Department of
Biodiversity, Conservation and Attractions

Biodiversity and Conservation Science Annual Report

2023-2024

Department of **Biodiversity, Conservation and Attractions**

GOVERNMENT OF WESTERN AUSTRALIA

Biodiversity and **Conservation Science**

Executive Director's Message

Biodiversity conservation and nature-based tourism are key aspects of our departmental service delivery, and our consolidated Biodiversity and Conservation Science function continues to provide the scientific excellence required to support business areas across the agency to achieve the Department's Strategic Directions 2022-2025 and the Government priorities.

I am proud to present our Biodiversity and Conservation Science report for 2023-24, which highlights the world-class applied science that Biodiversity and Conservation Science delivers for conservation of our diverse plants, animals and ecosystems, effective management of our parks and reserves, delivery of our fire management program, and engagement of visitors with our natural attractions. Our integrated science function continues to deliver the Government's commitment to build and share biodiversity knowledge to support conservation and nature-based tourism in Western Australia. The biodiversity knowledge we have informs our current management, and our research generates new knowledge and understanding so we are prepared for future management endeavours. We foster innovation in partnership with managers and science users to develop scientific knowledge and ensure effective translation to solve the challenges we face today, and to inform our approaches to management in the future.

Our collaborative and innovative science supports the current priorities of the department and Government in providing knowledge and advice for delivering Plan for Our Parks, the Aboriginal Ranger program, joint management arrangements, response to climate change, renewed forest management. and our nature based tourism ventures The combined challenges of climate change and biodiversity decline, and the innovative science required to assist in addressing these issues are becoming more strongly recognised in our society and by governments. We are undertaking science required to inform response to these issues through our climate adaptation research on threatened species and ecological communities, research and monitoring for forest and fire management in a drying climate, investigating plant responses to the drought conditions experienced over summer, and spatial data to contribute to effective regional planning. Other highlights of our scientific achievements this year include recovery actions for critically endangered flora, spatial modelling to understand expansion of invasive species under different climate scenarios, use of drone mounted instruments to enable consistent, repeatable analysis of ecological components in wetland, forest and Pilbara environments, surveying and estimating dugong abundance in partnership with Malgana people, successful artificial rearing of Margaret River hairy marron and genetic analysis to determine relatedness of captive individuals, breeding animals for release to improve wild populations, establishment of seven mammals and a bird through fauna reconstruction at Dirk Hartog Island, survey with joint managers at Badamia, and further enhancements to our biodiversity data repository and data management systems.

Our internal and external collaborations and partnerships extend and strengthen our work. We continue to work collectively with conservation staff in the Parks and Wildlife Service, and at Kings Park and Botanic Garden, Perth Zoo and Rottnest Island, to ensure our science is targeted and relevant for management. We engage with a wide range of external partners at universities, CSIRO, NGOs, WABSI, WAMSI, the National Environmental Science Program hubs and across industry, to ensure we are engaged with new initiatives and innovative approaches. Our wide-ranging science includes co-supervision of many Honours, Masters and PhD students and we value these opportunities to work with and inspire future scientists. We were very pleased to be part of a recent international collaboration mapping the angiosperm tree of life that was published in *Nature*, and a national collaboration that was a finalist in the Eureka Awards for Environmental Research.

Biodiversity and Conservation Science provides innovative science through the technical expertise and capability of our science staff and the excellent support of our administration staff. The challenges we are facing as a society are impacting all of us and our staff continue to show their professionalism and support for each other in the face of these ongoing challenges. Collectively, we are continuing to recognise and develop our people and knowledge leadership capabilities, foster inclusion and diversity, and bringing open mindsets to maximise our collaborative and innovative approaches.

We will continue to engage with all our partners to provide scientific excellence and innovation to support the department's functions and contribute to delivery of the biodiversity science priorities for Western Australia. The scientific innovations we generate and the biodiversity knowledge we provide is fundamental to ensuring the unique biodiversity we have around us is conserved and protected, and is valued and appreciated through our natural attractions.

