ chapter, and served as Communications Director for the Oceania section, mentored by Prof. Richard Kingsford and Dr. Stacy Jupiter (Director, WCS Melanesia). During my fellowship I also supervised two full-time research assistants (both subsequently awarded APAs).

In 2016 I was selected from over 200 applicants for a postdoctoral fellowship at the University of Hawaii (UH), a leading global institution in Marine Science, to facilitate a multi-agency (12 state and federal agencies) process supporting effective coral reef management. I am responsible for: project management, stakeholder engagement, and decision analysis: 10% teaching, 50% research, 40% project management and engagement. When I began, I took responsibility for a program urgently needed ahead of schedule to inform a Statewide Planning Process. To do

this and successfully deliver the 2-year project 9 months early to do so. I am mentored by world leading scientists Dr. Mike Runge (USGS), and Dr. Michelle Haynes (USFWS Asia-Pacific director). This strategic relocation has allowed me to directly influence coral reef management across the Pacific, learn to navigate complex interagency dynamics, develop new networks, and access US funding sources. UH also hosts a national Centre for Teaching Excellence, where I have learned to implement novel high-impact and inclusive techniques. I supervise 3 (2 MS, 1 PhD) students, and 1 postdoctoral researcher. Despite my high engagement load and early delivery, in 2016 I secured USD 80,000 in funds as sole CI, independently leading globally significant work, completed **6** publications (2 first author, 3 in press), with **2** more in review, supervised **3** PhD students and **2** postdoctoral scholars, and served on 2 scientific advisory panels. I have emerged as a global leader in protected area policy and decision-science, and am strongly positioned to continue my record of engagement to inform policy and local management.

My position working on social ecological systems in Indonesian fisheries at UQ was 100% research, but unfortunately cut short when I accepted the position **the Western Australian Department of Biodiversity, Conservation and Attractions (DBCA)**. Due to moving cross-country and changing positions after such a short time to take advantage of being offered the first ever decision science position in any Australian jurisdiction.

In my new role at DBCA, my role is nominally 100% research, but comprises approximately 65% research, 10% mentoring and training in Structured Decision Making, 5% Service, 10% administration, and 10% project management.

Research environment and mentoring

DBCA is extremely supportive of research and the Biodiversity and Conservation Science program provides an excellent environment for applied research outcomes to be translated into practice.

Research mentoring and research facilities available to me during my career have been good, but moving internationally has curtailed the ability to build long term high impact partnerships, and formal student supervision. This has been offset by the diverse experiences and mentors with whom I have been able to work.

RESEARCH ACHIEVEMENTS AND CONTRIBUTIONS

Metrics of research output quality @13 December 2019

I have an exceptional track record of high impact work, including 30 publications, consisting of **27 peer-reviewed journal articles** (7 as first author, 2 in press), 2 scholarly book chapters (1 first author), 8 commissioned scientific reports (**6** first author), and **2** white papers. I have two additional articles in review (1 last author as chief investigator) in peer-reviewed journals. I have also published 2 open source software products, and one R package.

Invited keynote and speaker addresses

I have contributed 27 presentations (12 as lead) at 9 international and 6 national conferences, and coordinated and chaired symposiums at 2 international conferences. I have been an invited guest speaker at the Cornell Lab of Ornithology, the University of Cambridge, the University of Kent, and the University of Western Australia. I have been an invited keynote speaker at the Maui Marine Science Forum, and **2** community town hall events. I was a distinguished guest speaker at NOAA, and I have delivered **two plenary keynote addresses**, exceptional for my early-career stage, as a **plenary** speaker at both the Queensland Ornithological Conference, and the **only early-career researcher** invited to deliver a **plenary** in the past 5 years, at the Australian Ornithological Conference. As part of the IUCN taskforce on Biodiversity and Protected Areas, our core team of 5 presented the groups research at 17 conferences, 6 policy forums and 3 other venues, the capstone being an interactive workshop at the World Conservation Congress to elicit feedback and policy direction from scientists, practitioners, and policy professionals.

Scientific Service and Public Engagement

I am an internationally accredited trainer in structured decision-making, administering courses to land managers across the USA, teaching decision science, SDM, and science communication through short courses and guest lectures including mentoring UH faculty, and National Parks Service, and USFWS staff managing lands across the USA. I have also conducted Marxan training, in support of international conservation NGO PacMARA. From 2013-2017 I was an Editor for the community-run Eremaea-eBird, managing article flow, conducting web design, report writing, and community engagement, as well as convening and organising the first international eBird conference in 2015. I serve as an editor at the newly launched journal *Rethinking Ecology*, a forum for innovation in ecology and conservation. For the past 8 years I have been an active member of the Society for Conservation Biology. During my

PhD I founded the first Oceania Chapter, based at the University of Queensland, and served as the founding president for three years. The chapter is now a thriving hub - leading policy submissions, local restoration activities and peer mentoring. During that time I also served as an adjunct member of the SCB-Oceania Section board during an active transition of the board to a more autonomous and policy active role in the Oceania region, including as communications director. I have been an active member of the IUCN protected areas and species survival commissions since 2011. I am an active member of the Conservation Planning Working Group, supported as part of my role at DBCA. I am currently a co-lead on the Knowledge, Learning, Innovation, & Technology for Advancing Conservation Theme for the 2020 World Conservation Congress (<https://www.iucncongress2020.org/>).

Research support income:

I have attracted **over AUD \$500,000** in competitive research funding during my postdoctoral career as sole CI (USD \$80,000), co-CI (USD \$271,000), and PI (AUD \$171,000, CI Hugh Possingham). This support for my research by competitive grants is exceptional for my career stage and indicative of my demonstrated capacity to achieve project objectives on time and of a high quality. During my career to date I have been awarded > \$18,000 for international travel to broker collaborations, present courses and professional seminars and attend meetings.

Other professional activities – Research Supervision and Mentoring:

Over the past 3 years, despite my early career stage and high time commitment to stakeholder engagement and project management, I have co-supervised **2 PhD students** (1 current), **2 Masters by coursework students** (completed), and **1 Honours student**, Meera Joyce (H1 Class, UQ), whose research on bird ecology and ecosystem dynamics is now published. I have also co-ordinated the work of **2 full-time Research Assistants** (1 year each) to ensure project delivery, mentored **2 research interns** (3 month terms) including as part of a program explicitly designed to financially support Native Hawaiian students to conduct internships, and supervised **two postdoctoral researchers** (Whitney Goodell, US Fulbright Scholar; Elisa Baykatorov, NESP fellow). I regularly provide formal and informal mentoring and statistical advice to early career researchers at universities and partner NGOs.

Identifiable benefits outside of academia

I have contributed to community initiatives outside my primary employment. For example, I have recently contributed to a local government authority (City of Kalamunda) as part of them establishing a new programme for invasive pest control, helping them to develop a robust approach to community engagement, ensuring that they identified the problem that community and LGA were aiming to focus on. These initial steps are vital to ensure that there is buy-in from residents and is therefore fundamental to success of any such programme. There are many similarities with the present project proposal in terms of the need to establish common goals that can be followed through the life of a project.

My work in Hawaii work directly benefited stakeholders and communities through: informing spatial and strategic priorities for conservation action for local NGOs (CORAL, 1.8 million dollars awarded to implement Best Management Practices in identified priority areas), permission to conduct management on private lands through identifying the locations of priority threats, and creating a platform for more cost-effective management of land-based pollution across the State. It also gave community members an opportunity to participate in policy and management activities.

At DBCA, although I have only been here a short time, my work is already resulting in transformative change to the process by which resources are allocated for threat management across the State.

How my research has led to a significant change or advance of knowledge, and how my achievements will contribute to this application:

Impact evaluation

I apply best-practice techniques in impact evaluation that are rarely implemented, combined with decision-theoretic principles, linked directly to adaptive management and marine spatial planning and policy through ongoing collaborations. For instance, my research in Indonesia implemented rigorous quasi-experimental techniques to test common rhetoric that increases in **fisheries management** leads to increases in social benefits in collaboration with world-leaders on social impacts Society for Conservation President Mike Mascia and WWF Lead Scientist for Conservation Evidence Louise Glew. Examining both **ecological and social impacts** of MPAs I integrated both to identify mechanisms underpinning social and ecological responses and investigated options to evolve existing policy and management to improve these outcomes [1-3]. By pairing **impact evaluation** (of social and ecological objectives) with cost benefit analysis and econometric techniques to identify synergies and trade-offs

(e.g. [2, 4]) I facilitate improved targeting of conservation management on land and at sea, as well as advancing understanding of the dynamics of complex social ecological systems.

Driven by a desire to embed learning in the policy and management process, and ensure conservation actions have the greatest possible impact, I have pursued expertise in impact evaluation, quantitative ecology and decision analytic techniques. In collaborative projects such as these, one of my primary contributions is to ensure robust analytical approaches including matching methods and quantitative modelling [e.g. [1, 5-7]]. In this project, I will contribute to the design and application of quantitative evaluation techniques and trade-off analysis.

Decision Science and Structured Decision Making

Decision-theoretic approaches underpin all my research and I apply decision analytic approaches in a range of systems, including multi-criteria analysis and evaluation within a Structured Decision Making context. I am part of the National Conservation Training Centre (NCTC) mentoring program, and work with exceptional decision scientists in USGS, the US Army-Corps of Engineers Institute for Water Resources, and Fish and Wildlife Service, and the University of Melbourne on structured decision making problems.

In my previous work at UQ we developed an optimisation tool for ERIN to identify complementary and cost-efficient monitoring priorities for threatened species across Australia, a novel implementation of the complementarity principle, translating tools from conservation planning to monitoring and evaluation. My work in Indonesia [2] examined trade-offs among monitoring and management strategies in the global centre of marine biodiversity, finding that community-based conservation is more cost-effective than alternate approaches, but that cost-recovery occurs over ten years, which has direct utility to four global NGOs selecting strategies for marine conservation worldwide, and will support more equitable and inclusive management strategies.

My research program at the University of Hawaii [4], identified efficiencies and explored trade-offs and synergies among management strategies, embedded in a **Structured Decision Making Framework** working with 12 state and federal agencies. It exploited the data rich environment in Hawaii to inform management of land-based pollutants to conserve coral reefs globally. I also collaborated on work across Hawaii to prioritise allocation of conservation fences to meet multiple objectives for watershed management, using empirically validated estimates of invasive species density to estimate threat exposure and select sites most likely to mitigate threat.

My current work at DBCA involves the application of Structured Decision Making to multi-objective natural resource management decisions across the state of Western Australia, including resource allocation for threatened species management, risk assessment, and using structured decision making to support translocation decision making.

Conservation Policy and Management

My interactions with environmental management and policy organisations extend globally. I worked collaboratively with the Global Environment Facility evaluation office in a partnership that provided guidance to the GEF and World Bank, and was incorporated into the GEF V evaluation. My work is now being incorporated into GEF VII funding priorities in the form of directed funding to underperforming MPAs, governance funding targeted at more inclusive decision making, and overlapping social-ecological monitoring. The continued support of my research by competitive grants is indicative of my demonstrated capacity to achieve project objectives on time and of a high quality. This engagement has formed the basis for more effective allocation of \$6 billion worth of research funds (approximate total value of the GEF VII funding round).

My work on protected areas policy has driven a new frontier in conservation evaluation [8, 9], and informed new global protected areas targets currently under debate as part of the Convention on Biological Diversity 2020 process.

My work in Hawaii incorporated **conservation planning** and **structured decision making** to identify optimal management strategies in a multi-jurisdictional land-sea management context, using multi-criteria analysis to evaluate trade-offs among management objectives. It created a platform for more cost-effective management and land-based pollution across the State [4]. It exploited the data rich environment in Hawaii to inform management of land-based pollutants to conserve coral reefs globally. This work fed directly into the Department of Health decision making process, and was recently flagged as critical in their report to the legislature.

As an adjunct fellow at the National Environmental Science Program Threatened Species Hub, I co-developed a national tracking index for threatened species to redress chronic information shortfalls (<http://www.nespthreatenedspecies.edu.au/projects/threatened-species-index>; paper currently in review). This

work extended partnerships developed during my post-doctoral research at UQ united 9 state and federal agencies. It will be a fully open access product that will function as a mechanism for mainstreaming environmental reporting, setting credible performance standards, establishing a baseline for evaluating national progress against conservation goals, and engaging the public.

I was awarded as Chief Investigator, a SeSync Working Group grant to evaluate the effectiveness of broad scale policy and management interventions for plastic pollution using a collaboratively developed predictive model (<https://www.plasticpeg.org/>). This work is supported by a full time postdoctoral fellow, and was explicitly designed to **engage directly with policy makers**, including UN Marine Debris Lead Heidi Savelli, and the US Fish and Wildlife Service. The project will have widespread policy implications, addressing the UN Environment Assembly objectives, and Sustainable Development Goals for Oceans, and timed to inform UNEA processes (e.g. <https://www.plasticpeg.org/news/white-paper>)

My role in this linkage project will be to provide intellectual input into methodological design, support facilitation of the complex multi-objective challenge (fire management) in a Structured Decision Making context, and mentoring project staff and students in Structured Decision Making. My quantitative skills and experience in evaluating social and ecological outcomes will also support robust transparent and participatory decisions supported by the evidence generated in this project.

References

1. Gill, D.A., et al., *Capacity shortfalls hinder the performance of marine protected areas globally*. Nature, 2017. **543**(7647): p. 665-669.
2. Fox, H.E., et al., *Generating actionable data for evidence-based conservation: The global center of marine biodiversity as a case study*. Biological Conservation, 2017. **210**, Part A: p. 299-309.
3. Mascia, M.B., et al., *A novel framework for analyzing conservation impacts: evaluation, theory, and marine protected areas*. Annals of the New York Academy of Sciences, 2017. **1399**(1): p. 93-115.
4. Barnes, M.D., et al., *Decision analysis to support wastewater management in coral reef priority area*. 2019, PeerJ Preprints.
5. Geldmann, J., et al., *A global analysis of management capacity and ecological outcomes in terrestrial protected areas*. Conservation Letters, 2018. **11**(3): p. e12434.
6. Joyce, M., et al., *Understanding avian assemblage change within anthropogenic environments using citizen science data*. Landscape and Urban Planning, 2018. **179**: p. 81-89.
7. Prowse, T.A., et al., *Prescribed burning impacts avian diversity and disadvantages woodland-specialist birds unless long-unburnt habitat is retained*. Biological Conservation, 2017. **215**: p. 268-276.
8. Barnes, M.D., et al., *Aichi targets: Protect biodiversity, not just area*. Nature, 2015. **526**(7572): p. 195-195.
9. Barnes, M.D., et al., *Prevent perverse outcomes from global protected area policy*. Nat Ecol Evol, 2018. **2**(5): p. 759-762.

D8. Research Opportunity and Performance Evidence (ROPE) - Currently held ARC projects

(This information is auto-populated from the applicants RMS profile and will include any active project which has not yet had a Final Report approved and the project file closed by the ARC. You will not be able to submit an application to the ARC that involves a researcher who has an overdue Final Report on an ARC-funded project. If there are any concerns with the information recorded here, contact Your organisation's Research Office.)

D9. Project/Role relinquishment or application withdrawal

(If you exceed the Linkage Program limits on projects and/or applications and have applied under the Industrial Transformation Research Hubs, Industrial Transformation Training Centres, Special Research Initiatives, Learned Academies Special projects, Supporting Responses to Commonwealth Science Council Priorities or any other Linkage Program scheme, list the application you wish to withdraw, or the existing project (or role) that that you wish to relinquish should this application be successful (see sections 6.35 to 6.39 of the grant guidelines). Failing to provide this information will jeopardise the eligibility of your applications. Provide project/application ID(s) separated by a comma.)

--

D10. Eligibility - Role of Partner Investigator

(Please indicate which of the Partner Investigator role options from section 6.29 of the grant guidelines apply to your role on this project. Select all options that apply.)

Provide effective supervision support and mentoring of research personnel as required.
Take significant intellectual responsibility for the planning and conduct of the project and for any strategic decisions required in its pursuit and the communication of results.

D11. Eligibility - Will the participant be residing predominately in Australia for the duration of the project activity period?

((This is a 'Yes' or 'No' question. Indicate whether the participant will be residing predominantly in Australia for the project activity period. If the participant is applying as a CI and they answer 'No' to this question you will be prompted to contact the Research Office to check the participant's eligibility. If the participant is a Foreign National, they must reside legally in Australia. Eligibility will be based solely on the information contained in this application.))

Yes

D12. Eligibility - Is the participant currently undertaking a Higher Degree by Research which will be conferred after the grant commencement date?

((This is a 'Yes' or 'No' question. If the participant is applying as a CI and they answer 'Yes' to this question they will be prompted to contact the Research Office and Part D will not validate. Eligibility will be based solely on the information contained in this application.))

No

D13. Eligibility - Employment Details as at grant commencement date of project

(This question will be used to determine your eligibility. Your eligibility will be based solely on the information contained in this application. Confirm your employment status at all organisations that you will be associated with as at the Grant Commencement Date. Enter the relevant appointment type and Full-Time Equivalent (FTE) for each organisation.)

Org name	Is this an Eligible Organisation?	Please choose your appointment type for this organisation.	Please enter your FTE for this Organisation
----------	-----------------------------------	--	---

DEPARTMENT OF BIODIVERSITY CONSERVATION AND ATTRACTIONS		Employee	1.0
---	--	----------	-----

D14. Eligibility - Further Details Regarding Partner Investigator Status - Does the participant hold a remunerated appointment at an Eligible Organisation as at the grant commencement date for this project?

(At A2 Partner Investigator has been selected as the role type, but it appears that the participant meets the criteria of a Chief Investigator.

NOTE: this question is mandatory ONLY FOR PIs WHO:

- *at D11 confirmed that they will reside predominantly in Australia for the project activity period of the proposed Project; AND*
- *at D12 confirmed that they are not currently undertaking a Higher Degree by Research which will be conferred after the grant commencement date; AND*
- *at D13 indicated that they would hold either:*
 - *an appointment at an Eligible Organisation equal or greater than 0.2 FTE; OR*
 - *an honorary academic appointment at an Eligible Organisation*

You do not need to answer these questions if it was indicated in question D11 that the participant will be living predominantly overseas OR if they have indicated in question D12 that the participant will be undertaking a Higher Degree by Research.)

Do you hold a remunerated appointment at an Eligible Organisation?

Justification of PI status

D15. Eligibility - Relevant Organisation for this application as at the grant commencement date for this project

(Enter the Organisation that is relevant to the participant's inclusion on this application, and that they will be associated with as at the grant commencement date. The 'relevant organisation' is the primary organisation that will be supporting the participant's involvement in this project if it is funded. Note that the Organisation must be listed in D13 for this question to validate.)

Relevant Organisation

D16. What is the participant's time commitment to this project?

(Enter the participant's time commitment to this project as a Full-Time Equivalent (FTE). Note that a FTE of 1.0 represents a full-time commitment (i.e. 5 days per week).)

D17. Research Opportunity and Performance Evidence (ROPE) - Research Outputs

(Research context: Provide clear information that explains the relative importance of different research outputs and expectations in the participant's discipline/s. The information should help assessors understand the context of the participant's academic research achievements but not repeat information already provided in this application. It is helpful to include the importance/esteem of specific journals in the participant's field; specific indicators of recognition within the participant's field such as first authorship/citations, or the significance of non-traditional research outputs. If this question is not relevant to a participant, for example a PI with non-academic background, the participant should include a short explanatory statement as to why this question is not applicable. (No more than 3,750 characters, approximately 500 words))

All of my journal articles since PhD completion are published in the top 5% of journals for my field (SciVal; Scopus) and 30% are published in the top 1% of journals in my field (SciVal; Scopus). The average impact factor of the 12 journals where I have published is 11.85. Although 13 of my journal articles are less than 2 years old, I have been cited a large number of times relative to my career stage (1391 Google Scholar 16/12/19; 906 Scopus 16/12/19), with an average of 51.51 citations per article.