Dr Margaret Byrne
Executive Director, Biodiversity and Conservation Science
October 2024

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Service Delivery Structure

Biodiversity and Conservation Science

Executive Director

Dr Margaret Byrne

Assistant Director Science

Katrina Walton

Leader Science Coordination

Rory McAuley

Business Manager

Natasha Omelchuk

Leader Biodiversity Knowledge

Sue Waite

Programs

Animal Science

Lesley Gibson

Plant Science and Herbarium

Carl Gosper

Ecosystem Science

Adrian Pinder

Species and Communities

Ruth Harvey

Fire Science

Ben Miller

Marine Science

Tom Holmes

Perth Zoo Science

Harriet Mills

Kings Park Science

Jason Stevens

Biodiversity Information Office

Rob Cechner

Remote Sensing and Spatial Analysis

Katherine Zdunic

Rivers and Estuaries Science

Kerry Trayler

Animal Science

Program Leader: Lesley Gibson

Applied research undertaken by the Animal Science Program seeks to understand the factors and processes critical for conserving Western Australia's rich and unique native fauna. The major objectives of the program are to ensure the persistence of threatened species through local and landscape-scale management actions, including reducing key threats such as predation by foxes and feral cats, inappropriate fire regimes, competition and predation by introduced rodents on islands, as well as assessing cane toad impacts and reconstructing the fauna of rangeland and arid areas.

Building resilience to change for mammals in a multi-use landscape: identifying refugia and landscape connectivity for small mammals in the Pilbara

SP-2021-8

K Ottewell, L Gibson, M Byrne, J Kinloch, K Zdunic, B Huntley

Context

To promote species' resilience over vast landscapes, long time-scales and under current rates of environmental change, it is essential for best-practice conservation strategies to: (i) identify historical refugia, areas that offer temporally and climatically stable habitat that species can retreat to, persist in and expand from under changing environmental conditions; (ii) protect key habitat in species' current distributions; and (iii) promote population connectivity to maintain metapopulation viability and to retain species' evolutionary potential.

Spatio-temporal landscape genetics, combined with Species Distribution Modelling (SDM), offers a novel approach to multi-species conservation planning. This project will provide current and historical insight into how small-medium sized mammals use the Pilbara landscape, providing information for conversation actions and habitat management. Therefore, this project is significant in bringing together key government and industry stakeholders engaged in conservation management in the Pilbara. Furthermore, the framework developed for integrating these findings into conservation priorities will be applicable for conservation management, globally.

Aims

- Locate core habitat and connectivity pathways (corridors) for species under current environmental conditions by modelling habitat suitability and contemporary gene flow.
- Locate key areas for persistence under changing climatic conditions by inferring locations of evolutionary refugia from population genomic data and spatial modelling of range dynamics under historical and predicted future environments.
- Identify strategies to enhance and protect these areas for optimal combinations of threatened and non-threatened species conservation.

Progress

- A manuscript is in preparation describing core-habitat for 19 mammal species (identified with SDM), as well as species richness and identification of guilds of small-medium-sized mammal species in the Pilbara.
- Genetically informed connectivity modelling across eight small-medium sized mammal species was completed, revealing that dispersal in rocky specialists was less restricted than for generalists and sand specialists across the Pilbara landscape.

Management Implications

- Identification of environmental variables that underpin core habitat for Pilbara small-medium sized mammal guilds is providing insight into species ecology and enables conservation efforts to be guided toward areas that benefit multiple species.
- The Fortescue Marsh is indicated as a major dispersal corridor for generalist and sand specialist small-medium sized mammals suggesting targeted conservation efforts in this region will assist in maintaining connectivity and gene flow amongst populations of these species.
- The generation of high-resolution genetic data for eleven mammal species, including four species listed as threatened under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), has assisted in the detection of historical refugia, key dispersal corridors, genetic diversity hotspots and potentially locally adapted populations that may act as foci for conservation protection.
- The spatial-genetic maps generated in this project are being made available to a range of end users to assist in various conservation-related activities, including assessment of development impacts in the Pilbara, survey planning for conservation translocations and fire management.

Future Directions

- Finalise manuscripts for the multispecies population genetics study, the refugia and population expansion study and the multi-species SDM/species richness and landscape connectivity results.
- Continue to disseminate decision-support spatial products to stakeholders in the Pilbara as required.

Distribution and conservation status of the heath mouse (*Pseudomys shortridgei*) in Western Australia

SP-2021-46

L Gibson, S Cowen

Context

The heath mouse *Pseudomys shortridgei* (50-80g) is one of several native rodent species that have declined in distribution and abundance since European colonisation. Originally collected in 1906 near Pingelly in WA's wheatbelt, the heath mouse was thought to be extinct in WA until its rediscovery in 1987. Until 2019, the last confirmed record of the heath mouse in WA was in 2004, from Lake Magenta. Targeted surveys in 2019 resulted in their detection at two locations, confirming that the heath mouse was still extant in WA. Further surveys in 2020 failed to detect the species despite sampling in areas where they had previously been recorded. As there is evidence of a significant decline in the distribution and abundance, further targeted survey is critical to determine the current conservation status of the species in WA and inform recovery action.

Aims

- Establish the current range and conservation status of heath mouse in WA.
- Identify populations that may be suitable for ongoing monitoring.
- Assess the possibility of sourcing heath mice for a captive breeding colony to provide founders for reintroductions.

Progress

- Extensive camera trap surveys were implemented at 210 sites at Lake Magenta between October 2023 and May 2024. Data from these cameras has not be fully processed but heath mice were detected at a small number of sites and these were then targeted with Elliott trap surveys. No heath mice were captured during these surveys.
- Vegetation condition surveys were carried out at four sites in May 2024 in areas where heath mice were detected in 2024 and in the early 2000s. Data from these surveys have not yet been analysed but the indications are that plant mortality is not significant in these areas. This is supported by remote sensing

data, which found no evidence of significant mortality in heath mouse habitat at a landscape scale across the reserve.

Management Implications

- The presence of heath mice has been confirmed at a number of sites at Lake Magenta, but they appear to be at very low density, making an assessment of their conservation status challenging.
- Camera surveys have proved useful in assessing the presence of heath mice and this species can be discriminated from other small mammals that occur at Lake Magenta. Camera surveys provide a useful baseline by which to assess the effectiveness of management actions but ongoing surveys are required to evaluate the recovery of heath mouse and other native mammals at this reserve.
- Significant vegetation senescence was not detected at the sites surveyed and there was no evidence from remote sensing data, suggesting that habitat for the heath mouse remains suitable.
- Management of introduced predators (foxes and feral cats) is likely to be important to facilitate recovery of the species.

Future Directions

- Further camera surveys at Lake Magenta will help to better assess the status of heath mice (and other native mammals) in the reserve, including responses to feral cat management.
- The use of cameras to assess the presence of heath mice at other reserves where they have previously been recorded such as Dragon Rocks Nature Reserve could be considered.
- Novel detection methods (e.g. eDNA, detection dogs) may be an option to support surveys for heath mice, especially while they occur at such low densities.

Genetics of Pilbara threatened bats

SP-2021-24

K Ottewell, D Prada, R Sun, L Umbrello, R Shaw, M Millar

Context

The orange leaf-nosed bat (*Rhinonicteris aurantia*) and the ghost bat (*Macroderma gigas*) were both once widespread across Australia but are now restricted to patchily distributed habitat across northern Australia. Isolated populations occur in the Pilbara bioregion, where a distinct form of the orange leaf-nosed bat is recognised (hereafter Pilbara leaf-nosed bat). Both species are considered to be declining in the Pilbara, being highly threatened by habitat loss through mining activity, and are consequently recognised as vulnerable under State and Commonwealth environmental legislation. Genetic analyses are providing insight into landscape-scale and fine-scale patterns of genetic structure and connectivity in these species. The development of novel genetic techniques for non-invasive monitoring of ghost bats is providing rich insights into roost occupancy patterns and animal movement. Further research is required to address priority knowledge gaps for the species, including estimation of population size and identification and characterisation of critical habitat for each species.

Aims

- Understand the historical and contemporary genetic diversity and landscape-scale genetic structure of Pilbara bat species.
- Understand the fine-scale patterns of genetic connectivity of bat populations and sex-biased dispersal.
- Undertake SNP genotyping of non-invasive samples for genetic monitoring of ghost bat populations.
- Undertake development and refinement of mark-recapture analyses to assist development of standard monitoring protocols.
- Integrate genetic, spatial and distributional data to identify and understand critical habitat for Pilbara bat species.