My h-index (Scopus: 13, Google Scholar: 15) is twice the number of years since I completed my PhD and my Google Scholar i-10 index = 18. My research is cited in high impact publications, by internationally renowned, and has been used by Dr. Thomas Brooks (IUCN Head of Science) in policy discussions. My Field Weighted Citation Index of 3.71 is almost 4 times the mean for all researchers of my career stage in the field, and more than twice the mean for all Group of 8 Universities in Australia in the field. Twenty-nine percent (6 of 14) of my journal articles are in the top 5% of all articles in the field. I have published peer-reviewed journal articles with > 50 co-authors from 31 institutions in 20 countries, and been cited by authors in 63 countries, demonstrating my global reach.

I have presented the outputs of my research via a number of popular articles, including 5 articles in The Conversation, 4 in Decision Point, 1 in Australian Geographic, and 1 in the National Parks Association of Queensland magazine. I regularly and proactively engage in policy discussion, as evidenced by 2 recent letters in Nature and Science, and attendance at policy fora including the CBD Conference of the Parties as part of the IUCN delegation. I communicate with multiple audiences via print media, such as The Guardian and local newspapers, social media, and public seminars and events including decision maker reef (<http://governor.hawaii.gov/newsroom/latest-news/dlnr-news-release-boatload-of-decision-makers-reveals-plight-of-west-maui-reefs/>) an at-sea outreach experience with local senators, indigenous and community leaders, and other local decision makers, community meetings and town hall events, scientist speed dating, where scientists speed dated community members.

I have publicised the results of my work through cartoons, infographics, videos, and public comment in response to legislation. I have been recognised for excellence in science communication using social media (ICRS 2016, ICCB 2015 and ESA 2014), and regularly guest lecture on the use of social media in science communication.

D18. Research Opportunity and Performance Evidence (ROPE) – Research Outputs Listing including Ten Career-Best Research Outputs

(List the research outputs marking those that are most relevant to this application categorised under the following headings: Ten career-best research outputs; Authored books; Edited books; Book chapters; Referred Journal articles; Fully refereed conference proceedings; Additional research outputs (including non-traditional research outputs). CVs and theses should not be included in this list. The participant's ten career-best research outputs should not be repeated under subsequent headings. (No more than 100 research outputs).)

Research Outputs Listing

Generated research output document follows on the next page

Ten Career-Best Research Outputs

- [1] Ian D. Craigie, Megan D. Barnes, Jonas Geldmann & Stephen Woodley 2015, 'International funding agencies: potential leaders of impact evaluation in protected areas?: Table 1.', *Phil. Trans. R. Soc. B*, vol. 370, no. 1681, pp. 20140283, doi:10.1098/rstb.2014.0283 (Refereed Journal Article)
- [2] * Megan D. Barnes, Louise Glew, Carina Wyborn & Ian D. Craigie 2018, 'Prevent perverse outcomes from global protected area policy', *Nature Ecology & Evolution*, vol. 2, no. 5, pp. 759–762, doi:10.1038/s41559-018-0501-y (Refereed Journal Article)
- [3] * David A. Gill, Michael B. Mascia, Gabby N. Ahmadi, Louise Glew & Sarah E. Lester et al. 2017, 'Capacity shortfalls hinder the performance of marine protected areas globally', *Nature*, vol. 543, no. 7647, pp. 665–669, doi:10.1038/nature21708 (Refereed Journal Article)
- [4] * Brown, Christopher J, Bode, Michael, Venter, Oscar, Barnes, Megan D & McGowan, Jennifer et al. 2015, 'Effective conservation requires clear objectives and prioritizing actions, not places or species', *Proceedings of the National Academy of Sciences*, vol. 112, no. 32, pp. E4342–E4342 (Refereed Journal Article)
- [5] Megan D. Barnes, Ian D. Craigie, Luke B. Harrison, Jonas Geldmann & Ben Collen et al. 2016, 'Wildlife population trends in protected areas predicted by national socio-economic metrics and body size', *Nature Communications*, vol. 7, no. 1, doi:10.1038/ncomms12747 (Refereed Journal Article)
- [6] Ayesha I. T. Tulloch, Megan D. Barnes, Jeremy Ringma, Richard A. Fuller & James E. M. Watson 2015, 'Understanding the importance of small patches of habitat for conservation', *J Appl Ecol*, vol. 53, no. 2, pp. 418–429, doi:10.1111/1365-2664.12547 (Refereed Journal Article)
- [7] Vanessa M. Adams, Megan Barnes & Robert L. Pressey 2019, 'Shortfalls in Conservation Evidence: Moving from Ecological Effects of Interventions to Policy Evaluation', *One Earth*, vol. 1, no. 1, pp. 62–75, doi:10.1016/j.oneear.2019.08.017 (Refereed Journal Article)
- [8] Megan D. Barnes, Ian D. Craigie, Nigel Dudley & Marc Hockings 2016, 'Understanding local-scale drivers of biodiversity outcomes in terrestrial protected areas', *Annals of the New York Academy of Sciences*, vol. 1399, no. 1, pp. 42–60, doi:10.1111/nyas.13154 (Refereed Journal Article)
- [9] M. Barnes, I. D. Craigie & M. Hockings 2016, 'Towards Understanding Drivers of Wildlife Population Trends in Terrestrial Protected Areas', *Protected Areas*, Wiley-Blackwell, pp. 134–149, doi:10.1002/9781118338117.ch8 (Book Chapter)
- [10] Jonas Geldmann, Lauren Coad, Megan D. Barnes, Ian D. Craigie & Stephen Woodley et al. 2018, 'A global analysis of management capacity and ecological outcomes in terrestrial protected areas', *Conservation Letters*, vol. 11, no. 3, pp. e12434, doi:10.1111/conl.12434 (Refereed Journal Article)

Book Chapters

- [1] Ian D. Craigie, Alana Grech, Robert L. Pressey, Vanessa M. Adams & Marc Hockings et al. 2014, 'Terrestrial protected areas of Australia' in Adam Stow, Norman Maclean & Gregory I. Holwell (eds.), *Austral Ark*, Cambridge University Press, pp. 560–581, doi:10.1017/cbo9781139519960.028

Refereed Journal Articles

- [1] * Megan D. Barnes, Whitney Goodell, Robert Whittier, Kim A. Falinski & Tova Callender et al. 2019, 'Decision analysis to support wastewater management in coral reef priority area', *Marine Pollution Bulletin*, vol. 148, pp. 16–29, doi:10.1016/j.marpolbul.2019.07.045
- [2] Emily Nicholson, Elizabeth A. Fulton, Thomas M. Brooks, Ryan Blanchard & Paul Leadley et al. 2019, 'Scenarios and Models to Support Global Conservation Targets', *Trends in Ecology & Evolution*, vol. 34, no. 1, pp. 57–68, doi:10.1016/j.tree.2018.10.006
- [3] Judith Schleicher, Johanna Eklund, Megan Barnes, Jonas Geldmann & Johan A. Oldekop et al. 2019, 'Statistical matching for conservation science', *Conservation Biology*, doi:10.1111/cobi.13448
- [4] * Laura J. Sonter, Megan Barnes, Jeffrey W. Matthews & Martine Maron 2019, 'Quantifying habitat losses and gains made by U.S. Species Conservation Banks to improve compensation policies and avoid perverse outcomes', *Conservation Letters*, vol. 12, no. 3, pp. e12629, doi:10.1111/conl.12629
- [5] Rochelle Steven, Megan Barnes, Stephen T. Garnett, Georgia Garrard & James O'Connor et al. 2019, 'Aligning citizen science with best practice: Threatened species conservation in Australia', *Conservation Science and Practice*, vol. 1, no. 10, doi:10.1111/csp2.100
- [6] Megan Barnes, Louise Glew, Carina Wyborn & Ian D. Craigie 2018, 'Preventing perverse outcomes from global protected area policy. Shifting the focus from quantity to quality to avoid perverse outcomes.', doi:10.7287/peerj.preprints.26486v1

- [7] Meera Joyce, Megan D. Barnes, Hugh P. Possingham & Berndt J. Van Rensburg 2018, 'Understanding avian assemblage change within anthropogenic environments using citizen science data', *Landscape and Urban Planning*, vol. 179, pp. 81–89, doi:10.1016/j.landurbplan.2018.07.006
- [8] * Helen E. Fox, Megan D. Barnes, Gabby N. Ahmadi, Grace Kao & Louise Glew et al. 2017, 'Generating actionable data for evidence-based conservation: The global center of marine biodiversity as a case study', *Biological Conservation*, vol. 210, pp. 299–309, doi:10.1016/j.biocon.2017.04.025
- [9] Michael B. Mascia, Helen E. Fox, Louise Glew, Gabby N. Ahmadi & Arun Agrawal et al. 2017, 'A novel framework for analyzing conservation impacts: evaluation, theory, and marine protected areas', *Annals of the New York Academy of Sciences*, vol. 1399, no. 1, pp. 93–115, doi:10.1111/nyas.13428
- [10] * Thomas A.A. Prowse, Stuart J. Collard, Alice Blackwood, Patrick J. O'Connor & Steven Delean et al. 2017, 'Prescribed burning impacts avian diversity and disadvantages woodland-specialist birds unless long-unburnt habitat is retained', *Biological Conservation*, vol. 215, pp. 268–276, doi:10.1016/j.biocon.2017.09.005
- [11] * Barnes, Megan D, Craigie, Ian D, Harrison, Luke B, Geldmann, Jonas & Collen, Ben et al. 2016, 'Wildlife population trends in protected areas predicted by national socio-economic metrics and body size', *Nature Communications*, vol. 7, pp. 12747
- [12] James E. M. Watson, Emily S. Darling, Oscar Venter, Martine Maron & Joe Walston et al. 2016, 'Bolder science needed now for protected areas', *Conservation Biology*, vol. 30, no. 2, pp. 243–248, doi:10.1111/cobi.12645
- [13] Megan Barnes 2015, 'Aichi targets: Protect biodiversity, not just area', *Nature*, vol. 526, no. 7572, pp. 195–195, doi:10.1038/526195e
- [14] Geldmann, Jonas, Coad, Lauren, Barnes, Megan, Craigie, Ian D & Hockings, Marc et al. 2015, 'Changes in protected area management effectiveness over time: A global analysis', *Biological Conservation*, vol. 191, pp. 692–699
- [15] Jonas Geldmann, Lauren Coad, Megan Barnes, Ian D. Craigie & Marc Hockings et al. 2015, 'Changes in protected area management effectiveness over time: A global analysis', *Biological Conservation*, vol. 191, pp. 692–699, doi:10.1016/j.biocon.2015.08.029
- [16] Vivitskaia JD Tulloch, Ayesha IT Tulloch, Piero Visconti, Benjamin S Halpern & James EM Watson et al. 2015, 'Why do we map threats? Linking threat mapping with actions to make better conservation decisions', *Frontiers in Ecology and the Environment*, vol. 13, no. 2, pp. 91–99, doi:10.1890/140022
- [17] * Megan Barnes, Judit K. Szabo, William K. Morris & Hugh Possingham 2014, 'Evaluating protected area effectiveness using bird lists in the Australian Wet Tropics', *Diversity Distrib.*, vol. 21, no. 4, pp. 368–378, doi:10.1111/ddi.12274
- [18] Ian D. Craigie, R.L. Pressey & Megan Barnes 2014, 'Remote regions – The last places where conservation efforts should be intensified. A reply to McCauley et al. (2013)', *Biological Conservation*, vol. 172, pp. 221–222, doi:10.1016/j.biocon.2014.02.032
- [19] Jonas Geldmann, Megan Barnes, Lauren Coad, Ian D. Craigie & Marc Hockings et al. 2013, 'Effectiveness of terrestrial protected areas in reducing habitat loss and population declines', *Biological Conservation*, vol. 161, pp. 230–238, doi:10.1016/j.biocon.2013.02.018
- [20] LIN SCHWARZKOPF, MEGAN BARNES & BRETT GOODMAN 2010, 'Belly up: Reduced crevice accessibility as a cost of reproduction caused by increased girth in a rock-using lizard', *Austral Ecology*, vol. 35, no. 1, pp. 82–86, doi:10.1111/j.1442-9993.2009.02015.x

Additional Research Outputs

- [1] A. L. M. Chauvenet & M. Barnes 2016, 'Expanding protected areas is not enough', *Science*, vol. 353, no. 6299, pp. 551–552, doi:10.1126/science.aah3762
- [2] Barnes, Megan, Woodley, Stephen, Geldmann, Jonas, Craigie, Ian D & Harrison, Luke et al. 2015, 'Species Populations Outcomes in Protected Areas Supported by the Global Environment Fund'
- [3] Craigie, Ian D, Barnes, Megan, Geldmann, Jonas, Anand, Anupam & Woodley, Stephen 2015, 'Deforestation in Protected Areas Supported by the Global Environment Fund'
- [4] Geldmann, Jonas, Barnes, Megan, Craigie, Ian D, Coad, Lauren & Woodley, Stephen 2014, 'Evaluation of the use of the Management Effectiveness Tracking Tool (METT) in protected areas supported by the GEF'

Part D - Personnel and ROPE (Dr Paul Barber)

D1. Personal Details

(To update personal details, click the 'Manage Personal Details' link below. Note this will open a new browser tab. When returning to the form ensure you 'Refresh' the page to capture the changes made to your profile.)

Participation Type

Partner Investigator

Title

Dr

First Name

Paul

Family Name

Barber

D4. Qualifications

(To update any qualifications, click on the 'Manage Qualifications' link below. Note this will open a new browser tab. When returning to the form ensure you 'Refresh' the page to capture the changes made to your profile.)

Conferral Date	AQF Level	Degree/Award Title	Discipline/Field	Awarding Organisation	Country of Award
01/01/2005	Doctoral Degree	PhD	Forest Pathology	La Trobe University	Australia

D5. Research Opportunity and Performance Evidence (ROPE) - Current and previous appointment(s) / position(s) - during the past 10 years

(To update any details in this table, click on the 'Manage Employment Details' link below. Note this will open a new browser tab. When returning to the form ensure you 'Refresh' the page to capture the changes made to your profile. Refer to the Instructions to Applicants for more information.)

Description	Department	Contract Type	Employment Type	Start Date	End Date	Organisation
Managing Director		Permanent	Full Time	01/04/2016		ARBOR CARBON PTY LTD
Director		Permanent	Full Time	01/07/2010	31/03/2016	ARBOR CARBON PTY LTD
Centre Manager	Centre of Excellence for Climate Change, Woodland & Forest Health	Contract	Full Time	01/07/2008	02/02/2009	Murdoch University
Project Manager, Tuart Health Research Group	School of Biological Sciences & Biotechnology	Contract	Full Time	28/05/2003	31/01/2009	Murdoch University

D6. Research Opportunity and Performance Evidence (ROPE) - Academic Interruptions

(You must read the ROPE Statement <http://www.arc.gov.au/arc-research-opportunity-and-performance-evidence-rope-statement> before filling out this section.)

Have you experienced an interruption that has impacted on your academic record?

Yes

From when

01/01/2010

To when

17/12/2019

FTE of academic interruption

1

Details

I work for a private business contracted by industry

D7. Research Opportunity and Performance Evidence (ROPE) - Details of the participant's academic career and opportunities for research, evidence of research impact and contributions to the field, including those most relevant to this application

(Provide details of your academic career and opportunities, evidence of research impact and contributions to the field. (Upload a PDF of no more than five A4 pages))

Uploaded PDF file follows on next page.

Research Opportunity and Performance Evidence (ROPE)

AMOUNT OF TIME AS AN ACTIVE RESEARCHER I was awarded my PhD in Forest Pathology in 2005. Since then, I worked for 5 years in a research capacity before I left to become Founding Director of an environmental consultancy ArborCarbon where I have been employed full time; this is not a primarily research role.

RESEARCH OPPORTUNITIES:

I was post-doctoral research fellow in forest pathology at Murdoch University for 6 years (2003-2009) as the Business Manager of the WA State funded Centre of Excellence for Climate Change, Woodland and Forest Health. Approximately 3 years after establishing ArborCarbon I was offered a position as Adjunct Senior Lecturer at Murdoch University, and this was upgraded to Adjunct Associate Professor around 2015. As an Adjunct I have volunteered my time to co-supervise several PhD students on a range of topics including remote sensing, forest pathology and urban forestry. Most of these topics have related to projects undertaken by ArborCarbon, and many have involved the provision of datasets and resources from ArborCarbon to the students resulting from projects for clients. My current role as the Managing Director is to develop business, manage projects and staff, and collaborations including several with universities and commercial partners. The majority of the R&D undertaken by ArborCarbon is to fulfil a core value of Innovation and to develop new commercial services, rather than publish outcomes in peer-reviewed journals. I currently co-supervise 4 PhD students, 3 of these at Murdoch University and 1 at University of Sydney.

Research mentoring and research facilities available to me during my career:

I undertook my PhD at La Trobe University in Bundoora, Victoria, where I was mentored by my PhD supervisor Dr Philip Keane. During the latter half of my PhD I was fortunate to be offered a Post-Doctoral position at Murdoch University in 2003, prior to completion of my PhD. Murdoch University and my Manager Professor Giles Hardy, were very understanding in allowing me to work in this role until I finally graduated from my PhD in 2005. During my time at Murdoch University I was fortunate to be supported in undertaking post-graduate units in remote sensing where I learnt about the potential for this technology to be used for spatial and temporal analysis of forest change. I was encouraged to continue to use my traditional fungal taxonomy skills in collaborations with various researchers at the university, even though this was not a core element of my project role. This included trips overseas to expand my knowledge in forest pathology and remote sensing, including Indonesia and South Africa. I was promoted to Business Manager of the WA State Centre of Excellence for Climate Change in 2007. My main mentors at Murdoch University were Professors Giles Hardy and Bernard Dell, both of them teaching me the importance of solid work ethic, desire to make a real difference through my research, publication of my research, and training of post-graduate students. During the latter part of my career at Murdoch University I had a strong desire to transition from publishing research to translation of research into daily management of vegetation. This led me to establish ArborCarbon in 2009 and my research mentors were supportive of me moving into a 0.5FTE research role and remainder consulting. To this day I maintain a strong relationship with both of these mentors through personal relationship and continued co-supervision of PhD students and research publication.

RESEARCH ACHIEVEMENTS AND CONTRIBUTIONS

Invited keynote and speaker addresses

I am regularly invited to deliver keynote addresses and presentations on a variety of topics across the globe. A selection of these is listed below for the past 2 years.

- *Using innovative technologies for measurement, monitoring and sustainable management of the urban forest.* ASEAN-China Symposium on Ecologically Friendly Urban Development 2019, 29-31 Oct 2019, Bangkok, Thailand.
- *Multispectral and thermal acquisition over Pinjar Pine Plantation – J19397.* Presentation to the European House Borer Management Team DPIRD WA, 15 November 2019, South Perth, Western Australia, Australia.
- *Using innovative technologies for measurement, monitoring and sustainable management of urban crowns and canopy.* The Arboricultural Association's 53rd National Amenity Conference Crown & Canopy Management *Working with Nature*, 8-11 Sept 2019, University of Exeter, United Kingdom.
- *Using innovative technologies for measurement, monitoring and sustainable management of urban crowns and canopy.* Presentation to the National Grid UK, 12 Sept 2019, Warwick, United Kingdom.
- *Using innovative technologies for measurement, monitoring and sustainable management of urban crowns and canopy.* Presentation to the Forestry Commission UK, 10 Sept 2019, New Forest, Surrey, United Kingdom.

- *Innovative approaches to the diagnosis, monitoring and sustainable management of pests and diseases in the urban forest.* Arboriculture and Sustainable Urban Forest Management Seminar Series. Pests, Diseases and Tree Decline Seminar 2, 10 Aug 2019, Technology & Higher Education Institute (Thei) Hong Kong, Chai Wan, Hong Kong.
- *ArborCarbon partner update.* CUAVA workshop 2019, 18 June 2019, University of Sydney, NSW, Australia.
- *Airborne precision measurement & monitoring urban forest cover & condition 2019.* Presentation to the City of Melbourne, 29 May 2019, City of Melbourne, Victoria, Australia.
- *Forest pathology & remote sensing for sustainable vegetation management.* Presentation to the City of Bunbury, 08 March 2019, City of Bunbury, Bunbury, Australia.
- *On the verge – the role of trees.* Verge Discussion Seminar, 20 Feb 2019, City of Cockburn, Perth, WA.
- *Introduction to ArborCarbon.* Biophilic Resilient Perth workshop, 13 February 2019, University of Western Australia, Perth, Australia.
- *Achieving City of Greater Dandenong's UTS Vision and Objectives.* Presentation to the City of Greater Dandenong, 05 February 2019, Dandenong, Victoria, Australia.
- *Combining forest pathology and remote sensing for forest surveillance & management.* WA Biosecurity Forum, 21 February 2019, Kensington, WA, Australia.
- *Health urban forests & communities.* Presentation to the Town of Bassendean Elected Members, 28 Nov 2018, Town of Bassendean Council Chambers, Bassendean, WA, Australia.
- *Creating resilient and liveable cities through precision green infrastructure measurement & management.* 11th International Urban Design Conference, 13 November 2018, Sydney, NSW, Australia
- *Real world applications of remote sensing for vegetation monitoring.* Presentation to the City of Auckland, 26 October 2018, Auckland, New Zealand.
- *Real world applications of remote sensing for vegetation monitoring.* Presentation to Waikato Regional Council, 25 October 2018, Hamilton, New Zealand.
- *Using cutting edge airborne imaging and ground-based sensing technology to combat urban greening, heat and human health impacts.* International Parks and Leisure Congress 2018, 15 October 2018, Melbourne Cricket Ground, Melbourne, VIC, Australia.
- *Early detection and mitigation of tree health disorders.* Sustainable Urban Forest Management Symposium Series, a masterclass in urban greening and re-sourcing excellence, Seminar 3: Healthy Trees, Healthy People, 09 October 2019, Perth City Farm, East Perth, WA, Australia.
- *Real world applications of remote sensing for vegetation monitoring.* Presentation to the Vietnam Academy of Forest Science (VAFS), 04 October 2018, HaNoi, Vietnam.
- *Monitoring & managing rail reserve vegetation condition.* The Last Stand Symposium, 05 September 2018, Moora Performing Arts Centre, Moora, WA, Australia.
- *Using new technologies – hyperspectral/multispectral methods.* Dieback Information Group (DIG) 2018 meeting, 31 August 2018, Wembley, WA, Australia.
- *The impact of declining canopy cover and increasing heat on Perth's liveability and well being.* Switch Your Thinking Change Makers Climate Science and Adaptation Biophilic Urbanism Symposium, 14 August 2018, Bassendean, WA, Australia.
- *Case studies of aerial measurement and monitoring of trees in urban spaces.* Sustainable Urban Forest Management Symposium Series, a masterclass in urban greening and re-sourcing excellence, Seminar 2: Measurement Monitoring & Strategic Planning, 13 August 2019, Perth City Farm, East Perth, WA, Australia.
- *A holistic and data driven approach to creating a resilient urban forest.* Parks & Leisure WA Conference, 21 June 2018, Esplanade Hotel, Fremantle, WA, Australia.
- *Outcomes and next steps Urban Forest monitoring Town of East Fremantle.* Presentation to the Town of East Fremantle Elected Members, 11 June 2018, Town of East Fremantle Council Chambers, East Fremantle, WA.
- *Urban tree health and death – debunking myths around the cause(s).* Sustainable Urban Forest Management Symposium Series, a masterclass in urban greening and re-sourcing excellence, Seminar 1: Tree Health Management in a Changing Climate, 29 May 2019, Perth City Farm, East Perth, WA, Australia.

- *Using digital technologies for precision natural resource management.* Living Landscapes Professional Development in Environmental Management Series, Using Digital Technology in Natural Resource Management, 10 April 2018, Perth Zoo Conference Theatre, South Perth, WA, Australia.
- *Using airborne high-resolution remote sensing to manage vegetation health with precision in urban forests.* Fenner Conference on the Environment: Urban Sustainability & Conservation, 06 April 2018, Canberra, Australia.
- *Early detection, surveillance and management of disease using airborne remote sensing systems.* Presentation to the Department of Agriculture, 29 March 2018, Canberra, Australia.

Scientific Service and Public Engagement

- Invited referee for international scientific publications: Forests, Int J of Remote Sensing, Remote Sensing of Environment, Plant Pathology, Biological Control, Urban Forestry & Urban Greening, Mycological Research
- 2014– Expert reviewer for the Australian Research Council (ARC) Linkage Grants Program
- Scientific review committee – International Society of Arboriculture
- 2016– Invited member of the Hong Kong Government Urban Forestry Advisory Panel
- 2014– Non-executive board member Not-For-Profit organisation Trillion Trees (formerly Men of the Trees WA)
- 2017– Management Committee member of the ARC ITTC for Cubesats, UAVs and their Applications (CUAVA).

Commercial outcomes and resulting benefits

I founded ArborCarbon in 2009 out of the need for a niche environmental consultancy to diagnose and treat tree health disorders using a combination of my expertise in remote sensing, forest pathology and arboriculture. Since that time ArborCarbon has grown from essentially a sole-trader to a company employing six people full-time with the majority university graduates. ArborCarbon has increased revenue annually even through a significant economic downturn in Western Australia. ArborCarbon has an office in Perth, established an office in Hong Kong in 2017 (ArborCarbon Hong Kong Ltd), and in the same year initiated a shareholding in Arborflight based in the UK, where I hold the position of Director of Technology and Innovation. I have managed consultancy projects in the USA, South America, United Kingdom, Hong Kong, New Zealand, Singapore and across most states of Australia. Projects are diverse with a focus on the improvement in management of vegetation and the environment by our clients. Some examples listed below:

- 2009-2012 – Designed, established and implemented a vegetation monitoring program utilising a combination of remote sensing and field based activities for Roy Hill Iron Ore. This project developed innovative methods for the early detection of impacts on vegetation health through mining activities.
- 2012-2019 – Consultation with the City of Joondalup to develop and implement the first Pathogen Management Plan by any local government in Australia. This project has used high-resolution airborne multispectral imagery for early detection of vegetation health decline, and subsequent sampling to determine causal factors. Council has approved the development of a quantitative measure of bushland and natural area condition (normalised Vegetation Condition Index – nVCI) as a Key Performance Indicator.
- 2012-2019 – Acquisition, processing and analysis of high-resolution airborne multispectral imagery for the measurement of canopy cover and condition of urban forests for numerous councils across Australia, including but not limited to Cities of Melbourne, Darebin, Sydney, North Sydney, Adelaide, Perth, Subiaco, Joondalup and Fremantle. The delivery of high-quality datasets, analytics and report writing for these councils has enabled them to make informed decisions about urban planning, urban forest and green space management. Our data has been used in a wide range of management plans and strategies, including: City of Joondalup Pathogen Management Plan, Resilient South Climate Change Adaptation Plan, City of Sydney Urban Forest Plan, City of Melbourne Urban Forest Strategy, City of Fremantle Greening Strategy. Our data has been used to conserve urban forests and inform the strategic planting and protection of trees to increase cover, and modify planning design to improve liveability of cities. As a result of our innovative work we have been appointed to a 5-year preferred supplier panel for the City of Sydney to provide airborne canopy cover and condition measurement of their canopy and urban heat, and in 2014 we were appointed to the Western Australian Local Government Agency (WALGA) preferred supplier panel for Environmental Consultants.
- 2016-2019 – Design and implementation of the Phytophthora Eradication Trial for Main Roads Western Australia. This field trial is ongoing and showing great promise and is the result of a collaboration between MRWA, DBCA and ArborCarbon. If successful, it will enable MRWA to source gravel for road building from

dieback-infested sites rather than 'pristine' state forest where trees would need to be cut over to source the gravel. It will also result in the rehabilitation of previously dieback infested forest to dieback free.

- 2017 – Development of the ArborCam multisensor 11-band camera for very high-resolution (2cm GSD) imagery at high altitudes. This camera system was designed and engineered, along with the proprietary processing methodologies, specifically for precision monitoring of vegetation. Since its deployment we have completed projects across urban forests, horticulture and agriculture throughout Australia and South America. The data generated from this system has created opportunities for the development of many new applications that are not possible with current satellites or UAVs/drones, improving early detection of vegetation health disorders, species classification, yield forecasting and precision urban forest measurements.

Other professional activities – Research Supervision and Mentoring:

I currently co-supervise the following PhD students:

- Jacqueline Parker (commenced 2019) Green infrastructure: A means of supporting resilient and sustainable urban development. School of Veterinary & Life Sciences, Murdoch University.
- Savannah McGuirk (commenced 2018). Integrating UAV and CubeSat hyperspectral, multi-spectral and thermal observations into farm-scale estimation of Soil Organic Carbon stocks. CUAVA, University of Sydney.
- Thu. T. Nguyen (commenced 2017) Maintaining ecosystem health in urban forests: the role of golf courses. School of Veterinary & Life Sciences, Murdoch University.
- Trung. K. Nguyen (commenced 2017). Assessment of carbon sequestration in dryland forestry. School of Veterinary & Life Sciences, Murdoch University.

I have co-supervised the students below through to graduation:

- Mohammed Baidhani (2019) The diversity, distribution and impact of *Phytophthora* species associated with declining urban vegetation. School of Veterinary & Life Sciences, Murdoch University.
- Tam Tran Thi Thanh (2019) The distribution and impact of *Ceratocystis* wilt on Acacia plantations in Vietnam. Nguyen University of Agriculture and Forestry, Vietnam.
- Lily Ishaq (2012) The role of mycorrhizal fungi in tuart (*Eucalyptus gomphocephala*) health. School of Biological Sciences & Biotechnology, Murdoch University Experience – Regional Projects
- Endah Yulia (2011) The decline of the red flowering gum (*Corymbia ficifolia* F. Muell. (K.D. Hill 2 and L.A.S. Johnson) in urban environments in Western Australia. The role of fungal and oomycete pathogens. School of Biological Sciences & Biotechnology, Murdoch University
- Peter Scott (2011) The role of *Phytophthora* soilborne pathogens in *Eucalyptus gomphocephala* woodland decline. School of Biological Sciences & Biotechnology, Murdoch University.
- Kobus Wentzel (2010) Is tuart (*Eucalyptus gomphocephala*) decline detrimental for fauna? School of Biological Sciences & Biotechnology, Murdoch University.

Identifiable benefits outside of academia – Other professional activities:

2015-2019. Expert witness on several cases, two of these in the Supreme Court of NSW and South Australia. One case involved the failure of a tree onto powerlines resulting in the destruction of more than 300 homes in the Blue Mountains Sydney. I was required to provide expert witness evidence on the fungal decay within the remaining tree stump, and the risk assessment undertaken by contractors prior to failure. This utilised my expertise in pathology and arboriculture. The other case involved the assessment of airborne imagery of agricultural land to determine the land use in relation to tax paid to the state. This utilised my expertise in remote sensing for earth observation. I have also provided expert witness in the State Administrative Tribunal (SAT) involving a dispute between a business in the extractive industries and local government whereby the site was under consideration for approval for extractive industries whilst being *Phytophthora* dieback infested. This utilised my expertise in forest pathology and knowledge of the science around *Phytophthora* dieback.

2016-2017. Appointed by the Food and Agriculture Organization (FAO) of the United Nations as their Expert Forest Health consultant to undertake a mission in Iran to improve capacity of government and stakeholders in the management of a serious forest disease known as Boxwood Blight. This utilised my expertise in forest pathology and engagement with scientists in non-english speaking countries. I was also required to provide training in the use of remote sensing and novel technologies for forest health monitoring.

How my research has led to a significant change or advance of knowledge, and how my achievements will contribute to this application:

My research expertise and broad expertise and focus on remote sensing, forest pathology and urban forestry has resulted in the translation of technologies more traditionally used in forestry and agriculture, into urban forestry. This has enabled numerous local, state and national government agencies to engage my services to design and implement consultancy projects based on proven research methodologies, to carry out accurate and repeatable measurement of the cover and condition of vegetation across urban forests. High profile government agencies and entities include the Highways Department (HyD) of Hong Kong, Te Reroa Group New Zealand, City of Melbourne, City of Sydney and City of Perth. In addition, we have utilised ArborCam imagery, and machine learning techniques to develop models for the remote detection of dead wood in forested landscapes. We will utilise this expertise and our strong track record of partnering with research organisations and government departments to ensure this project has access to the latest innovative technologies for vegetation health and fuel load assessment.

D8. Research Opportunity and Performance Evidence (ROPE) - Currently held ARC projects

(This information is auto-populated from the applicants RMS profile and will include any active project which has not yet had a Final Report approved and the project file closed by the ARC. You will not be able to submit an application to the ARC that involves a researcher who has an overdue Final Report on an ARC-funded project. If there are any concerns with the information recorded here, contact Your organisation's Research Office.)

Identifier	Investigators	Admin Organisation	Project Title	Funding	End Date	Final Report Due Date	Final Report Status
IC170100023	Prof Iver Cairns ; Prof Andrew Dempster ; Dr Eleanor Bruce ; A/Prof Joe Khachan ; A/Prof KC Wong ; A/Prof Roy Hughes ; A/Prof Elias Aboutanios ; Dr Ediz Cetin ; A/Prof Sergio Leon-Saval ; Dr Bradley Evans ; Dr Xiaofeng Wu ; Dr Richard Murphy ; Dr Jason Held ; Dr Weitang Li ; Mr Paris Michaels ; Mr Andreas Antoniadis ; Prof Gregory Chamitoff ; Prof Jonathan Lawrence ; Dr Stephen Carr ; Dr Daniel Bongiorno ; A/Prof Charles Bachmann ; Dr David Neudegg ; Dr Paul Barber ; Dr Terry Cocks ; Dr Kirco Arsov	The University of Sydney	ARC Training Centre for Cubesats, Uncrewed Aerial Vehicles, and Their Applications	\$4,619,950	13/12/2022	13/12/2023	Draft

D9. Project/Role relinquishment or application withdrawal

(If you exceed the Linkage Program limits on projects and/or applications and have applied under the Industrial

Transformation Research Hubs, Industrial Transformation Training Centres, Special Research Initiatives, Learned Academies Special projects, Supporting Responses to Commonwealth Science Council Priorities or any other Linkage Program scheme, list the application you wish to withdraw, or the existing project (or role) that that you wish to relinquish should this application be successful (see sections 6.35 to 6.39 of the grant guidelines). Failing to provide this information will jeopardise the eligibility of your applications. Provide project/application ID(s) separated by a comma.)

D10. Eligibility - Role of Partner Investigator

(Please indicate which of the Partner Investigator role options from section 6.29 of the grant guidelines apply to your role on this project. Select all options that apply.)

D11. Eligibility - Will the participant be residing predominately in Australia for the duration of the project activity period?

((This is a 'Yes' or 'No' question. Indicate whether the participant will be residing predominantly in Australia for the project activity period. If the participant is applying as a CI and they answer 'No' to this question you will be prompted to contact the Research Office to check the participant's eligibility. If the participant is a Foreign National, they must reside legally in Australia. Eligibility will be based solely on the information contained in this application.))

D12. Eligibility - Is the participant currently undertaking a Higher Degree by Research which will be conferred after the grant commencement date?

((This is a 'Yes' or 'No' question. If the participant is applying as a CI and they answer 'Yes' to this question they will be prompted to contact the Research Office and Part D will not validate. Eligibility will be based solely on the information contained in this application.))

D13. Eligibility - Employment Details as at grant commencement date of project

(This question will be used to determine your eligibility. Your eligibility will be based solely on the information contained in this application. Confirm your employment status at all organisations that you will be associated with as at the Grant Commencement Date. Enter the relevant appointment type and Full-Time Equivalent (FTE) for each organisation.)

Org name	Is this an Eligible Organisation?	Please choose your appointment type for this organisation.	Please enter your FTE for this Organisation
ARBOR CARBON PTY LTD		Employee	1

D14. Eligibility - Further Details Regarding Partner Investigator Status - Does the participant hold a remunerated appointment at an Eligible Organisation as at the grant commencement date for this project?

(At A2 Partner Investigator has been selected as the role type, but it appears that the participant meets the criteria of a Chief Investigator.

NOTE: this question is mandatory ONLY FOR PIs WHO:

- at D11 confirmed that they will reside predominantly in Australia for the project activity period of the proposed Project; AND
- at D12 confirmed that they are not currently undertaking a Higher Degree by Research which will be conferred after the grant commencement date; AND

- at D13 indicated that they would hold either:
 - an appointment at an Eligible Organisation equal or greater than 0.2 FTE; OR
 - an honorary academic appointment at an Eligible Organisation

You do not need to answer these questions if it was indicated in question D11 that the participant will be living predominantly overseas OR if they have indicated in question D12 that the participant will be undertaking a Higher Degree by Research.)

Do you hold a remunerated appointment at an Eligible Organisation?

Justification of PI status

D15. Eligibility - Relevant Organisation for this application as at the grant commencement date for this project

(Enter the Organisation that is relevant to the participant's inclusion on this application, and that they will be associated with as at the grant commencement date. The 'relevant organisation' is the primary organisation that will be supporting the participant's involvement in this project if it is funded. Note that the Organisation must be listed in D13 for this question to validate.)

Relevant Organisation

D16. What is the participant's time commitment to this project?

(Enter the participant's time commitment to this project as a Full-Time Equivalent (FTE). Note that a FTE of 1.0 represents a full-time commitment (i.e. 5 days per week).)

D17. Research Opportunity and Performance Evidence (ROPE) - Research Outputs

(Research context: Provide clear information that explains the relative importance of different research outputs and expectations in the participant's discipline/s. The information should help assessors understand the context of the participant's academic research achievements but not repeat information already provided in this application. It is helpful to include the importance/esteem of specific journals in the participant's field; specific indicators of recognition within the participant's field such as first authorship/citations, or the significance of non-traditional research outputs. If this question is not relevant to a participant, for example a PI with non-academic background, the participant should include a short explanatory statement as to why this question is not applicable. (No more than 3,750 characters, approximately 500 words))

D18. Research Opportunity and Performance Evidence (ROPE) – Research Outputs Listing including Ten Career-Best Research Outputs

(List the research outputs marking those that are most relevant to this application categorised under the following headings: Ten career-best research outputs; Authored books; Edited books; Book chapters; Referred Journal articles; Fully refereed conference proceedings; Additional research outputs (including non-traditional research outputs). CVs and theses should not be included in this list. The participant's ten career-best research outputs should not be repeated under subsequent headings. (No more than 100 research outputs).)