Progress

- Mitochondrial and microsatellite analysis of the Pilbara ghost bat has been completed.
- Four genetic monitoring reports for Pilbara ghost bats have been completed for industry.
- Two manuscripts have been published for the ghost bat, including a literature review of survey and management approaches in *Journal of the Royal Society of Western Australia* and development of the MassArray SNP panel in *Scientific Reports.*

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- Close-kin and DnaDot methods have been investigated to derive population estimates from mark-recapture data from non-invasive genetic monitoring.
- Assembly and annotation of the ghost bat genome is being finalised in collaboration with University of Sydney.
- Species distribution modelling based on roosting and foraging data has been completed for the ghost bat and is near completion for the Pilbara leaf-nosed bat.
- A combined genetic assessment of the Pilbara leaf-nosed bat and orange leaf-nosed bat is being investigated using SNP sequence data from multiple projects.
- A review of research outcomes and management options for both ghost bats and Pilbara leaf-nosed bats was completed.

Management Implications

- Genetic analysis of non-invasively collected samples and refinement of robust mark-recapture protocols for the ghost bat will assist monitoring of abundance and population trajectories, enabling better assessment of development impacts and/or mitigation approaches for the species.
- Species Distribution Models (SDM) will assist in identification of critical roosting and foraging habitat for both bat species to inform development guidelines as well as providing a guide for targeted surveys.
- Range-wide genomic analysis of orange leaf-nosed bat will assist in resolving the taxonomy of the species, including the identity of the Pilbara form.

Future Directions

- Complete publication of manuscript on population genetic structure of ghost bats.
- Undertake ghost bat genetic monitoring projects as requested.
- Complete draft manuscript on mark-recapture approaches for ghost bats.
- Complete ghost bat genome and transcriptome assemblies in collaboration with University of Sydney.
- Complete SDM for Pilbara leaf-nosed bat and finalise manuscript.
- Complete range-wide genomic analyses of orange leaf-nosed bat.

Ecology, threats and monitoring of the Pilbara olive python (*Liasis olivacea barroni*)

SP-2020-6

D Pearson

Context

The Pilbara olive python (*Liasis olivaceus barroni)* is a threatened species confined to the Pilbara and adjacent northern part of the Gascoyne IBRA region. Little is known about its ecology, habitat preferences and conservation threats. It is an introduced predator consuming a diet of large birds, reptiles and mammals as an adult, including other threatened species such as northern quolls. A number of potential threats confront Pilbara olive pythons, but their relative importance is not understood. They include the loss of important prey items due to exotic predators; habitat loss and modification from mining activities and infrastructure development; and on a local scale, increases in road kills by vehicular traffic due to resource projects and tourism. The project will resolve some of the unknown life history parameters important for conservation of this species and for effective population monitoring. In particular, research will focus on important habitat elements, the reproductive cycle of the species and the predation of juvenile snakes.

Aims

- Collate and publish existing information on Pilbara olive python biology and management, including the proceedings of a 2013 workshop.
- Document the ecology of Pilbara olive pythons focusing on habitat preferences and life history characteristics (diet, shelter sites, juvenile mortality, reproductive frequency, etc.) likely to be influential in population dynamics and impacted by threats such as wildfire, grazing and mining activities
- Undertake experiments to determine threats to juveniles, the population cohort likely to be most affected by feral animal predation and habitat changes due to fire or grazing.
- Trial and improve existing and novel survey and monitoring techniques to enable more effective assessment and mitigation of potential impacts of resource projects and other land uses on Pilbara olive pythons.

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Progress

- Radio-telemetry at Millstream-Chichester National Park study site has collected data on habitat use, home ranges and dietary preferences. A total of 18 Pilbara olive pythons have been surgically implanted with radio-transmitters.
- Detailed daily radio-tracking has been carried out during the breeding season (June-August) at Millstream to document this unknown aspect of the life history.
- Searches have continued at a second study site in Karijni National Park/Tom Price, but no pythons have been captured to date.
- A paper on the taxonomic position of the Pilbara olive python is in final draft.

Management Implications

- Radio-telemetry data from the last year further indicate the importance of riparian and wetland habitat for olive pythons over the summer months and elevated rocky areas during the winter months. This information has been shared with regional fire and nature conservation staff so that aerial and ground-based burning in these areas is implemented to achieve mosaic patches.