Research Outputs Listing

Generated research output document follows on the next page

Ten Career-Best Research Outputs

- [1] * Barber, P.A., Paap, T., Burgess, T.I., Dunstan, W. & Hardy, G. 2013, 'A diverse range of Phytophthora species are associated with dying urban trees', *Urban Forestry and Urban Greening*, vol. 12, no. 4, pp. 569-575 (Refereed Journal Article)
- [2] * Scott, P.M., Burgess, T.I., Barber, P.A., Shearer, B.L. & Stukely, M.J.C. et al. 2009, 'Phytophthora multivora sp. nov., a new species recovered from declining Eucalyptus, Banksia, Agonis and other plant species in Western Australia', *Persoonia: Molecular Phylogeny and Evolution of Fungi*, vol. 22, pp. 1-13 (Refereed Journal Article)
- [3] * Ruthrof, K.X., Douglas, T.K., Calver, M.C., Barber, P.A. & Dell, B. et al. 2010, 'Restoration treatments improve seedling establishment in a degraded Mediterranean-type Eucalyptus ecosystem', *Australian Journal of Botany*, vol. 58, no. 8, pp. 646-655, LP0668195 (2007-2010), LP0346931 (2004-2007) (Refereed Journal Article)
- [4] * Evans, B., Stone, C. & Barber, P. 2013, 'Linking a decade of forest decline in the south-west of Western Australia to bioclimatic change', *Australian Forestry*, vol. 76, no. 3-4, pp. 164-172 (Refereed Journal Article)
- [5] * Scott, P.M., Shearer, B.L., Barber, P.A. & Hardy, G.E.S.J. 2013, 'Relationships between the crown health, fine root and ectomycorrhizae density of declining Eucalyptus gomphocephala', *Australasian Plant Pathology*, vol. 42, no. 2, pp. 121-131, LP0668195 (2007-2010) (Refereed Journal Article)
- [6] * Ishaq, L., Barber, P.A., Hardy, G.E.S.J., Calver, M. & Dell, B. 2013, 'Seedling mycorrhizal type and soil chemistry are related to canopy condition of Eucalyptus gomphocephala', *Mycorrhiza*, vol. 23, no. 5, pp. 359-371, LP0668195 (2007-2010) (Refereed Journal Article)
- [7] * Yulia, E., Hardy, G.E.S.J., Barber, P. & Dell, B. 2014, 'A severe canker disease of Corymbia ficifolia caused by Quambalaria coyrecup in native and urban forests of Western Australia', *Forest Pathology*, vol. 44, no. 3, pp. 201-210 (Refereed Journal Article)
- [8] * Cai, Y.F., Barber, P., Dell, B., O'Brien, P. & Williams, N. et al. 2010, 'Soil bacterial functional diversity is associated with the decline of Eucalyptus gomphocephala', *Forest Ecology and Management*, vol. 260, no. 6, pp. 1047-1057 (Refereed Journal Article)
- [9] * Taylor, K., Barber, P.A., St J. Hardy, G.E. & Burgess, T.I. 2009, 'Botryosphaeriaceae from tuart (Eucalyptus gomphocephala) woodland, including descriptions of four new species', *Mycological Research*, vol. 113, no. 3, pp. 337-353, LP0668195 (2007-2010) (Refereed Journal Article)
- [10] * Evans, B., Lyons, T., Barber, P., Stone, C. & Hardy, G. 2012, 'Enhancing a eucalypt crown condition indicator driven by high spatial and spectral resolution remote sensing imagery', *Journal of Applied Remote Sensing*, vol. 6, no. 1 (Refereed Journal Article)

Authored Books

- [1] Burgess, T.I., Barber, P.A., Mohali, S., Pegg, G. & De Beer, W. et al. 2006, 'Three new Lasiodiplodia spp. from the tropics, recognized based on DNA sequence comparisons and morphology', *Mycologia*, vol. 98, no. 3, pp. 423-435

Refereed Journal Articles

- [1] Migliorini, D., Khdiar, M.Y., Padrón, C.R., Vivas, M. & Barber, P.A. et al. 2019, 'Extending the host range of Phytophthora multivora, a pathogen of woody plants in horticulture, nurseries, urban environments and natural ecosystems', *Urban Forestry and Urban Greening*, vol. 46
- [2] * Wentzel, J.J., Craig, M.D., Barber, P.A., StJ Hardy, G.E. & Fleming, P.A. 2019, 'Microbat responses to forest decline', *Austral Ecology*, vol. 44, no. 2, pp. 265-275
- [3] Christian, H., Lester, L., Trost, S.G., Trapp, G. & Schipperijn, J. et al. 2019, 'Shade coverage, ultraviolet radiation and children's physical activity in early childhood education and care', *International Journal of Public Health*, vol. 64, no. 9, pp. 1325-1333
- [4] T. T. T. Tran, T. Q. Pham, Paul A. Barber & C. M. Nguyen 2018, 'Control of Ceratocystis manginecans causing wilt disease on Acacia mangium seedlings', *Australasian Plant Pathology*, vol. 47, no. 6, pp. 579-586, doi:10.1007/s13313-018-0594-4
- [5] * Ishaq, L., Barber, P.A., Hardy, G.E.S.J. & Dell, B. 2018, 'Diversity of fungi associated with roots of Eucalyptus gomphocephala seedlings grown in soil from healthy and declining sites', *Australasian Plant Pathology*, vol. 47, no. 2, pp. 155-162
- [6] * Wentzel, J.J., Craig, M.D., Barber, P.A., Hardy, G.E.S.J. & Fleming, P.A. 2018, 'Tuart (Eucalyptus gomphocephala) decline is not associated with other vegetation structure and composition changes', *Australasian Plant Pathology*, vol. 47, no. 5, pp. 521-530
- [7] Simamora, A.V., Stukely, M.J.C., Barber, P.A., Hardy, G.E.S. & Burgess, T.I. 2017, 'Age-related susceptibility of Eucalyptus species to Phytophthora boodjera', *Plant Pathology*, vol. 66, no. 3, pp. 501-512

- [8] Crous, P.W., Wingfield, M.J., Burgess, T.I., St. J. Hardy, G.E. & Barber, P.A. et al. 2017, 'Fungal planet description sheets: 558-624', *Persoonia: Molecular Phylogeny and Evolution of Fungi*, vol. 38, no. JUNE, pp. 240-384
- [9] Paap, T., Croeser, L., White, D., Aghighi, S. & Barber, P. et al. 2017, 'Phytophthora versiformis sp. nov., a new species from Australia related to P. quercina', *Australasian Plant Pathology*, vol. 46, no. 4, pp. 369-378
- [10] Crous, P.W., Wingfield, M.J., Burgess, T.I., Hardy, G.E.S.J. & Crane, C. et al. 2016, 'Fungal Planet description sheets: 469-557', *Persoonia: Molecular Phylogeny and Evolution of Fungi*, vol. 37, no. DECEMBER, pp. 218-403
- [11] Crous, P.W., Wingfield, M.J., Guarro, J., Hernández-Restrepo, M. & Sutton, D.A. et al. 2015, 'Fungal Planet description sheets: 320-370', *Persoonia: Molecular Phylogeny and Evolution of Fungi*, vol. 34, pp. 167-266
- [12] Scott, P.M., Barber, P.A. & Hardy, G.E.S.J. 2015, 'Novel phosphite and nutrient application to control Phytophthora cinnamomi disease', *Australasian Plant Pathology*, vol. 44, no. 4, pp. 431-436, LP120200581 (2013-2016)
- [13] * Evans, B., Lyons, T.J., Barber, P.A., Stone, C. & Hardy, G. 2014, 'Dieback classification modelling using high-resolution digital multispectral imagery and in situ assessments of crown condition', *Remote Sensing Letters*, vol. 3, no. 6, pp. 541-550, LP0668195 (2007-2010)
- [14] * Scott, P.M., Dell, B., Shearer, B.L., Barber, P.A. & Hardy, G.E.S.J. 2013, 'Phosphite and nutrient applications as explorative tools to identify possible factors associated with Eucalyptus gomphocephala decline in South-Western Australia', *Australasian Plant Pathology*, vol. 42, no. 6, pp. 701-711, LP0668195 (2007-2010)
- [15] Taylor, K., Andjic, V., Barber, P.A., StJ. Hardy, G.E. & Burgess, T.I. 2012, 'New species of Teratosphaeria associated with leaf diseases on Corymbia calophylla (Marri)', *Mycological Progress*, vol. 11, no. 1, pp. 159-169
- [16] * Scott, P.M., Jung, T., Shearer, B.L., Barber, P.A. & Calver, M. et al. 2012, 'Pathogenicity of Phytophthora multivora to Eucalyptus gomphocephala and Eucalyptus marginata', *Forest Pathology*, vol. 42, no. 4, pp. 289-298, LP0668195 (2006-2010)
- [17] Agostini, C., Agudelo, P.A., Bâ, K., Barber, P.A. & Bisol, P.M. et al. 2011, 'Permanent Genetic Resources added to Molecular Ecology Resources Database 1 October 2010-30 November 2010', *Molecular Ecology Resources*, vol. 11, no. 2, pp. 418-421
- [18] Andjic, V., Dell, B., Barber, P., Hardy, G. & Wingfield, M. et al. 2011, 'Plants for planting; indirect evidence for the movement of a serious forest pathogen, Teratosphaeria destructans, in Asia', *European Journal of Plant Pathology*, pp. 1-10
- [19] Barber, P.A., Crous, P.W., Groenewald, J.Z., Pascoe, I.G. & Keane, P. 2011, 'Reassessing Vermisporium (Amphisphaeriaceae), a genus of foliar pathogens of eucalypts', *Persoonia: Molecular Phylogeny and Evolution of Fungi*, vol. 27, pp. 90-118
- [20] Adair, R.J., Burgess, T., Serdani, M. & Barber, P. 2009, 'Fungal associations in Asphondylia (Diptera: Cecidomyiidae) galls from Australia and South Africa: implications for biological control of invasive acacias', *Fungal Ecology*, vol. 2, no. 3, pp. 121-134
- [21] Crous, P.W., Summerell, B.A., Carnegie, A.J., Wingfield, M.J. & Hunter, G.C. et al. 2009, 'Unravelling Mycosphaerella: Do you believe in genera?', *Persoonia: Molecular Phylogeny and Evolution of Fungi*, vol. 23, pp. 99-118
- [22] Barber, P.A., Carnegie, A.J., Burgess, T.I. & Keane, P.J. 2008, 'Leaf diseases caused by Mycosphaerella species in Eucalyptus globulus plantations and nearby native forest in the Green Triangle Region of southern Australia', *Australasian Plant Pathology*, vol. 37, no. 5, pp. 472-481
- [23] Pavlic, D., Wingfield, M.J., Barber, P., Slippers, B. & Hardy, G.E.St.J. et al. 2008, 'Seven new species of the Botryosphaeriaceae from baobab and other native trees in Western Australia', *Mycologia*, vol. 100, no. 6, pp. 851-866
- [24] Barber, P.A. & Keane, P.J. 2007, 'A novel method of illustrating microfungi', *Fungal Diversity*, vol. 27, pp. 1-10
- [25] Andjic, V., Barber, P.A., Carnegie, A.J., Pegg, G.S. & Hardy, G.E.St.J. et al. 2007, 'Kirramyces viscidus sp. nov., a new eucalypt pathogen from tropical Australia closely related to the serious leaf pathogen, Kirramyces destructans', *Australasian Plant Pathology*, vol. 36, no. 5, pp. 478-487
- [26] Burgess, T.I., Barber, P.A., Sufaati, S., Xu, D. & Hardy, G.E.St.J. et al. 2007, 'Mycosphaerella spp. on Eucalyptus in Asia; new species; new hosts and new records', *Fungal Diversity*, vol. 24, pp. 135-157
- [27] Andjic, V., Barber, P.A., Carnegie, A.J., Hardy, G.S.J. & Wingfield, M.J. et al. 2007, 'Phylogenetic reassessment supports accommodation of Phaeophleospora and Colletogloeopsis from eucalypts in Kirramyces', *Mycological Research*, vol. 111, no. 10, pp. 1184-1198
- [28] Crous, P.W., Slippers, B., Wingfield, M.J., Rheeder, J. & Marasas, W.F.O. et al. 2006, 'Phylogenetic lineages in the Botryosphaeriaceae', *Studies in Mycology*, vol. 55, pp. 235-253

- [29] Barber, P.A., Burgess, T.J., Hardy, G.E.St.J., Slippers, B. & Keane, P.J. et al. 2005, 'Botryosphaeria species from Eucalyptus in Australia are pleoanamorphic, producing Dichomera synanamorphs in culture', *Mycological Research*, vol. 109, no. 12, pp. 1347-1363, DP0343600 (2003-2007)
- [30] Burgess, T.I., Barber, P.A. & Hardy, G.E.St.J. 2005, 'Botryosphaeria spp. associated with eucalypts in Western Australia, including the description of Fusicoccum macroclavatum sp. nov.', *Australasian Plant Pathology*, vol. 34, no. 4, pp. 557-567, DP0343600 (2003-2007)
- [31] Whyte, G., Burgess, T.I., Barber, P.A. & Hardy, G.E.St.J. 2005, 'First record of Mycosphaerella heimii in Australia', *Australasian Plant Pathology*, vol. 34, no. 4, pp. 605-606
- [32] Barber, P.A., Kularatne, H.A.G.C. & Keane, P.J. 2005, 'First record of Mycosphaerella tasmaniensis on mainland Australia', *Australasian Plant Pathology*, vol. 34, no. 1, pp. 121-122
- [33] Kularatne, H.A.G.C., Lawrie, A.C., Barber, P.A. & Keane, P.J. 2004, 'A specific primer PCR and RFLP assay for the rapid detection and differentiation in planta of some Mycosphaerella species associated with foliar diseases of Eucalyptus globulus', *Mycological Research*, vol. 108, no. 12, pp. 1476-1493
- [34] Barber, P.A., Smith, I.W. & Keane, P.J. 2003, 'Foliar diseases of Eucalyptus spp. grown for ornamental cut foliage', *Australasian Plant Pathology*, vol. 32, no. 1, pp. 109-111

Fully Refereed Conference Proceedings

- [1] * Evans, B., Lyons, T.J., Barber, P.A., Stone, C. & Hardy, G. 2011, 'Detecting change in vegetation condition using high resolution digital multispectral imagery', *34th International Symposium on Remote Sensing of Environment - The GEOSS Era: Towards Operational Environmental Monitoring*

Part E - Project Cost (LP190100295)

E1. What is the proposed budget for the project?

(There are rules around what funds can be requested from the ARC. You must adhere to the grant opportunity specific requirements listed in the grant guidelines. It is important that the Administering Organisation participating in this application has been added at Part A3 prior to entering information in the budget table.)

Total requested budget: \$586,124

Year 1

Description	ARC	Admin Org		Partner Org	
	Cash	Cash	In-kind	Cash	In-kind
Total	150,443	76,184	133,932	50,000	357,827
Personnel	144,443	56,184	93,332	50,000	193,827
CI FLEMING (0.2FTE)			46,666		
CI HARDY (0.2FTE)			46,666		
PI BEAL RICHARDSON (0.2FTE)					19,404
PI MILLER (0.1FTE), Lead of the Fire Science Program, DBCA					17,373
PI BARNES (0.1 FTE), Research Scientist Decision Science, DBCA					11,875
PI BARBER (0.05FTE), Director, ArborCarbon					31,500
Research Associate 1 (1FTE, Y1-3) – Quantitative Ecologist in tree health and soil health	67,220			50,000	
Research Associate 2 (0.3FTE, Y1-3) Fire Ecologist	35,166				
Research Associate 3 (0.2FTE, Y1-5) – Social Scientist	23,444				
PhD 1 stipend (3.5 years) - soil and tree health		28,092			
PhD 2 stipend (3.5 years) - fauna		28,092			
Technician (0.2 FTE Y1-5 appointed at H0506)	18,613				
ESLICK (0.1FTE), Research Scientist, ArborCarbon					40,500
Project Officer - Bushfire Mitigation, City of Mandurah (0.2FTE, Y1)					14,748
Coordinator Emergency Management, City of Mandurah (0.2FTE, Y1)					20,304
Senior Environmental Management Officer, City of Mandurah (0.2FTE, Y1)					19,404
Environmental Management Officer, City of Mandurah (0.2FTE, Y1)					15,481
Environmental Education Officer, City of Mandurah (0.05FTE, Y1 & 2)					3,238
Equipment			26,600		
Field equipment			5,000		
Camera trap hire			21,600		
Maintenance	1,000	8,000	4,000		5,000
PhD 1 maintenance funding		4,000			

PhD 2 maintenance funding		4,000			
DBCA laboratory facilities					5,000
Laboratory consumables	1,000				
Plant pathology laboratory facilities			4,000		
Fieldwork Expenses	5,000	12,000	10,000		159,000
Manual fuel load reduction work - staff, contractors, local residents					100,000
Field travel - Perth to Mandurah return 150km x 100 trips pa @80c/km		12,000			
4WD vehicle access: \$10,000 pa in-kind (Y1-5)			10,000		
Follow-up weed control @\$5k/ha for grassy/bulbous weed control for 3 years for 4 of our 6 treatments (i.e. 4ha per replicate x 4 replicates =\$80,000)					40,000
Fieldwork accommodation.	5,000				
Survey of community responses to bushland amenity values					15,000
Remote sensing data capture					4,000

Year 2

Description	ARC	Admin Org		Partner Org	
	Cash	Cash	In-kind	Cash	In-kind
Total	159,615	79,194	135,054	50,000	167,890
Personnel	154,115	57,194	94,454	50,000	123,890
CI FLEMING (0.2FTE)			47,227		
CI HARDY (0.2FTE)			47,227		
PI BEAL RICHARDSON (0.2FTE)					19,404
PI MILLER (0.1FTE), Lead of the Fire Science Program, DBCA					17,373
PI BARNES (0.1 FTE), Research Scientist Decision Science, DBCA					11,875
PI BARBER (0.05FTE), Director, ArborCarbon					31,500
Research Associate 1 (1FTE, Y1-3) – Quantitative Ecologist in tree health and soil health	73,023			50,000	
Research Associate 2 (0.3FTE, Y1-3) Fire Ecologist	36,907				
Research Associate 3 (0.2FTE, Y1-5) – Social Scientist	24,605				
PhD 1 stipend (3.5 years) - soil and tree health		28,597			
PhD 2 stipend (3.5 years) - fauna		28,597			
Technician (0.2 FTE Y1-5 appointed at H0506)	19,580				
ESLICK (0.1FTE), Research Scientist, ArborCarbon					40,500
Environmental Education Officer, City of Mandurah (0.05FTE, Y1 & 2)					3,238
Equipment			26,600		
Field equipment			5,000		

Camera trap hire			21,600		
Maintenance	500	4,000	4,000		5,000
PhD 1 maintenance funding		2,000			
PhD 2 maintenance funding		2,000			
DBCA laboratory facilities					5,000
Laboratory consumables	500				
Plant pathology laboratory facilities			4,000		
Travel		6,000			
Conference travel (Fleming, Hardy)		6,000			
Fieldwork Expenses	5,000	12,000	10,000		39,000
Field travel - Perth to Mandurah return 150km x 100 trips pa @80c/km		12,000			
4WD vehicle access: \$10,000 pa in-kind (Y1-5)			10,000		
Follow-up weed control @\$5k/ha for grassy/bulbous weed control for 3 years for 4 of our 6 treatments (i.e. 4ha per replicate x 4 replicates =\$80,000)					20,000
Fieldwork accommodation.	5,000				
Survey of community responses to bushland amenity values					15,000
Remote sensing data capture					4,000

Year 3

Description	ARC	Admin Org		Partner Org	
	Cash	Cash	In-kind	Cash	In-kind
Total	169,377	81,222	136,482	50,000	149,652
Personnel	163,877	58,222	95,882	50,000	120,652
CI FLEMING (0.2FTE)			47,941		
CI HARDY (0.2FTE)			47,941		
PI BEAL RICHARDSON (0.2FTE)					19,404
PI MILLER (0.1FTE), Lead of the Fire Science Program, DBCA					17,373
PI BARNES (0.1 FTE), Research Scientist Decision Science, DBCA					11,875
PI BARBER (0.05FTE), Director, ArborCarbon					31,500
Research Associate 1 (1FTE, Y1-3) – Quantitative Ecologist in tree health and soil health	78,851			50,000	
Research Associate 2 (0.3FTE, Y1-3) Fire Ecologist	38,655				
Research Associate 3 (0.2FTE, Y1-5) – Social Scientist	25,770				
PhD 1 stipend (3.5 years) - soil and tree health		29,111			
PhD 2 stipend (3.5 years) - fauna		29,111			
Technician (0.2 FTE Y1-5 appointed at H0506)	20,601				
ESLICK (0.1FTE), Research Scientist, ArborCarbon					40,500

Equipment			26,600		
Field equipment			5,000		
Camera trap hire			21,600		
Maintenance	500	2,000	4,000		5,000
PhD 1 maintenance funding		1,000			
PhD 2 maintenance funding		1,000			
DBCA laboratory facilities					5,000
Laboratory consumables	500				
Plant pathology laboratory facilities			4,000		
Travel		9,000			
PhD 1 conference travel		1,500			
PhD 2 conference travel		1,500			
Conference travel (Fleming, Hardy)		6,000			
Fieldwork Expenses	5,000	12,000	10,000		24,000
Field travel - Perth to Mandurah return 150km x 100 trips pa @80c/km		12,000			
4WD vehicle access: \$10,000 pa in-kind (Y1-5)			10,000		
Follow-up weed control @\$5k/ha for grassy/bulbous weed control for 3 years for 4 of our 6 treatments (i.e. 4ha per replicate x 4 replicates =\$80,000)					20,000
Fieldwork accommodation.	5,000				
Remote sensing data capture					4,000

Year 4

Description	ARC	Admin Org		Partner Org	
	Cash	Cash	In-kind	Cash	In-kind
Total	52,687	47,424	110,978		129,652
Personnel	47,687	29,424	96,978		120,652
CI FLEMING (0.2FTE)			48,489		
CI HARDY (0.2FTE)			48,489		
PI BEAL RICHARDSON (0.2FTE)					19,404
PI MILLER (0.1FTE), Lead of the Fire Science Program, DBCA					17,373
PI BARNES (0.1 FTE), Research Scientist Decision Science, DBCA					11,875
PI BARBER (0.05FTE), Director, ArborCarbon					31,500
Research Associate 3 (0.2FTE, Y1-5) – Social Scientist	26,065				
PhD 1 stipend (3.5 years) - soil and tree health		14,712			
PhD 2 stipend (3.5 years) - fauna		14,712			
Technician (0.2 FTE Y1-5 appointed at H0506)	21,622				
ESLICK (0.1FTE), Research Scientist, ArborCarbon					40,500

Maintenance			4,000		5,000
DBCA laboratory facilities					5,000
Plant pathology laboratory facilities			4,000		
Travel		6,000			
Conference travel (Fleming, Hardy)		6,000			
Fieldwork Expenses	5,000	12,000	10,000		4,000
Field travel - Perth to Mandurah return 150km x 100 trips pa @80c/km		12,000			
4WD vehicle access: \$10,000 pa in-kind (Y1-5)			10,000		
Fieldwork accommodation.	5,000				
Remote sensing data capture					4,000

Year 5

Description	ARC	Admin Org		Partner Org	
	Cash	Cash	In-kind	Cash	In-kind
Total	54,002	18,000	106,978		124,652
Personnel	49,002		96,978		120,652
CI FLEMING (0.2FTE)			48,489		
CI HARDY (0.2FTE)			48,489		
PI BEAL RICHARDSON (0.2FTE)					19,404
PI MILLER (0.1FTE), Lead of the Fire Science Program, DBCA					17,373
PI BARNES (0.1 FTE), Research Scientist Decision Science, DBCA					11,875
PI BARBER (0.05FTE), Director, ArborCarbon					31,500
Research Associate 3 (0.2FTE, Y1-5) – Social Scientist	26,360				
Technician (0.2 FTE Y1-5 appointed at H0506)	22,642				
ESLICK (0.1FTE), Research Scientist, ArborCarbon					40,500
Travel		6,000			
Conference travel (Fleming, Hardy)		6,000			
Fieldwork Expenses	5,000	12,000	10,000		4,000
Field travel - Perth to Mandurah return 150km x 100 trips pa @80c/km		12,000			
4WD vehicle access: \$10,000 pa in-kind (Y1-5)			10,000		
Fieldwork accommodation.	5,000				
Remote sensing data capture					4,000

Partner Organisation

Organisation	Year 1		Year 2		Year 3		Year 4		Year 5	
	Cash	In-kind	Cash	In-kind	Cash	In-kind	Cash	In-kind	Cash	In-kind

CITY OF MANDURAH	50,000	247,579	50,000	57,642	50,000	39,404		19,404		19,404
DEPARTMENT OF BIODIVERSITY CONSERVATION AND ATTRACTIONS		34,248		34,248		34,248		34,248		29,248
ARBOR CARBON PTY LTD		76,000		76,000		76,000		76,000		76,000
Total	50,000	357,827	50,000	167,890	50,000	149,652		129,652		124,652
Committed Total	50,000	357,827	50,000	167,890	50,000	149,652		129,652		124,652

Part F - Budget Justification (LP190100295)

F1. Justification of funding requested from the ARC

(Fully justify, in terms of need and cost, each budget item requested from the ARC. Use the same headings as in the Description column in the budget at the Project Cost Part of this application. (Upload a PDF of no more than four A4 pages and within the required format))

Uploaded PDF file follows on next page.

F1. Justification of funding requested from the ARC

1. PERSONNEL. We request support for four positions (total 1.7FTE) – due to the intensity of work in the first year and as part of annual monitoring in subsequent years.

- 1) **Research Associate 1** (1FTE, Y1-3 Associate Lecturer Level A, Step 6) – **Quantitative Ecologist** in tree health and soil health with expertise in tree health and fauna assessment methods, project coordination. RA1 will work with Fleming to coordinate activities for the collection of biological data in years 1-3. This role will include establishing field sites. Their role is required to ensure that the outcomes are cohesive and remain applicable to management requirements. There will be seasonal recording of field data across multiple concurrent projects, meeting administrative requirements of the project (e.g. animal ethics reporting), and regular communication/working with a number of industries, governmental and non-governmental conservation agencies. They will also have the opportunity for assisting with student supervision. *Relevant skills* – quantitative ecology, fire ecology and social science, competence in the field, including extensive skills with animal trapping and handling, assessments of fuel load, data analysis and modelling, strong social and communication skills as they will be working alongside community and residents during this project. Ideally, they will have a good track record publishing in ecology. *Time commitment* – The RA will drive the day-to-day running of the project in terms of field and laboratory data collection. Their responsibilities include being the primary coordinator of field trials and day-to-day project management, coordinating and assisting with running field trials. Their participation is vital for the success of the project since we require coordinated field data collection across the parts of the programme of study. The RA will also work closely with ArborCarbon to ground-truth the remotely captured very high resolution (2.5 cm pixels) airborne imagery.
- 2) **Research Associate 2** (0.3FTE, Y1-3 Associate Lecturer Level A, Step 6) – **Fire Ecologist** with part-time contract to undertake the field assessments of fuel load and vegetation structural and composition changes, quantifying vegetation responses, and fire modelling and therefore calculation of hazard reduction measures. This role requires an expert in fire science who understands the methods and assumptions of fire mapping and modelling. They need substantial engagement with modelling methods and development of outputs based on the quantitative data collected. The fire ecologist will work closely with ArborCarbon and the remotely sensed airborne imagery across thermal and 10 spectral bands. This will enable robust 'ground-truthing' of the remotely sensed very high resolution (2.5 cm pixels) imagery. Models can then be built to enable future acquisitions of imagery across the City of Mandurah to be utilised across all of their bushland reserves for fire and biodiversity management.
- 3) **Research Associate 3** (0.2FTE, Y1-5 Associate Lecturer Level A, Step 6) – **Social Scientist** to coordinate stakeholder and community engagement and communications, design and coordinate social values assessment, and to ensure that results of this study will contribute to a Structured Decision Framework. This researcher will be responsible for co-ordinating a fully participatory Structured Decision-Making process over the full project period (Y1-5), which will comprise a range of stakeholder engagement workshops and other activities to clarify community and stakeholder objectives, co-design feasible alternative spatial and temporal management strategies, present and communicate interim findings and formally elicit stakeholder feedback as part of an iterative design and evaluation process, venues will be provided by City of Mandurah. Facilitation will be supported by PI Barnes. In Y1 and Y2 (~2 months each year), the social scientist will also design (including applying for human ethics approval) the social amenity survey and coordinate with the Mandurah City Council to disseminate it. City of Mandurah will cover all other costs associated with the deployment of surveys such as mailout, online tool development and delivery. In Y3, the Social Scientist will lead and publish analysis of the social amenity values. In Y4 the social scientist will evaluate the consequences of existing fire regimes and alternatives for which biological data has been collected to forecast social amenity value using quantitative modelling to forecast expected outcomes. In Y4 and Y5 the social scientist will be responsible for the development of educational workshops and training materials in collaboration with the City of Mandurah. The City will provide in-kind support from the education officer, as well as graphic design, printing and media. The Social Scientist would work with PI Barnes to lead an overall strategy evaluation to identify synergies and trade-offs across objectives.

F1. Justification of funding requested from the ARC

- 4) **Technician** (appointed at H0506 0.2 FTE in years 1-5). Field analyses of vegetation structure and composition are estimated to require 100 person days per year and will be carried out by the RA, PI Miller and CI Hardy assisted by a casually-appointed Technician. Professional Casual Rates at 9.5% Superannuation - In addition to occupational health and safety issues with regard to fieldwork, the field work requires multiple people to work in a coordinated manner. We can often use volunteers to assist with this work, but each new volunteer needs to have the system explained to them and differences in how people approach the work introduce inconsistencies in the data. We therefore request a small salary to pay (casually) and therefore commit a single technician as field assistant during the data collection phases of the project.

RA 2, RA 3, and the technician will be specifically contracted for intensive data collection periods. For all three RA positions, we have applied for appointment at Associate Lecturer Level A, Step 6, due to the high level of input that will be required, in terms of their intellectual input – there is a high level of technical, practical and intellectual input required from these positions in order to establish the field studies, supervise or carry out the field analyses, and analyse and interpret the data outputs. The employment of staff with an excellent research background, strong evidence of publications as first author, and knowledge of the latest theoretical advances in their research area is critical to the project since they will often be required to work independently and demonstrate their initiative, especially when working in the field. We expect that they will take a major role in the design and implementation of the fieldwork and surveys as well as be good at engaging with community participants and disseminating information to a broad audience. They will also be expected to undertake student supervision and expand upon the field studies outlined in the current proposal; training of research students requires that the person holds a higher degree (i.e. is a PhD graduate themselves). This level of responsibility warrants appointment at the proposed level.

Importantly for both RA 1 and RA2, ArborCarbon will be based on the Murdoch South Street Campus from January 2020. This will allow the Research Associate, CI Fleming and CI Hardy to interact very closely with ArborCarbon on a daily basis, or as required. It will also create further opportunities for other researchers at Murdoch and ArborCarbon to interact. For example, A/Prof. Fergus Sohler (a previous DECRA fellow) an expert in artificial intelligence and image processing, illustrates a research area where value adding could occur around the current project.

2. TEACHING RELIEF			\$0
3. EQUIPMENT			\$0
4. MAINTENANCE			
Laboratory consumables includes the costs of glassware, gloves, preservatives etc.		years 1-3	\$2,000
5. TRAVEL			
6. FIELDWORK EXPENSES			
Fieldwork accommodation. Our field sites require 2 hours travel and therefore we will require accommodation to ensure that we can access fauna trapping during early hours of the day and for the annual 5 weeks intensive vegetation surveys.		\$5,000 pa	\$25,000
7. OTHER			

F2. Details of Partner Organisation and other non-ARC contributions

(Provide details of how non-ARC contributions will support the project. (Upload a PDF of no more than two A4 pages and within the required format))

Uploaded PDF file follows on next page.

F2. DETAILS OF NON-ARC CONTRIBUTIONS

1. PERSONNEL	In kind OR <u>Cash contributions</u>	
CoM is providing \$150,000 cash that will contribute towards salary for RA 1. This cash contribution represents very substantial support for a Local Government Authority. Securing this cash contribution in the City's budget is demonstration of significant engagement with and commitment to this research project.	CoM	<u>\$150,000</u>
Salaries of the CIs and PIs as in-kind contributions:		
CI FLEMING (0.2FTE) will take over-all oversight of the overall project, supervise the PhD and Honours students and liaise directly with the Research Associates, as well as playing a lead role in the design and execution of this project, contribute to data analysis and interpretation, and development of communications.	MU	\$238,812
CI HARDY (0.2 FTE) will supervise the PhD and Honours students and liaise directly with the Research Associates, play a lead role in the design and execution of this project, contribute to data analysis and interpretation, and development of communications.	MU	\$238,812
PI BEAL RICHARDSON (0.2FTE) Senior Environmental Education Officer, Environmental Services, City of Mandurah. She will also ensure dissemination of research findings to the City and wider community. This project will also involve substantial contribution from four staff directly engaged with the fuel load reduction treatments each contributing 0.2FTE in year 1: Project Officer - Bushfire Mitigation, Coordinator Emergency Management, Senior Environmental Management Officer , and Environmental Management Officer . Furthermore, an Environmental Education Officer (0.2FTE) will be involved in surveys of public response to the treatments in years 1 and 2.	CoM	\$30,000
PI MILLER (0.1FTE) , Lead of the Fire Science Program, DBCA will contribute to experimental design, development of the fuel load reduction methodology, fuel load and vegetation structure data collection, analysis and interpretation working closely with the Fire Ecologist (RA 2) to ensure that the data are collected to appropriately analyse and model fire between experimental treatments and contribute to the development of communications.	DBCA	86,865
PI BARNES (0.1 FTE) , Research Scientist Decision Science, DBCA will lead the Decision Science aspects of this project, ensuring that the research objectives are clearly articulated at the start of the programme so that they can appropriately address Structured Decision Making goals.	DBCA	59,375
PI BARBER (0.05FTE) , Director, ArborCarbon and Collaborator ESLICK (0.1FTE) , Research Scientist, ArborCarbon will contribute their expertise in data analysis for remote sensing of our field sites. They will work with the quantitative Ecologist (RA 1) and Fire Ecologist (RA2). PhD scholarship (two 3.5 year Research Training Program Stipend Scholarships). The work that we have planned out to be conducted by the RAs, CIs and PIs will be complemented by work carried out under two PhD projects (PhD scholarships supported by Murdoch University). The PhD research projects are an excellent training opportunity, where the student can make a novel and substantial contribution to science that is intellectually challenging and provides opportunity for them to develop further and obtain ownership.	Arbor-Carbon	360,000
	MU	<u>\$201,025</u>
<p>PhD project 1: Soil biodiversity and function. Background. Fungi are an essential element of forest microbiomes, where they play a key role as pathogens, beneficial symbionts and decomposers. In particular, mycorrhizal fungi play critical roles in ecosystems and many woody plants would not exist without them. Benefits they provide include increased uptake of minerals and water through nutrient exchange (especially N+P use efficiency), resistance to plant pathogens, acquiring fixed carbon from plants and fixing it in soil [4], and improved drought tolerance. Previously, we have shown sites where trees are in decline, arbuscular mycorrhizal fungi (AMF) replace ectomycorrhizal fungi (EMF) [6,7]. Methods. (i) The student will compare mycorrhizal diversity and richness between fire and FLR treatments using high throughput sequencing (HTS) for root samples collected from the rhizospheres of four tuart trees per sample point. (ii) Soil nutrients will be determined for each sampling point, including all major macro and micronutrients, pH, exchangeable cations and total organic matter (loss on ignition). (iii) Soil microorganism activity will be analysed for each sample using total respiration methods. Team track record. We have carried out similar soil analyses in and around Mandurah in relation to tuart health (e.g. [11]), including the analysis of soil respiration [3], and have published high throughput sequencing methods for mycorrhizal diversity and richness (e.g. [8]), including studies within this ecosystem [6,7].</p>		

F2. DETAILS OF NON-ARC CONTRIBUTIONS

PhD project 2: Quenda responses to FLR treatments. **Background.** Quenda play a pivotal role in ecosystem processes (e.g. [9,10]) that contribute to maintaining vegetation health [5]. Quenda rely on availability of dense vegetation for cover during the day and predator refuge when foraging overnight [1]; their persistence of across the urban landscape is therefore closely reliant on vegetation management and these iconic mammals therefore act as a sentinel of habitat availability for other wildlife species. **Methods.** (i) The student will quantify activity indices for quenda through the presence of foraging digs and camera trapping surveys. (ii) they will quantify movement patterns and space use by tracking animals across the study sites to identify how they use the landscape. (iii) Combining tracking to identify vegetation structure preferred by quenda with the structure of readily-available nursery-recommended garden plant species will inform potential plant selection for residents. The ultimate outcome will be to contribute to the SERCUL 'Fertilise Wise and Grow Local Plants' guides available at <https://www.sercul.org.au/our-projects/fertilise-wise/> with information on quenda plant preferences that makes specific recommendations that consider the arrangement of garden plantings and the flammability of plant species. (iv) we will investigate the opportunity of providing refuge for quenda as a means of encouraging their retention in sites where the fuel loads have been manipulated. **Team track record.** We have published quenda survey results using foraging digs [2] and have a number of publications in preparation for other survey methods. The novelty of combining quenda biology with garden plantings will make a valuable community contribution.