Future Directions

- Ongoing radio-telemetry of Pilbara olive pythons will document habitat preferences, microhabitat use, diet, reproductive behaviour and sources of mortality.
- Trials to ascertain a suitable method to attach transmitters to the exterior of juvenile pythons.
- Continue trials of various monitoring techniques and their suitability for various geological surfaces and population densities of Pilbara olive pythons.

Felixer grooming trap trial: Feral cat control for threatened fauna conservation in the southern forests.

SP-2020-23

A Wayne, M Maxwell, C Ward

Context

Feral cats are one of the most significant threats to native terrestrial vertebrate species in Australia. The Felixer™ cat grooming trap is a novel method of controlling feral cats that takes advantage of their compulsive grooming behaviour. The Felixer unit detects the presence of a feral cat and sprays a lethal dose of 1080 toxic gel onto the fur of the feral cat. The feral cat instinctively grooms itself to remove the gel and, in doing so, ingests a lethal dose of the poison. The unit takes a photograph every time the detection beams are crossed, allowing an assessment of the efficacy of the trap in differentiating feral cats from non-target species.

Proper testing of this new technology is essential to validate if the Felixer is an effective and low-risk feral cat management tool and at what scale they are most effective. This project is a research trial to assess the effectiveness of these traps to deliver feral cat control at a meso-spatial scale (around 10,000 hectares) for threatened fauna conservation and recovery. The trials are being conducted in high conservation value areas in and around the Tone-Perup Nature Reserve and the Lake Muir-Byenup Ramsar site.

Aims

- Determine the safety of the Felixer™ grooming trap for use in the presence of the native fauna in the Upper Warren area.
- Determine whether Felixer™ grooming traps can reduce feral cat densities by at least 60% at a meso-spatial scale (>10,000 hectares) in the southern jarrah forests, Western Australia.
- Improve the efficiency and effectiveness of Felixer™ grooming traps by refining the deployment design through adjusting spatio-temporal factors such as density, duration, mobility and location in the landscape.
- Investigate the timing, frequency and spatial scale of Felixer™ trapping required to overcome recruitment from breeding and immigration. Maintain a reduction in cat densities to allow for the recovery of native prey species.

Progress

- The final report for the project was published in September 2023.

- Results demonstrate that Felixer™ traps pose no risk to non-target native wildlife in the southern jarrah forest.
- On average between 42% and 58% of the feral cat individuals detected by the Felixers were ultimately targeted by the Felixer in conservative targeting mode.
- 100% of the feral cat individuals detected by the Felixers in standard targeting mode were targeted.

Management Implications

- The Felixer units are safe to use in the presence of native fauna present in the southern jarrah forests of Western Australia.
- Early indications are that these units may be able to remove a substantial proportion of the cat individuals present at a meso-spatial scale, and therefore be an important and complementary tool to deliver improved conservation outcomes for threatened species vulnerable to cat and fox predation in the jarrah forest.

Future Directions

- Publication of results in a peer-reviewed paper.

Investigation into the decline of chuditch (*Dasyurus geoffroii*) in the south-west of Western Australia

SP-2019-29

A Wayne, L Gibson, K Ottewell

Context

Comprehensive information about the distribution, abundance and genetic diversity of the chuditch in Western Australia is lacking. Information to date has largely been captured using Western Shield monitoring, and while this has provided some data for selected locations, the monitoring sites and methods used are designed to capture information on a range of species. Consequently, captures of chuditch are often sparse and monitoring is not comprehensive across its distribution. Analysis of Western Shield data suggests that there has been a significant decline in the relative abundance of chuditch in the period 2013-17, although inconsistent trap effort in some years may have confounded this result. Further analyses suggested that the currently sparse data could not provide reliable population size estimates for the species. This project will undertake targeted surveys in poorly sampled areas to fill information gaps using an approach specific to chuditch. Concurrent DNA sampling will improve understanding of the genetic structure across the entire species range. The information gained will help to inform decisions both in relation to the effective conservation management of chuditch, as well as sourcing animals for translocations to ensure newly established populations are genetically diverse and representative of the species.

Aims

- Evaluate survey and monitoring methods to improve future assessments of population change in chuditch.
- Improve knowledge on the distribution of the chuditch by undertaking targeted surveys in poorly sampled areas, and on the margins of its known range.
- Undertake concurrent DNA sampling to improve understanding of the genetic structure across the entire species range, and to identify source populations for translocations.
- Compile and interrogate all data to help identify potential processes influencing population change in chuditch.

Progress

- Sites were surveyed within the South Coast, Swan, Warren, Wheatbelt and South West regions.
- Captures were significantly higher using an approach specific to chuditch (including using chicken instead of universal bait) compared to captures when traditional Western Shield methods were used.
- Chuditch were captured at Ravensthorpe, Cocanarup, Tone-Perup, Dragon Rocks, Dryandra, Batalling, Julimar, Avon Valley, Jarrahdale, Wearne, Dwellingup, Boyagin, Mt Frankland, Ravensthorpe and Lake Magenta. Lake Magenta yielded the lowest captures and Avon valley, the highest.
- Tissue samples for genetic analyses were collected at Ravensthorpe, Cocanarup, Batalling, Dryandra, Tone-Perup and Jarrahdale.

Management Implications

- Knowledge on the current distribution of chuditch has been improved, although further surveys are needed to define the eastern extent of the species' range to better understand the conservation status of the species in terms of extent of occurrence.
- Survey data will facilitate improvements in chuditch population estimates to inform the current conservation status of the species.
- Results of genetic analyses will inform population management, including future translocations to ensure newly established populations are genetically diverse and representative of the species.

Future Directions

- Further surveys to more clearly define the species' range.
- Continue repeat surveys to robustly estimate population size at all sites and determine population trends across the state.
- Complete analysis of tissue samples to determine population genetic structure.

Conservation of the night parrot

SP-2017-36

A Burbidge

Context

The critically endangered night parrot has been confirmed breeding in only two locations, one in Queensland and one in Western Australia, although roost sites have now been identified in a number of other locations in WA, and these are likely also to be breeding sites. The night parrot has not been adequately surveyed across much of its potential habitat, and a lack of knowledge of foraging and roosting habits has hampered progress in understanding the ecology of the species. This constrains possible recovery actions and management relating to resource development proposals. Identifying the conservation requirements of the night parrot is essential for informed management of this poorly known species.

Aims

- Assess the spatial extent of the population in Matuwa Kurrara Kurrara National Park, surrounding areas, and the entire Lake Carnegie catchment.
- Determine where the birds are foraging by identifying vegetation types they are using and the spatial relationship between roosting and foraging habitat.
- Determine differences in the vegetation at occupied versus non-occupied roost and foraging sites to inform predictive models.
- Engage with Traditional Owners to encourage surveys for night parrots and culturally sensitive management for the species.

Progress

- The genome sequence of the night parrot has been determined and published on GenBank.
- Advice has been provided to resource development proponents and regulatory bodies in relation to survey protocols and potential impacts of individual development proposals.
- Participated in a public presentation on night parrots at the Western Australian Museum.
- A revised version of guidelines for survey for night parrots has been completed and published on the DBCA website.
- Input provided to a review of research progress, on-ground management and future directions for EPBC listed species in the Pilbara.

Management Implications

- The revised survey guidelines will assist environmental consultants in conducting more rigorous surveys, and will result in improved knowledge to inform decisions by regulators.
- Genomic sequencing, in conjunction with other genetic data, will assist in understanding of population structure and variation, underpinning future management actions.

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Future Directions
- Contribute to CSIRO led genetic analyses to inform understanding of population biology and underpin future management proposals.
- Continue to investigate development of robust software recognition algorithms.
- Seek funding to support field work to improve understanding of habitat use and foraging ecology.

Understanding and reducing python predation of the endangered Gilbert's potoroo

SP-2017-1

D Pearson

Context

Carpet pythons are predators of multiple threatened mammal fauna, including the critically endangered Gilbert's potoroo (*Potorous gilberti*). Python predation can reduce adult survival and curtail recruitment. Current 'predator proof' fences, while effective at reducing or eliminating predation by foxes and feral cats, are likely to have little or no effect on levels of python predation.

Python predation has been identified as a significant threat to the Gilbert's potoroo population in the Waychinicup National Park enclosure. In a review of options following a 2015 fire that impacted the only known wild population at Two Peoples Bay, it was considered that management intervention is required to reduce python predation of potoroos within the enclosure. Python predation may be limiting population growth and hence the production of individuals for translocation.