3. EQUIPMENT

Field equipment: The westernWEB lab at Murdoch has access to animal trapping equipment (e.g. traps, bags, scales etc., \$2,000), field and camping equipment (Handheld GPS @ \$500, 4WD recovery equipment @\$1,000, Engel fridge @600).	MU	\$15,000
Camera trap hire. Access to Reconyx camera traps (valued at \$750 each). Camera trap surveys of each plot: 48 cameras (2 per plot) for 3 months for Y1-3 @\$5 per day per camera	MU	\$64,800

4. MAINTENANCE

PhD student maintenance funding. In addition to scholarships, our school supports maintenance funding (Y1 \$4,000, Y2 \$2,000, Y3 \$1,000); students are allocated dedicated desk and office space, and have access to software under university licences (e.g. ArcGIS).	MU	\$14,000
DBCA laboratory facilities. Kings Park Science and Kensington laboratory facilities incl. drying ovens, ecology/seed lab, seed stores, basic field equipment, field vehicles (\$5,000 pa for 4 y)	DBCA	\$20,000
Plant pathology laboratory facilities, including molecular laboratory for DNA extraction and the State Agricultural Biotechnology Centre (SABC) for sequencing (\$5 000 per year for 4 y)	MU	\$20,000

5. TRAVEL

PhD student conference travel	MU	\$3,000
Travel (Fleming, Hardy). Murdoch values research dissemination and is therefore supporting (cash) conference travel to ESA.	MU	\$24,000

6. FIELDWORK EXPENSES

Manual fuel load reduction work – staff, contractors, local residents – in year 1 to carry out the fuel reduction measures. This represents a substantial amount of in-kind directed specifically towards carrying out the fuel manipulations.	CoM	\$100,000
Follow-up weed control @\$5k/ha for grassy/bulbous weed control for 3 years for 4 of our 6 treatments (i.e. 4ha per replicate x 4 replicates =\$80,000)	CoM	\$80,000
Field travel - Perth to Mandurah return 150km x 100 trips pa @80c/km \$12,000 pa (Y1-5)	MU	\$60,000
4WD vehicle access: The westernWEB lab at Murdoch has a dedicated 4WD at discounted rate (half the rate of hiring vehicles from external sources). Furthermore, the costs of vehicle use can be off-set for student projects – this is the only way that wildlife projects involving substantial fieldwork can be undertaken, as the nominal maintenance funding for student projects would not cover these expenses.	MU	\$50,000
		\$10,000 pa in-kind (Y1-5)

7. OTHER

Survey of community responses to bushland amenity values	CoM	\$30,000
--	-----	----------

References. [1] Bryant, et al. (2017) *Urban Forestry & Urban Greening* 28:131. | [2] Bryant, et al. (2017) *Urban Forestry and Urban Greening* 28:131. | [3] Cai, et al. (2010) *Forest Ecology and Management* 260:1047. | [4] Clemmensen, et al. (2013) *Science* 339:1615. | [5] Fleming, et al. (2014) *Mammal Rev* 44:94. | [6] Ishaq, et al. (2013) *Mycorrhiza* 23:359. | [7] Ishaq, et al. (2018) *Aust Plant Pathol* 47:155. | [8] Tay, et al. (2018) *Aust Ecol* 43:742. | [9] Valentine, et al. (2017) *Austral Ecology* 42:265. | [10] Valentine, et al. (2018) *Funct Ecol* 32:2138. | [11] Wentzel, et al. (2018) *Australasian Plant Pathology* 47:521.

F3. Does this application request funding for research activities, infrastructure or a project previously funded, or currently being funded, with Australian Government funding (from the ARC or elsewhere)?

(This is a 'Yes' or 'No' question. If 'Yes' provide the project ID and outline the similarities of the research and explain how it will be managed.)

No

Funded Project ID

Outline the similarities and explain how these similarities will be managed if this application is funded. (No more than 2000 characters, approximately 285 words)

F4. Does this application request funding for research activities or infrastructure which are the subject of an application already submitted to the ARC?

(This is a 'Yes' or 'No' question. If 'Yes' provide the application ID and outline the similarities of the research.)

No

Provide the application ID

Outline the similarities and explain why more than one application has been submitted for the same research. (No more than 2000 characters, approximately 285 words)

Part G - Research Support and Statements on Progress (LP190100295)

G1. Research support for all participants

(For each participant on this application, provide details of:

i) current submitted ARC applications (i.e. for which the outcome has not yet been announced);

ii) any newly funded ARC Projects which are not yet showing in the participant's question (Currently held ARC Projects); and

iii) research funding from non-ARC sources (in Australia and overseas). For research funding from non-ARC sources, list all projects/applications/awards/fellowships awarded or requests submitted involving that participant for funding for the years 2018 to 2024 inclusive.)

Uploaded PDF file follows on next page.

ARC Proposals

Description (all named investigators on any ARC proposal in which a participant is involved, proposal title, scheme and round)	Same Research Area (Yes/No)	Support Status (Requested/Current/Past)	Application/ project ID	2019	2020	2021	2022	2023	2024	2025
				(\$'000)	(\$'000)	(\$'000)	(\$'000)	(\$'000)	(\$'000)	(\$'000)
Fleming, Hardy, Beal Richardson, Miller, Barnes, Parker, Barber. Alternative fuel load reduction methods for urban bushland. LP 2019	Y	R	LP190100295	NA	141	141	141	82	82	
Fleming, Hardy, Baudains Backyard Bandicoots: ecosystem engineers engage community in conservation. LP 2016.	Y	C	LP160100441	35						
Hardy, O'Hara, Howieson, McComb, Wickenden. Transition from phosphate mining to an economically, environmentally and socially viable agricultural industry on Christmas Island LP 2014	N	C	LP140100690	0						
Rymer, Hardy, Tissue, Byrne, Devoe Do hotter and drier regions harbour adaptive variation for climate change? LP 2015	Y	C	LP150100936	0	0					
Veneklaas, McGrath, Callow, Aitken, Miller, Malcolm, Stevens. Managing ecosystem change requires the integration of above and belowground hydrological processes at relevant scales. LP 2014	Y	P	LP140100736	0						
Whiteley, Dixon, Storer, Miller. Mine-site rehabilitation through novel plant and microbe interactions. ARC LP 2015	N	P	LP150101111	183						
Enright, Fontaine, Miller. Optimising fire management for a resilient future. LP 2016	Y	C	LP160100996	166	151	85				
Ooi, Keith, Cornwell, Lyons, Munoz-Rojas, Auld, Miller, Ruthrof, Gonzalez-Perez, Denham, Mackenzie, Cochrane, Yates. Beyond fire frequency: understanding fire season for ecosystem management. LP 2018	Y	C	LP180100741	-	108	180	190	100	25	

ARC Proposals

Cairns, Dempster, Bruce, Khachan,
Wong, Hughes, Aboutanios, Cetin,
Leon-Saval, Evans, Wu, Murphy, Held,
Li, Michaels, Antoniadis, Chamitoff,
Lawrence, Carr, Bongiorno,
Bachmann, Neudegg, **Barber**, Cocks,
Arsov
ARC Training Centre for Cubesats,
Uncrewed Aerial Vehicles, and Their
Applications

ARC Training Centre

Y

C

IC170100023

924

924

924

924

Funding from non-ARC sources									
Description (all named investigators on any ARC proposal in which a participant is involved, proposal title, scheme and round)	Same Research Area (Yes/No)	Support Status (Requested/Current/Past)	Application/ project ID	2019 (\$'000)	2020 (\$'000)	2021 (\$'000)	2022 (\$'000)	2023 (\$'000)	2024 (\$'000)
Collins, Barnes, Fleming , Miller. Welfare Indicator Dashboard; a pilot study for the live export supply chain. MLA and Livecorp	N	C	NA	170	110				
Fleming , Adams, Kreplins, Bateman, Whiting, Stuart (student). Predation of marine turtle nests and hatchlings by the red fox (<i>Vulpes vulpes</i>); understanding predator behaviour at marine turtle rookeries along the Pilbara Coast of Western Australia. Department of Parks and Wildlife	N	C	NA	8					
Fleming . Identifying alternate storage methods for baits. Department of Primary Industries and Regional Development (DPIRD)	N	C	NA	50					
Fleming . Identifying baits that are more attractive to wild dogs. DPIRD	N	C	NA	150					
Miller <i>Tetradlea erubescens</i> translocation research Mineral Resources Limited	N	C	NA	173	174	179	92		
Hardy , Burgess Improving avocado orchard productivity through disease management. AV16007 HIA	N	C	NA	187	125	63			
Hardy , Burgess, Dunstan Investigation into riparian vegetation decline, pathogenicity and soil influence. Department of Biodiversity, Conservation and Attractions	N	C	NA	27					
Bayliss, Hardy . Cold plasma treatment of postharvest strawberry pathogens. APC P1922 126	N	C	NA	15	15	15	15		
Burgess, Hardy . Pre- and post-emergent damping-off within rehabilitated and natural kwongan plant communities	N	C	NA	15					

G2. Statements on Progress for ARC-funded projects

(A progress statement must be provided for any currently funded ARC project that involves a participant on this application. This requirement applies to all ARC funding with the exception of ARC Centres of Excellence, Supporting Responses to Commonwealth Science Council Priorities, Learned Academies Special Projects and Special Research Initiatives grant opportunities. Refer to the Instructions to Applicants for further information. (Upload a PDF of no more than one A4 page for each project))

Project ID

LP160100441

First Named Investigator

Fleming

Scheme

Linkage Projects

Statement

Uploaded PDF file follows on next page.

Statement on progress Fleming, Hardy, Baudains 'Backyard Bandicoots: ecosystem engineers engage community in conservation' ARC LP 2016, Administering Organisation: Murdoch University

Personnel and timing changes

Project funded in 2016. Contracts signed in October 2016. Amanda Kristancic was appointed as Postdoctoral Research Fellow (1 Nov 2016); Amanda took maternity leave has returned part time on the project. Our timeline has consequently been extended (we successfully applied to the ARC for permission to extend). We have three PhD students (Janine Kuehs July 2016-, Natasha Tay 2017-, Pauna Truong 2017-) and two honours students (Monique Smith 2018, Joseph Casperz-Loney 2018/9) working on this project. This has been an excellent team of students who have each brought to their projects a diversity of skills and approaches.

Aims and success. To use an iconic ecosystem engineer to increase community involvement and engagement with conservation actions, contributing to increased connectivity and improved quality of urban bushland habitat.

Project objectives:

Aim 1. Identify how bandicoots ('quenda') contribute to healthy urban bushland through dispersal of mycorrhizal fungi. We successfully grew tuart seedlings inoculated with quenda scats, demonstrating that the inoculant is an excellent source of mycorrhiza spores under greenhouse conditions [1]. We expanded on this project with a similar trial, but have planted out the seedlings in a restoration site within the city. We will be harvesting our seedlings in 2019 to carry out microscopic and molecular analyses to determine whether the inoculation treatment has been successful.

Aim 2. Identify habitat use by quenda, using the latest technology to track and monitor animals. Janine Kuehs has carried out a camera trap survey of backyards and urban reserves as part of her PhD studies. This study has identified both quenda and stray/domestic cat movements through the urban matrix. Janine has also been tracking quenda through urban reserves and backyards to identify their use of available habitat resources. Amanda Kristancic and Catherine Baudains carried out an extensive survey of backyards, talking to residents and identifying where their properties are being used by quenda. Joseph Casperz-Loney is using the surveys to identify what people think of their marsupial co-inhabitants.

Aim 3. Increase community engagement with a local iconic species. Amanda Kristancic has been facilitating a link between the City of Mandurah (industry partner) and other local councils and community groups to increase community engagement with bandicoot conservation, e.g. Eastern Metropolitan Regional Council "quenda workshop" (March 2017), "MyPark Grooves", attended by 300+ local residents. We have been involved in multiple community events, all aimed at increasing community engagement with their local environment. e.g. Fungal Forays (each attracting between 25-30 residents, community members learned how to find native truffle-like fungi in the bush). The samples collected were set aside for future molecular work and as inoculant to be used in our Tuart Inoculation Experiment. We have also engaged with the media about our project, e.g. Mandurah Mail (January 2017) and launched a website to allow people to connect with our research and learn about quenda conservation.

Other. We have continued to publish work that has been supported under our collaboration with the City of Mandurah over last decade. This includes work carried out under ARC LP [2, 3] and funding through the WA State Government Centre of Excellence in Climate Change, Woodland and Forest Health [4-6].

1. Tay, Hopkins, Ruthrof, Burgess, Hardy, Fleming (2018) The tripartite relationship between a bioturbator, mycorrhizal fungi, and a key Mediterranean forest tree. *Aust Ecol* 43:742-751.
2. Wentzel, Craig, Barber, Hardy, Fleming (2019) Microbat responses to forest decline *Aust Ecol*
3. Wentzel, Craig, Barber, Hardy, Fleming (2018) Tuart (*Eucalyptus gomphocephala*) decline is not associated with other vegetation structure and composition changes. *Australasian Plant Pathology* In press:
4. Valentine, Bretz, Ruthrof, Fisher, Hardy, Fleming (2017) Scratching beneath the surface: Bandicoot bioturbation contributes to ecosystem processes. *Aust Ecol* 42:265-276.
5. Bryant, Kobryn, Hardy, Fleming (2017) Habitat islands in a sea of urbanisation. *Urban Forestry & Urban Greening* 28:131-137.
6. Valentine, Ruthrof, Fisher, Hardy, Hobbs, Fleming (2018) Bioturbation by bandicoots facilitates seedling growth by altering soil properties. *Funct Ecol* 32:2138-2148.

Project ID

LP160100996

First Named Investigator

Enright

Scheme

Linkage Projects

Statement

Uploaded PDF file follows on next page.

Project ID: LP160100996

Project Title: Optimising fire management for a resilient future

Chief Investigators: Prof Neal Enright ; Dr Joseph Fontaine ; Dr Ben Miller

Project Aims:

- 1) Identify the range of fire regimes (combination of interval and season) that optimise the persistence of native biodiversity in urban and peri-urban *Banksia* woodlands;
- 2) Determine the effect of varying fire interval on fuel loads, including with the contribution of invasive grassy weeds as fuels;
- 3) Quantify the importance of interactions between fire season, post-fire rainfall, weed abundance, and herbivore effects on the relationships of fire-interval and plant population persistence;
- 4) Validate the current best-practice juvenile-period approach to estimating tolerable fire intervals, and;
- 5) Provide unambiguous evidence to allow agencies to develop plans that balance the impacts and trade-offs of different fire management options.

Progress to date against Aims:

We have undertaken four years of pre-burn vegetation survey to date with sites subsequently burnt under the management of project partner Parks and Wildlife Service (PAWS). This is a 5- year project that comprises comparison of pre-fire vegetation attributes with post-burn attributes measured a few years subsequently. We are over half way through and have commenced the post-burn assessments. Results for aim 1 and 3 await completion of final post-burn surveys at the end of the project. A total of 69 pre-burn sites with known time since last fire have been surveyed: 50 were planned. We aimed to assess autumn versus spring fire season impacts, but no autumn fires have been implemented so the experiment will not achieve the seasonal comparison that we intended: we have supported this objective through a manipulative experiment (ms in prep) and a *TREE* review. Likewise, only 1/3rd of the 69 sites that we installed, selected with close planning with PAWS, have subsequently been burnt. Although the aims focus on the post fire recovery, the pre-fire dataset will provide some important ancillary outcomes. Primary among these is a model of fuel accumulation with time, an honours project has already completed using this data, and we have a ms based on the fuels data up to 2019. Results from this work have already been communicated with industry partners with great interest. Four PhDs are associated with the study, receiving some support and assisting with the field program. One of these completed in 2019, a second, focussing on the 4th aim is nearing completion.

Publications/Outputs:

1. Miller RG, Tangney R, Enright NJ, Fontaine JB, Merritt DJ, Ooi MKJ, Ruthrof KX, Miller BP (2019) Mechanisms of fire seasonality effects on plant populations. *Trends in Ecology & Evolution* **34**:1104-17
2. Tangney R, Merritt D, Fontaine J, Miller BP (2018) Seed moisture content as a primary trait regulating the lethal temperature of seeds. *Journal of Ecology*. **107**: 1093-105
3. Mason L, Bunce M, Miller BP, Wardel Johnson G. (2018) Ashes to ashes: intense fires extinguish populations of urban short-range endemics ... *Austral Ecology* **44**: 514-522
4. Saatkamp A, Cochrane A, [Miller BP, Miller RG,...Tangney R] *et al.* (2018), A research agenda for seed-trait functional ecology. *New Phytologist*. **221**: 1764-75
5. Tangney R, Merritt DJ, Callow N, Issa N, Miller BP (2018) Extensive spatiotemporal assessment of soil temperatures during an experimental fire using distributed temperature sensing in optical fibre. *International Journal of Wildland Fire*. **27**: 135-140
6. Huss JC, Schoeppler V, Merritt DJ, Best C, Maire E, Adrien J, Spaeker O, Janssen N, Gladisch J, Gierlinger N, Miller BP, Fratzl P, Eder M (2018) Climate-Dependent Heat-Triggered Opening Mechanism of *Banksia* Seed follicles. *Advanced Science*. **5**:1700572
7. Miller BP and Murphy BP (2017) Fire in Australian Vegetation. In Keith D (ed) *Australian Vegetation* (3rd ed). Cambridge Univ. Press. pp 113-134

Project ID

P140100736

First Named Investigator

Veneklaas

Scheme

Linkage Projects

Statement

Uploaded PDF file follows on next page.

Project ID: LP140100736

Project Title: Managing ecosystem change requires the integration of above and belowground hydrological processes at relevant scales

Chief Investigators: A/Prof Erik Veneklaas; Dr Gavan McGrath; Dr John Callow; Dr Alan Aitken; Dr Ben Miller; Mr Andrew Malcolm; Dr Jason Stevens

Project Aims:

- 1) Determine the roles of varying fire and management history, groundwater access, and climate in spatio-temporal patterns of tree decline and ecosystem change assessed since the 1930s
- 2) Identify how biotic and abiotic processes interact with the physiological function and demographic patterns of two tree species whose respective increase / decrease in abundance is driving ecosystem change.
- 3) Model trajectories of ecosystem change under varying management interventions & climate scenarios to develop a predictive understanding of change and determine appropriate management responses.

Progress to date against Aims:

This project commenced with the appointment of Research Associate, Dr Paul Drake, initially at 0.5 FTE, in May 2015. Dr Drake changed to a 0.9 FTE appointment from 1 July 2016. Fieldwork was completed mid-2018.

Monitoring of selected tree physiological variables and soil moisture has continued from Honours projects. Trees of three species have been measured in plots with contrasting landscape positions. At these same locations, sap flow equipment has revealed differences between species, which may relate to drought susceptibility. PhD student Pires (funded by a Brazilian scholarship) completed into the combined effects of heat and drought stress on major species.

Remote Sensing imagery was collected in March 2015. CI Callow worked with Partner Specterra Services Pty Ltd who have provided imagery across the period 2009-2015. Imagery and derived products were assessed against current and past BPGA datasets of tree mortality at two key field sites. Two Masters students were involved. Focus shifted to drone-based remote sensing, associated with physiological monitoring, exploring the usefulness of multispectral and thermal images to be correlated with physiological measurements.

Surveying of soil moisture with the electrical resistivity method was originally done at 2-month intervals along two 250 m long transects at the park, and is now recommencing to coincide with the drone flights and physiological monitoring. Unfortunately there were very large unseasonal rainfall episode (>100 mm) in February 2017 and January 2018, making these very atypical dry seasons, where severe late summer stress is poorly expressed. Stable isotope data, however, suggest differences in rooting depth, which are being followed up.

The Gravity monitoring programme commenced in March 2015. Observations were made at 2-month intervals. Each observation involves multiple re-occupation of all four sites over two survey days, each being an independent sample. Data showed clear seasonal patterns, and clear differences in rainfall storage between years.

Student completions and publication preparation are continuing.