Aims
- To determine the most effective ways to locate and remove carpet pythons from within and around Gilbert's potoroo populations and reduce the current level of predation of this critically endangered mammal.

Progress
- Fieldwork is complete and results have been reported to the Gilbert's Potoroo recovery team.
- Home range data for male and female pythons have been collated in readiness for movement and home range analysis.
- Two publications reporting on the threat that carpet pythons pose to Gilbert's Potoroo populations and management options to reduce python predation are being prepared.

Management Implications
- Carpet pythons have been identified as significant predators of Gilbert's potoroo and will require management to reduce loss of potoroos in translocations.
- Relocation of large female carpet pythons would dramatically reduce predation risk.
- The translocation of female pythons may result in high mortality of these snakes and needs to be further investigated.

Future Directions
- Complete paper on the threat that carpet pythons pose to Gilbert's potoroo populations.
- Complete paper on survey techniques to find pythons and management actions to reduce their impact.

Dirk Hartog Island National Park ecological restoration project – fauna reconstruction

SP-2016-30

M Smith, L Gibson, K Ottewell, S Garretson, J Angus, K Rayner, C Sims, A Burbidge

Context

The Dirk Hartog Island National Park Ecological Restoration Project aims to restore the ecological condition of Western Australia's largest island to that seen by Dirk Hartog when he landed on the island in 1616. The establishment of populations of 12 mammal and one bird species on Dirk Hartog Island (DHI) over a 12-year period is a key part of this project. Of these species, one is listed as critically endangered, one as endangered and six as vulnerable under the *Biodiversity Conservation Act 2016*. The other three species are either conservation dependent or near threatened. Their successful re-establishment will contribute to improving the overall conservation status of these species. The translocation of 13 native species to an island 633 square km in area makes it the largest fauna reconstruction project in Australia and one of the largest in the world. For successful re-establishment to occur, sheep, feral goats, and feral cats have been removed. The eradication of feral cats represents the most extensive eradication program achieved globally. Genetic information on source populations is being used to inform founder selection, genetic monitoring of released animals, and ongoing management practices.

Aims

- Identify the most suitable source populations to act as founders for new populations on DHI, using the criteria set out in the *Dirk Hartog Island National Park Ecological Restoration Strategic Plan*.
- Establish new populations of 12 mammal species and one bird species on DHI, using the species selection criteria set out in the Strategic Plan.
- Confirm that the translocations are successful and that all new populations on DHI are healthy and self-sustaining, using criteria set out in the Strategic Plan and approved translocation proposals.
- Promote scientific research associated with the translocations, monitoring and establishment of fauna, and publish scientific findings.

Progress

- Brush-tailed mulgara appear to be persisting on the island and are dispersing away from the release area. There have been sufficient camera detections to be satisfied with the progress of the translocations at the six-month mark. Images captured on remote cameras confirm that animals have successfully bred. An advanced draft manuscript on range-wide genetic analyses has been completed.
- All the short term and the majority of the medium-term success criteria for greater stick-nest rats have been met, with dispersal away from the release area and ongoing evidence of reproduction. Development of a SNP array for scat monitoring is underway.
- All short and medium-term success criteria for Shark Bay mice have been met, as well as most of the long-term criteria. The species is persisting, dispersing away from the release area and there is ongoing evidence of reproduction. Genetic analyses to assess genetic success criteria are underway.
- There is some evidence that dibblers are persisting and reproducing on the island, but there is insufficient data to quantitatively assess many of the current criteria due to a need to capture animals. Alternative approaches to monitoring are being investigated including the use of some form of environmental or insect-borne DNA.
- Shark Bay bandicoots appear to be establishing well on the island. Genetic analyses to assess genetic success criteria are underway.
- Monitoring to date suggests that western grasswren are successfully establishing on the island.
- Ongoing observational and scat monitoring records indicate that rufous and banded hare-wallabies are dispersing and establishing on the island.