Publications/Outputs:

1. Drake, P.L., de Boer, H.J., Schymanski, S.J. and Veneklaas, E.J. (2019), Two sides to every leaf: water and CO₂ transport in hypostomatous and amphistomatous leaves. *New Phytol*, 222: 1179-1187. doi:[10.1111/nph.15652](https://doi.org/10.1111/nph.15652)
2. Ruthrof KX, ...Miller BP... et al. (2018) Subcontinental heat wave triggers terrestrial and marine, multi-taxa responses. *Scientific Reports* 8: 13094
3. Callow N, P Drake, E Veneklaas, M Leopold, B Miller (2018) Hyper-spatial and hyper-temporal field ecohydrology: scaling park-plot-plant processes using an integrated satellite-airborne-drone-field-geophysics approach. *EGU General Assembly Conference Abstracts* 20, 7590
4. Teste FP, VA Marchesini, EJ Veneklaas, KW Dixon, H Lambers (2018) Root dynamics and survival in a nutrient-poor and species-rich woodland under a drying climate *Plant and Soil* 424: 91-102
5. Aitken A, C Adams, S Easton, B Miller, E Veneklaas (2018) Using Microgravity to Characterise Water Storage and Usage at Kings Park, Perth, WA. *ASEG Extended Abstracts 2018* 1, 1-6

Project ID

LP150101111

First Named Investigator

Whiteley

Scheme

Linkage Projects

Statement

Uploaded PDF file follows on next page.

Project ID: LP150101111

Project Title: Mine-site rehabilitation through novel plant and microbe interactions

Chief Investigators: Prof Andrew Whiteley; Prof Kingsley Dixon; Mr Paul Storer; Dr Ben Miller

Project Aims:

- 1) Initiate controlled Phytotron experimental screenings for seed emergence, survival and microbial colonisation within a range of soil:waste rock ratios, amended with novel biologically active seed dressings and biomineral fertilisers under controlled watering regimes. We will also use stable isotope (^{15}N) based analysis to investigate resource partitioning, particularly N within plants derived from labelled bio-mineral fertilisers to demonstrate active microbial nutrient cycling.
- 2) Transfer optimum combinations of substrate mix and bio-active treatments derived from controlled screening studies to large scale field conditions and comprehensively assess the development of belowground microbial community composition and functional gene traits, using high throughput DNA sequencing of the emerging microbial communities.
- 3) Synthesise both above and belowground community development data into a mechanistic framework to assess the optimum conditions of substrate composition, ameliorant addition and watering regime to provide the most reliable and effective rehabilitation practice.

Progress to date against Aims:

The focus of 2019 has been Isolation of beneficial microbes from Pilbara soil following experiments towards **WP1: Choosing the optimum fertilizer-microbe-watering regime for deployment to the Pilbara: Glasshouse trials**. Selection of key fast-growing planting species will be analysed in the Pilbara region in late 2019. In 2018/19 we assessed microbiome interactions with seed germination and possible methods of generating targeted seed inocula for effective germination and colonization of tailings systems with Pilbara-based native species. In 2017/18 we initiated the first major trial of native species (8) in a matrix of +/- fertilizer, with and without microbial inocula and under two simulated Pilbara watering regimes. A major experiment was performed to resolve out the hardiest of these species for rehabilitation (*Acacias*) and also indicated that the position of fertilizer in relation to the seed was critical to survival. If the fertiliser was in close proximity during germination, then success rates were low. If removed away from the seed, then germination, emergence and growth were enhanced. We further worked to resolve the interactions between native microbiomes and commercially available and amended microbiomes with *Acacia* seeds to assess whether native microbiomes can be manipulated to increase germination rates, or, whether exogenously added commercially available microbiomes can aid in germination in topsoil/tailings landforming simulations. These experiments yielded critical information that native plants likely require native microbiomes to aid in germination. In fact, the use of commercially available inocula actually reduced germination rates for the *Acacia* species tested, together with overall plant fitness, the effect exacerbated even further when nitrogen fertilizer was added. For the commercially available inocula, we detected select components of an added microbial inocula (e.g. *Pseudomonas*) became highly dominant within the system, when compared to native states, and likely led to antagonistic interactions with the seeds and an ultimate reduction in germination efficiency.

Using the information derived in 2018, we planned microbiome surveys of rehabilitation sites to determine key belowground pathways that are absent/present and needed for plant establishment, common native plants to assess what a suitable 'native' inocula may consist of and also to assess whether the use of 'weedy natives' to condition the planting substrates with Pilbara adapted microbes will yield success toward increasing germination rates and survival. In tandem, we also examined the physiology of 'Biocrusts', common in the Pilbara region, as a further source of microbial inocula to be incorporated into the microbiome screening/inocula trials.

Publications/Outputs:

1. Moreira-Grez B, Muñoz-Rojas M, Kariman K, Storer P, O'Donnell AG, Kumaresan D and Whiteley AS (2019) Reconditioning Degraded Mine Site Soils With Exogenous Soil Microbes: Plant Fitness and Soil Microbiome Outcomes. *Frontiers in Microbiology*. 10:1617.
2. Moreira-Grez Benjamin, Tam Kang, Cross Adam T., Yong Jean W. H., Kumaresan Deepak, Nevill Paul, Farrell Mark, Whiteley Andrew S. (2019) The Bacterial Microbiome Associated With Arid Biocrusts and the Biogeochemical Influence of Biocrusts Upon the Underlying Soil. *Frontiers in Microbiology*. 10: 2143 doi:10.3389/fmicb.2019.02143

Project ID

LP180100741

First Named Investigator

Ooi

Scheme

Linkage Projects

Statement

Uploaded PDF file follows on next page.

Project ID: LP180100741

Project Title: Beyond fire frequency: understanding fire season for ecosystem management.

Chief Investigators: Dr Mark Ooi; Prof David Keith; A/Prof William Cornwell; Dr Mitchell Lyons; Dr Miriam Munoz-Rojas; Dr Tony Auld; Dr Ben Miller; Dr Katinka Ruthrof; Dr Jose A. Gonzalez-Perez; Mr Andrew Denham; Mr Berin Mackenzie; Dr Jennifer Cochrane; Dr Colin Yates

Project Aims:

- 1) Identify how fire season has shifted and how a shift in the timing of fire interacts with fire frequency and habitat fragmentation
- 2) Explore landscape-scale effects of fire season on plant community diversity and species abundances
- 3) Experimentally assess fire season effects on soil properties, and plant survival and regeneration processes, and how these may interact with responses to other components of the fire regime for different functional groups
- 4) Determine which and how many threatened plant species are affected by seasonal shifts in the fire regime, in combination with other components of the fire regime, and
- 5) Develop an explicit framework for defining inappropriate fire regime thresholds beyond frequency alone, across different rainfall climates of temperate Australia. Progress to date against Aims:

Progress to date against Aims:

The project has only just been awarded and contracts with partners are yet to be signed. Hence work is yet to commence.

Nonetheless, three project collaborators have contributed to two papers in the journal *Trends in Ecology and Evolution* (*TREE*). One* is an output of ARC Linkage Grant LP160100996, but represents the commencement of collaboration among the new project team. In both cases, the work was commenced after the funding application had been submitted for this project, and both papers were submitted after its funding had been announced.

Publications/Outputs:

Keith, D.A. *et al.* (2019) Dispersal: the eighth fire seasonality effect on plants. *Trends in Ecology and Evolution* **in press**

- * Miller RG, Tangney R, Enright NJ, Fontaine JB, Merritt DJ, Ooi MKJ, Ruthrof KX and Miller BP (2019) Mechanisms of fire seasonality effects on plant populations. *Trends in Ecology and Evolution* **34**:1104-1117 [DOI:10.1016/j.tree.2019.07.009](https://doi.org/10.1016/j.tree.2019.07.009)

Project ID

LP150100936

First Named Investigator

Rymer

Scheme

Linkage Projects

Statement

Uploaded PDF file follows on next page.

Project ID: LP150100936. **First Named Investigator:** Dr Paul Rymer

Project Title: Do hotter and drier regions harbour adaptive variation for climate change?

Investigators: Rymer (WSU), Tissue (WSU), Hardy (MU), Byrne (DBCA), Lyon (FPC)

Project dates: Final contract signed Jan 2016. Extension granted to Feb 2020

Progress to date against Aims:

1) Characterise neutral and adaptive genetic variation.

Reduced representation genomic sequencing has been undertaken for two ecologically and economically important eucalypt species (Jarrah, Marri) with overlapping distributions in south-west Australia. Ahrens, Bryne, Rymer (2018) Molecular Ecology paper highlights high levels of gene flow among populations with adaptive genomic variants identified for temperature and rainfall in Marri. Training in genomic analyses has allowed for our PhD student (Fillipe) to develop key findings presented at an international meeting (Eucalypt Genetics 2019), and a draft manuscript for Jarrah is now being prepared for publication. A comparative genomic analysis is underway to test for parallel evolution to climate in these dominant eucalypts.

2) Estimate the heritability of plant functional traits in field trials.

Large scale quantitative genetic experimental trials have been used to estimate genetically-determined trait variation for Marri. Growth and disease resistance were found to be heritable traits with adaptive clines revealing fast growing, disease resistant, populations in the cool-wet region (Ahrens et al. 2018 Evolutionary Applications; EcoTAS 2017 meeting). Functional traits contributing to plant growth and drought response were found to have varying evolutionary potential and climatic responses, which may decouple co-ordinated traits and limit the capacity to respond to climate change (Ahrens et al. 2018 Ecology and Evolution). Our PhD student has been sampling leaf spectral signatures in these experimental trials throughout the hot-dry summers to characterise the dynamic response of plants from contrasting climate-origins.

3) Determine the physiological and molecular capacity to respond to drought.

We have conducted experimental manipulations to test the capacity of different populations to respond to heatwaves and droughts. The temperature response of photosynthesis and dark respiration showed a high degree of plasticity in cool-wet populations (Aspinwall et al 2017). Drought tolerance was greater in hot-dry populations and plants grown under warm conditions (Blackman et al 2017). The resistance and recovery to heatwaves of varying intensity provide evidence for a cost growing under warm conditions (Challis in prep). We reveal adaptive plasticity to drought in hot-dry populations exposed to chronic water limitation (Challis in prep; American Geophysical Union 2019). experiment completed.

Publications/Outputs

Blackman CJ, Aspinwall MJ, Tissue DT, Rymer PD, (2017) 'Genetic adaptation and phenotypic plasticity contribute to greater leaf hydraulic tolerance in response to drought in warmer climates', Tree Physiology, vol.37, no.5, pp 583-592

Aspinwall MJ, Varhammar A, Blackman CJ, Tjoelker MG, Ahrens C, Byrne M, Tissue DT, Rymer PD, (2017) 'Adaptation and acclimation both influence photosynthetic and respiratory temperature responses in *Corymbia calophylla*', Tree Physiology, vol.37, no.8, pp 1095-1112

Ahrens, C. W., M. Byrne, and P. D. Rymer. 2019. Standing genomic variation within coding and regulatory regions contributes to the adaptive capacity to climate in a foundation tree species. Molecular Ecology 28:2502-2516.

Ahrens, C. W., P. D. Rymer, A. Stow, J. Bragg, S. Dillon, K. D. L. Umbers, and R. Y. Dudaniec. 2018. The search for loci under selection: trends, biases and progress. Molecular Ecology 27:1342-1356.

Ahrens, Andrew, Mazanec, Ruthrof, Challis, Hardy, Byrne, Tissue, Rymer 2019 Plant functional traits differ in adaptability and are predicted to be differentially affected by climate change. Ecology and Evolution

<https://doi.org/10.1002/ece3.5890>

Eucalypt Genetics 2019 "Genomic variation and trait differentiation reveal signatures of selection in an Australian foundation tree"

EcoTAS 2017 symposium "Scientific basis for assisted migration under climate change"

AGU 2019 "Adaptive Plasticity in Plant Traits Delays Modelled and Observed Time to Critical Hydraulic Failure Under Drought in a Tree"

Project ID

LP140100690

First Named Investigator

Hardy

Scheme

Linkage Projects

Statement

Uploaded PDF file follows on next page.

Project ID: LP LP140100690: Transition from phosphate mining to an economically, environmentally and socially viable agricultural industry on Christmas Island

Chief Investigators: G. Hardy, G. O'Hara, H. Howieson, J. McComb

Partner Investigators: J. Wickenden and M. Hungria

Three disused minesites were prepared and used for broad-acre cropping and embedded experiments. This was undertaken together with MINTOPE (Mining to Plant Enterprises, funded through the Australian Government Department of Infrastructure and Regional Development, Christmas Island Phosphates and Murdoch University). A cereal crop (sorghum), and legume crops (lablab, cowpea, mung bean and soybean) were planted between January and April 2016 using agricultural techniques established for the ex-mine sites by MINTOPE. Sorghum was sown after the preceding crop of Highworth Lablab was ploughed into the soil as a green manure. Dry matter yield of the crop was estimated to be 8.9 tonnes/ha dry weight. Quadrat harvests of soybean produced a yield of 0.9 tonne/ha in September. However, the continuous and late rains (5000mm+ on Christmas Island in 2016) prevented a machine harvest of this crop. Mungbean yielded 1.2- 1.8 tonne/ha.

We have grown sorghum after a legume to utilize biological nitrogen, to do this we needed to understand its complete nitrogen requirements. Furthermore, the soils on the island naturally contain cadmium and other heavy metals, and thus finding methods of reducing plant uptake of these metals is critical. Maximum growth was reached at 160 kg/ha Urea. Initial analysis for heavy metal concentrations in leaf material showed that 40, 80, 120 and 160 kg N/ha treatments had significantly lower levels of cadmium than the control. Trials in 2017 will explore controlled release nitrogen fertilisers.

Research trials on a range of legumes showed that addition of potassium (80 and 160kg/ha) significantly increased plant biomass, enhanced root growth and mycorrhizal fungal colonisation rates of Lablab. Potassium amendment was also associated with significantly lower heavy metal levels. We hypothesise that heavy metals were either being diluted in a larger biomass and/or healthy plants can select against heavy metal uptake. However, we do not want this highly soluble fertilizer to wash into water drainage systems, so another research nutrient trial was established to investigate methods of increasing plant biomass and health using Lablab, using controlled release fertilisers (CRF). Our results revealed that 3 and 9mth CRF K₂SO₄ (Macrocrete®), and 160kg/ha K₂SO₄ (the traditional powder), significantly increased biomass compared with other treatments (40kg/ha K₂SO₄ 3 mth CRF KCl [Sulsync®] and the control). In addition, plants treated with the 3mth CRF KCl [Sulsync®], had significantly reduced heavy metal content compared with the traditional K₂SO₄ fertiliser powder. Thus, high biomass and reduced heavy metal uptake can be attained with appropriate specific fertilisers (Ruthrof et al. in prep –b).

A fungal survey has been completed, and a list of fungi has been compiled. Microbial prospecting was also undertaken to find a suite of endemic rhizobia species for use in agriculture, native rehabilitation and product development for the mining company. Authentication of these is underway.

Ph.D. student Luca de Prato has successfully shown industrial hemp can be grown on the island. He has completed a range of controlled phytotron experiments comparing tropical can temperate cultivars, for a range of growth, flowering and cannabinoid traits.

Outreach/ outputs:

- Visitors were given a tour of the crops, and provided with information on progress.
- Papers published to date (2 other in preparation. :
 - a- K.X. Ruthrof, J.B. Fontaine, A.J.M. Hopkins, M.P. McHenry, G. O'Hara, J. McComb, G.E.St.J. Hardy and J. Howieson (2017). Potassium amendment increases biomass and reduces heavy metal concentrations in *Lablab purpureus* after phosphate mining. Land Degradation Development, 1-10.
 - K.X. Ruthrof, E. Steel, S. Misra, J. McComb, G. O'Hara, G.E.St.J. Hardy, J. Howieson (2018). Transitioning from phosphate mining to agriculture: Responses to urea and slow release fertilizers for *Sorghum biocolor*. Science of the Total Environment 625, 1-7
 - J. Howieson, H. Calmy, N. Ballard, P. Skinner, J.W. O'Hara, L. Skinner, K.X. Ruthrof, R. Swift, V. Ballard, G.E.St.J. Hardy, M. P. Henry (2017). Bread from stones: Post-mining land use change from phosphate mining to farmland. The Extractive Industries and Society 4, 290-299
 - S. E. De Myer, K.X. Ruthrof, T. Edwards, A.J.M. Hopkins, G. Hardy, G. O'Hara, J. Howieson (2018). Systematic and Applied Microbiology 41, 641-649.

Project ID

IC170100023

First Named Investigator

Cairns

Scheme

Other ARC scheme

Statement

Uploaded PDF file follows on next page.

Project ID: IC170100023: The ARC Training Centre for CubeSats, UAVs, and Their Applications

Chief Investigators: Prof Iver Cairns, Prof Andrew Dempster, Dr Eleanor Bruce, A/Prof Joe Khachan, A/Prof KC Wong, A/Prof Roy Hughes, A/Prof Elias Aboutanios, Dr Ediz Cetin, A/Prof Sergio Leon-Saval, Dr Xiaofeng Wu, Dr Richard Murphy. **Partner Investigators:** Dr Bradley Evans, Dr Jason Held, Dr Weitang Li, Mr Paris Michaels, Mr Andreas Antoniadis, Prof Gregory Chamitoff, Prof Jonathan Lawrence, Dr Daniel Bongiorno, A/Prof Charles Bachmann, Dr David Neudegg, Dr Paul Barber, Dr Terry Cocks, Dr Kirco Arsov

The ARC Training Centre for CubeSats, Uncrewed Aerial Vehicles, and their Applications, otherwise known as CUAVA to represent our primary research areas (see the red letters), is making very good progress in training PhD and undergraduate students and postdoctoral fellows (as well as the entire collaboration's people), in solving our research problems, and progressing our work towards commercial outcomes. In particular, for the 2018 calendar year, which corresponds to the first year of CUAVA's existence, we started four PhD students (25% female) on CUAVA projects, attracted three others to start in calendar 2019 (67% female), and worked with eight advanced 3rd-4th year students and one advanced 1st-year undergraduate students on CUAVA research. In addition, we conducted hiring searches for four of CUAVA's five funded postgraduate fellows, appointing three in 2018 with one starting in 2019, and managed to leverage this funding with university teaching and other external funding so that external three of the four will be funded for either four or five years instead of the 2.7 years that CUAVA's total budget permits. This leveraging of funds is a theme in the funded PhD students as well, with RTP funds and an international tuition fee scholarship being used to maximise the number of students supported and reduce the number of CUAVA PhD stipends committed. The aim of this is to substantially increase the Centre's graduating PhD students beyond the 11 funded and to stimulate many undergraduate students to enter the broad space and UAV communities for the long-term, many in industry and many based long-term in Australia rather than overseas.

CUAVA's Chief Investigators, Partner Investigators, and students have made very good progress towards our research objectives, setting up several new research groupings, deepening collaborations, and bringing previously unlinked industry partners together in new ways. We have had a Centre Establishment Workshop, a Media Training Workshop, an Advisory Board meeting, approximately 10 Management Committee meetings, and over 50 small group meetings. Our people have presented multiple talks and posters at relevant meetings in Australia (including the Australian Space Research Conference or ASRC) and overseas, have published several papers, and are working hard to develop new research and commercialisation outputs. We engaged with the new Australian Space Agency at multiple meetings, including CEO Megan Clark and her 4 Executive Directors, and met the Honourable Karen Andrews, Commonwealth Minister for Industry, Innovation, and Science, and Dr Larry Marshall, CEO of the CSIRO. CUAVA Director Cairns was an Australian representative on an Asia Pacific Regional Space Agency Forum and with CUAVA Deputy Director Dempster, CI Aboutanios, and PI Lawrence has been extensively engaged with the NSW Department of Industry in discussions on how to develop NSW's space industry.

In 2018 CUAVA personnel collaborated on two ARC and 1 CRC-P proposals in new directions related to CUAVA, so far unsuccessfully, but received 2 verbal offers of funding related to our "CubeSat and UAV Systems" theme. We also started discussions on two new long-term international collaborations, one involving both student training and research with University Twente (Netherlands) and one primarily involving research and commercialisation with Vito, a Belgian company. We also found ways to deepen the student training and exchange aspects between partners USydney and Rochester Institute of Technology, both of which are likely to extend into benefits for partners ArborCarbon, DSTG, and HyVista.

The initial appointees to the positions of CUAVA's Research and Operations Manager and Training Centre Engineer had to leave unexpectedly for personal reasons, resulting in gaps of at least four months each that reduced our effectiveness and increased the burdens on the Director. However, the new Manager started in May 2018 and is excellent, while the new Engineer starts in mid-April 2018. CUAVA plans to launch one CubeSat into space and fly one UAV campaign per year, to test our new systems, instruments, and technical application solutions and our new services. The NDAs for accessing the special UAV services provided by one of our industry partners have taken a long time to develop, but the first one is now complete (March 2019). The first CubeSat project progressed reasonably well, with initial designs for the CUAVA payloads ready (including an advanced communications package, an advanced hyperspectral imager, an advanced GPS instrument, and two radiation counters, most of which have involved extensive discussion between university, industry, and government partners) and an initial agreement for launch developed with a Japanese start-up company Space-BD.

Outcomes for previous year: Recruited 3 PhD students with RTPs; Number of research outputs for last year: 1 journal article, 2 conference papers, 23 others (Conference presentations); \$110k Additional funding secured attributable to ITTC engagement

Part H - Partner Organisation Details (CITY OF MANDURAH)

H1. Is this a Partner Organisation whose funds are appropriated predominantly from Commonwealth or Australian State or Territory Government funding sources for the purposes of research?

No

H2. Type of Partner Organisation

(Is this Partner Organisation an Exempt Archive and Public Record Office, an Exempt Charity, an Exempt Herbarium, an Exempt Museum and Collecting Organisation, an Exempt Non-Profit Organisation, an Exempt Small Business or an Exempt Start-up? Please refer to sections 6.9 and 6.15 of the grant guidelines and the Instructions to Applicants for further information.)

No

Type of Exempt Organisation

H3. Attach a letter of support for this application including Partner Organisation certification

(Provide a Partner Organisation letter of support, signed by the CEO or delegate. Please refer to section 9.4 of the grant guidelines for details of the required content for this letter. (Upload a PDF of no more than two A4 pages))

Uploaded PDF file follows on next page.



Enquiries: Tony Free
Our Ref: R0002655103

16 December 2019

To Whom It May Concern

Support for Australian Research Council Linkage Project: Alternative fuel load reduction methods for urban bushland – Structured Decision Making comparing biodiversity and social outcomes for hazard reduction approaches

On behalf of the City of Mandurah, it is my pleasure to write a letter of support for Murdoch University's application for an Australian Research Council Linkage Project.

The City of Mandurah is a local government area located in the Peel region, 74 km south of Perth, Western Australia. Mandurah is one of Australia's fastest growing cities and is the largest regional city in the state. The management area lies within a recognised global biodiversity hotspot and the local community have highlighted the natural environment as one of Mandurah's most important assets.

The City of Mandurah has partnered with Murdoch University on environmental research for over a decade. Most recently, the City has been working with Murdoch on LP16010044 - Backyard Bandicoots: engaging community in urban bushland conservation. To build on the success of this project, the City of Mandurah and Murdoch University have developed an exciting and innovative project which aims to address the important issue of managing fire risk in urban bushland in a way that has minimal impact on flora and fauna. This addresses an important problem for the City (and local government more broadly) because managing bushfire risk is fundamental for the protection of property and lives.

As human population in Australia's cities grows, weeds spread, and increasingly hot and dry summers exacerbate fire risk and reduce windows for safe controlled burns, the issue of fire risk management for urban bushland is increasingly important. The activities outlined in the proposal will assist the City by providing decision support tools for complex urban bushland interface areas that consider the biodiversity, social and risk outcomes of fuel load reduction approaches.

There are a number of threatened ecological communities, such as tuart woodland and banksia woodland, and iconic fauna species present in Mandurah bushland that require special consideration for bushfire management. Such species include Quenda (*Isoodon fusciventer*), which play an invaluable role in maintaining ecosystem processes, and the Western Ringtail Possum (*Pseudocheirus occidentalis*). Mandurah's southern reserves are home to the most northern population of the western ringtail, which is Critically Endangered and recognised as a

vibrant, prosperous, connected and sustainable...a city excited about its future

3 Peel Street | PO Box 210 | Mandurah WA 6210
T (08) 9550 3777 | F (08) 9550 3888 | E council@mandurah.wa.gov.au
www.mandurah.wa.gov.au



threatened species protected under State and Commonwealth legislation. By partnering with Murdoch University to undertake this project, the City of Mandurah will be able to better manage reserves in a way that both reduces bushfire risk and protects these threatened species. As such, the City of Mandurah is pleased to support Murdoch University, and confirms the following cash and in-kind support for the project:

Total In-Kind Contribution (\$)	Total Cash Contribution (\$)	Source of Financial Contribution
\$363,433	\$150,000 (\$50,000 annually over three years)	Financial contributions in the form of cash contribution and yearly budget allocation will be sourced from the City's annual operational budget, subject to Council approval each year

The City of Mandurah's in-kind contribution includes the following:

- A Senior Environmental Education Officer salary at 0.2 FTE. This position will coordinate engagement across the research projects and act as a central liaison between City of Mandurah staff and Murdoch University. It will also support in the delivery of community surveying.
- Salary for the following officers at 0.2 FTE in Year 1 of the project. These positions will manage the planning and delivery of fuel load reduction activities and apply for relevant environmental permits:
 - o Project Officer – Bushfire Mitigation
 - o Coordinator Emergency Management
 - o Senior Environmental Management Officer
 - o Environmental Management Officer
- In-kind support from the City's Environmental Education Officer to assist with community surveying in years 1 and 2 of the project.
- In-kind support in the form of undertaking fuel load reduction activities and ongoing weed control.

I certify that no part of this City of Mandurah Cash Contribution is drawn from funds previously appropriated or awarded from Commonwealth or Australian State or Territory sources for the purposes of research.

I certify that this is not a commercial project and that intellectual property will be shared between the City of Mandurah and Murdoch University.

Kind Regards,

Tony Free
Director, Sustainable Communities

vibrant, prosperous, connected and sustainable...a city excited about its future

3 Peel Street | PO Box 210 | Mandurah WA 6210
T (08) 9550 3777 | F (08) 9550 3888 | E council@mandurah.wa.gov.au
www.mandurah.wa.gov.au

H4. Partner Investigator participating on this application for this Partner Organisation, where applicable

Mrs Bonnie Beal Richardson

Part H - Partner Organisation Details (DEPARTMENT OF BIODIVERSITY CONSERVATION AND ATTRACTIONS)

H1. Is this a Partner Organisation whose funds are appropriated predominantly from Commonwealth or Australian State or Territory Government funding sources for the purposes of research?

Yes

H2. Type of Partner Organisation

(Is this Partner Organisation an Exempt Archive and Public Record Office, an Exempt Charity, an Exempt Herbarium, an Exempt Museum and Collecting Organisation, an Exempt Non-Profit Organisation, an Exempt Small Business or an Exempt Start-up? Please refer to sections 6.9 and 6.15 of the grant guidelines and the Instructions to Applicants for further information.)

No

Type of Exempt Organisation

H3. Attach a letter of support for this application including Partner Organisation certification

(Provide a Partner Organisation letter of support, signed by the CEO or delegate. Please refer to section 9.4 of the grant guidelines for details of the required content for this letter. (Upload a PDF of no more than two A4 pages))

Uploaded PDF file follows on next page.



Department of Biodiversity,
Conservation and Attractions



*We're working for
Western Australia.*

Enquiries: Dr Ben Miller

Phone: (08) 9480 3600

Email: ben.miller@dbca.wa.gov.au

Director Linkage Program
Australian Research Council
GPO Box 2701
CANBERRA ACT 2601

Dear Sir/Madam

LETTER OF SUPPORT FOR ARC LINKAGE PROJECT LP190100295 ALTERNATIVE FUEL LOAD REDUCTION METHODS FOR URBAN BUSHLAND – STRUCTURED DECISION MAKING COMPARING BIODIVERSITY AND SOCIAL OUTCOMES FOR HAZARD REDUCTION APPROACHES

I am writing to confirm eligibility and support from the Western Australian Department of Biodiversity Conservation and Attractions (the Department) for the Australian Research Council Linkage Scheme proposal LP190100295 '*Alternative fuel load reduction methods for urban bushland – Structured Decision-Making comparing biodiversity and social outcomes for hazard reduction approaches*'. This five-year project would be administered by Murdoch University.

The Department is responsible for managing fire on lands under its care. This comprises approximately 29 million hectares of conservation lands including national parks, State forests and other reserves. The Department also contributes to bushfire risk management on 89 million hectares of unallocated Crown land and unmanaged reserves.

Under the WA Biodiversity Conservation Act (2016), the Department is also responsible for the management of biodiversity in WA, including 429 threatened plant species. Pertinent to this proposal, of these threatened species, 398 are from the Mediterranean-climate SW of the State. In addition to these listed threatened species a further 3368, 2032, and 66 taxa have conservation priority listing (respectively).

Alignment of Project with DBCA's Objectives and Strategic Plan

The Department has three relevant strategic plans: the Science Strategic Plan 2018-21; the associated, 3-year Science Program Plans (including the Fire Science Program Plan); and the Parks and Wildlife Service's Fire Management Strategy 2019-24. These documents demonstrate the complete alignment of the Project with the department's strategy which include intent to:

- Develop fire management that is supported by science, enabling evidence-based decision making and implementation of integrated fire management programs.
- Use fire management to maintain and enhance the diversity, health and resilience of the State's ecosystems.
- Undertake and support science to deliver the department's Strategic Directions for Biodiversity and Conservation, Natural and Cultural Values, Fire Management, Community and Partners, and our People.
- Undertake research to address knowledge gaps for threatened species and ecological communities, so that Biodiversity conservation and recovery programs are based on scientific knowledge.
- Undertake science to guide evidence-based decision making.

Biodiversity and Conservation Science
Department of Biodiversity, Conservation and Attractions
Locked Bag 104, Western Australia 6983
Web: dbca.wa.gov.au

- Understand effects of variation in fire regimes on species, ecosystems and landscapes.
- Understand interactions between fire regimes and other threatening processes, including climate change.
- All to ensure that best available scientific information is used for integrated fire management to protect communities and natural values.
- Collaborate with other science providers, government agencies, to undertake science where it is aligned with the department's strategic directions.

The DBCA staff included as Partner Investigators (Drs Ben Miller and Megan Barnes) will ensure the transfer and uptake of results and products from the Project into strategic science and management outcomes.

The Project creates a new collaboration between the Department and Murdoch University partners.

Cash and in-kind contributions to the Project from DBCA

I confirm that DBCA will provide contribution to the project to the value of \$ 166,000 as follows:

Total Contribution (\$)	In-Kind	Total Cash Contribution (\$)	Source of Cash Contribution
\$ 166,000 (\$29-34,000/yr.)		Nil	N/A

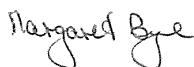
The in-kind contribution of \$166,240 consists of \$34,000 per year for 4 years and \$29,000 in a 5th year. It includes:

- Staff time (0.1 FTE) including 30 per cent on-costs for Principal Research Scientist Ben Miller as a Partner Investigator (\$17 373 per year) (expertise in fire and plant species response)
- Staff time (0.1 FTE) including 30 per cent on-costs for Research Scientist Megan Barnes as a Partner Investigator (\$11 875 per year) (expertise in decision science)
- Use of Kings Park Science and Kensington laboratory facilities: drying ovens, ecology/seed lab, seed stores, basic field equipment, field vehicles (\$5 000 per year for 4 years)

I certify that no part of the DBCA Cash Contribution is drawn from funds previously appropriated or awarded from Commonwealth or Australian State or Territory sources for the purposes of research.

I certify that DBCA will meet the requirements outlined in a standard ARC Funding Agreement, including the requirement to enter into arrangements regarding Intellectual Property which do not unreasonable prevent or delay academic outputs.

Yours sincerely



Dr Margaret Byrne
EXECUTIVE DIRECTOR

17 December 2019

H4. Partner Investigator participating on this application for this Partner Organisation, where applicable

Dr Ben Miller

Part H - Partner Organisation Details (ARBOR CARBON PTY LTD)

H1. Is this a Partner Organisation whose funds are appropriated predominantly from Commonwealth or Australian State or Territory Government funding sources for the purposes of research?

No

H2. Type of Partner Organisation

(Is this Partner Organisation an Exempt Archive and Public Record Office, an Exempt Charity, an Exempt Herbarium, an Exempt Museum and Collecting Organisation, an Exempt Non-Profit Organisation, an Exempt Small Business or an Exempt Start-up? Please refer to sections 6.9 and 6.15 of the grant guidelines and the Instructions to Applicants for further information.)

Yes

Type of Exempt Organisation

Exempt Small Business

H3. Attach a letter of support for this application including Partner Organisation certification

(Provide a Partner Organisation letter of support, signed by the CEO or delegate. Please refer to section 9.4 of the grant guidelines for details of the required content for this letter. (Upload a PDF of no more than two A4 pages))

Uploaded PDF file follows on next page.

ArborCarbon Pty. Ltd.
ABN 62 145 766 472
1 City Farm Place
East Perth, WA 6004
December 16, 2019

Enquiries: Mr Dirk Mitchell

16 December 2019

To Whom It May Concern

Support for Australian Research Council Linkage Project

On behalf of ArborCarbon, it is my pleasure to write a letter of support for Murdoch University's application for an Australian Research Council Linkage Project.

ArborCarbon was founded in Perth Western Australia in 2010 to bridge the gap between science and sustainable vegetation management. Over recent years our company has developed several exciting and innovative technologies for management of vegetation in cities, agriculture and natural environments, including a range of airborne imaging platforms and sensors. Although ArborCarbon is a small company our footprint is global with the establishment of a Hong Kong office and entity (ArborCarbon Hong Kong Limited) in 2017 and a shareholding in a UK based start-up (ArborFlight Ltd) 2016. We have been engaged by cities to accurately map and monitor their urban forests, including repeat quantitative measures of biodiversity and bushland condition, and remote detection of dead wood. These capabilities provide an opportunity to researchers within this project to utilise innovative technologies and datasets previously not accessible.

Our clients span many sectors including:

- Government e.g. Hong Kong Highways Department (HK), Florida Keys Mosquito Control (USA) Main Roads WA, Department of Primary Industries and Regional Development, Cities of Melbourne, Sydney, Adelaide and Perth.
- Resources e.g. Roy Hill, Global Advanced Metals Wodgina.
- Private e.g. Santanol, ARC Infrastructure, Moora Citrus, ArborCulture (SIN), TeRoroa Group (NZ).
- Universities (Murdoch University, UWA).

This project will provide an opportunity for ArborCarbon to actively engage with The Department of Fire and Emergency Services (DFES) in the use of airborne remote sensing and analytics for very high-resolution measurement of bushland condition and fuel loads. It will also enable us to ground validate very high-resolution imagery from our manned aircraft mounted ArborCam sensor mounted and develop new applications for the data derivatives. Although we have existing partnerships with City of Mandurah and Murdoch University, this project will expand upon these by formally engaging with new personnel within these institutes.

ArborCarbon's four core values include: Partnership, Innovation, Expertise and Sustainability. This project includes the partnership of several organisations and will facilitate new partnerships (e.g. DFES) for ArborCarbon. The research is innovative in using a combination of very high-resolution imagery from our

a: PO Box 106, Willagee Central, WA, 6156 | **w:** arborcarbon.com.au | **p:** +61 8 9467 9876 | **e:** p.barber@arborcarbon.com.au

airborne ArborCam sensor along with recently developed machine learning methods for detection of dead wood, measurement of fuel loads, and quantitative measurement of vegetation condition. We will utilize a wide range of expertise across industry, government and research sectors, and through co-supervision of researchers hopefully provide a pathway for researchers to work with our company building our expertise. Finally, the development of robust methods for remote measurement of biodiversity and bushland condition, and measurement of fuel loads and fire risk has the potential to reduce resources and improve management outcomes therefore aligning with our fourth core value of sustainability.

ArborCarbon confirms the following in-kind support for the project:

Total In-Kind Contribution (\$)	Total Cash Contribution (\$)	Source of Financial Contribution
\$76,000pa for 5 years Total \$380,000	\$0	NA

's in-kind contribution includes the following:

- Salary for PI Paul BARBER, Director, at 0.05 FTE over the 5 years of the project (\$157,500) for data analysis.
- Salary for Collaborator ESLICK (0.1FTE), Research Scientist, at 0.1 FTE over the 5 years of the project (total \$202,500) for data analysis.
- We are also contributing in-kind support (total \$20,000) in the form of facilitation of remote sensing data capture.

I certify that this is not a commercial project and that intellectual property will be shared between the project partners.

Sincerely,



Paul Barber BSc PhD
Managing Director
ArborCarbon Pty Ltd

H4. Partner Investigator participating on this application for this Partner Organisation, where applicable

Dr Paul Barber

Certification

Certification by the Deputy/Pro Vice-Chancellor (Research) or their delegate or equivalent in the Administering Organisation

I certify that—

- I have read, understood and complied with the *Grant Guidelines for the Linkage Program (2018)*, *Linkage Projects For funding applied for in 2019* (the grant guidelines) and, to the best of my knowledge all details provided in this application form and in any supporting documentation are true and complete in accordance with the grant guidelines.
- Proper enquiries have been made and I am satisfied that the participants and the organisations listed in this application meet the requirements specified in the grant guidelines.
- I will notify the ARC if there are changes to any named participant or organisation after the submission of this application.
- The listed participants are responsible for the authorship and intellectual content of this application, and have appropriately cited sources and acknowledged significant contributions to this application.
- To the best of my knowledge, all Conflicts of Interest relating to parties involved in or associated with this application have been disclosed to the Administering Organisation, and, if the application is successful, I agree to manage all Conflicts of Interest relating to this application in accordance with the *Australian Code for the Responsible Conduct of Research (2018)*, the *ARC Conflict of Interest and Confidentiality Policy* and any relevant successor documents.
- I have obtained the agreement, attested to by written evidence, of all the relevant persons and organisations necessary to allow the project to proceed. This written evidence has been retained and will be provided to the ARC if requested.
- This application complies with the eligible research requirements set out in the *ARC Medical Research Policy*, located on the ARC website.
- This application does not request funding for the same research activities, infrastructure or project previously funded or currently being funded through any other Commonwealth funding.
- If this application is successful, I am prepared to have the project carried out as set out in this application and agree to abide by the terms and conditions of the grant guidelines and the *Grant Agreement for the Linkage Program (2018)*, *Linkage Projects for funding applied for in 2019*.
- The project can be accommodated within the general facilities of this organisation and if applicable, within the facilities of other relevant organisations specified in this application and sufficient working and office space is available for any proposed additional staff.
- All funds for this project will only be spent for the purpose for which they are provided.
- The project will not be permitted to commence until appropriate ethical clearance(s) has/have been obtained and all statutory requirements have been met.
- I consent, on behalf of all the parties, to this application being referred to third parties, including to overseas parties, who will remain anonymous, for assessment purposes.
- I consent, on behalf of all the parties, to the ARC copying, modifying and otherwise dealing with information contained in this application.
- To the best of my knowledge, the Privacy Notice appearing at the top of this form has been drawn to the attention of all the participants whose personal details have been provided in the Personnel section.
- To the best of my knowledge, the Partner Organisation(s) involved in this application are solvent at the time of submission of this application.