Management Implications

- The successful translocation and establishment of large self-sustaining populations of these eight species on DHI is likely to have beneficial outcomes for their conservation and for the ecosystems they inhabit.
- The development of innovative techniques to enhance translocation and post-release monitoring success will not only be beneficial to this project but may also improve translocation outcomes at other locations.
- The development of non-invasive approaches to monitor fauna species will provide an effective solution that can be implemented to reduce time in the field.
- Genomic analysis informs population management strategies and provides a suite of novel, affordable monitoring tools to support the ongoing adaptive management of these populations.

Future Directions

- Translocations for woylies and boodies are now well into their planning phases. Translocation of woylies is planned for 2025 and boodies for 2026.
- Monitoring of all translocated species on DHI and source populations will continue to be undertaken.
- Population genomic analyses for translocated species will be progressed including high-throughput SNP arrays for GSNR faecal DNA monitoring.
- Continued assessment of the utility of environmental DNA techniques to monitoring species such as dibblers.

South-west threatened fauna recovery project: southern jarrah forest

SP-2016-68

A Wayne, M Maxwell, C Ward

Context

The primary goal of the South West Threatened Fauna Recovery Project (SWTFRP) is to contribute to the recovery of key threatened mammal and bird species at four key sites in south-west Western Australia, through integrating feral cat baiting with existing introduced predator control programs, undertaking monitoring of threatened species and translocations to supplement and establish new, secure populations where necessary. The key sites selected were South Coast reserves, Upper Warren reserves, Dryandra Woodland and Kalbarri National Park.

This project is a component of the SWTFRP, focussing on the southern jarrah forest, which is an important area for the conservation of several mammal and bird species threatened by introduced predators. To date there has been no effective cat control within the southern jarrah forest, including the priority conservation areas within the Upper Warren region. Eradicat® presents an opportunity for developing an important tool within an effective cat control program that is essential to the long-term conservation of imperilled fauna threatened by introduced predators.

Aims

- To recover wild populations of western ringtail possums, woylies and numbats in the Upper Warren area, by developing effective integration of feral cat control with existing fox control in the southern jarrah forest.
- Evaluate the efficacy of Eradicat® baiting under current operational delivery methods (aerial and ground) and time of year.
- Quantify the risk to potentially vulnerable non-target native mammals in the southern jarrah forest from operational use of Eradicat®.
- Improve live capture of feral cats in the southern jarrah forest by minimising non-target captures.
- Engage effectively with neighbours about the control of introduced predators and the recovery of native species.

Progress

- Results show that the efficiency and effectiveness of Eradicat® baits in the southern jarrah forests were low due largely to a high uptake by non-target native species. Recommendations for improvements are provided in a paper currently in review.
- A paper was submitted describing an analysis of fire effects on introduced predator control, showing that compared to the reference sites, there were no significant differences in encounter rates or bait removals by feral cats or foxes immediately after autumn burns.
- Nine comparative trials investigating bait efficiency and effectiveness of Eradicat baits placed on-track versus off-track (5-20m) showed that feral cat and fox detection rates were 15 and 17 times higher on-track than off-track. While no baits were taken by a feral cat, 5% (19/381) baits were removed by foxes, all of which were on-track. Analyses and preparation of a paper for publication is underway.

Management Implications

- High uptake of Eradicat by non-target native species means controlling feral cats in the southern jarrah forest is challenging. Additional introduced predator threat abatement may be needed to conserve and recover many threatened native mammals in the southern jarrah forests.

Future Directions

- Complete analyses and manuscripts for publication, including bait longevity, non-target bait interactions and risk assessments for potentially vulnerable non-target species, and spatial ecology of feral cats.

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Improving the use of remote cameras as a survey and monitoring tool

SP-2013-5

M Cowan

Context

The use of camera traps is often regarded as an effective tool for fauna survey and monitoring with the assumption that they provide high-quality, cost-effective data. Nevertheless, understanding of appropriate methods for general survey and species detection, particularly in the small to medium sized range of mammals, remains poor. Within the department, the use of camera traps to date has usually been restricted to simple species inventories or behavioural studies, and beyond this, there has been little assessment of deployment methods or appropriate analytical techniques. This has sometimes limited the usefulness of data derived from captured images. Camera traps have the potential to offer a comparatively reliable and relatively unbiased method for monitoring medium to large native and introduced mammal species throughout the State, including several significant cryptic species that are currently not incorporated under the Western Shield fauna monitoring program. Further research is required to validate and assess the temporal and spatial components of different survey designs, methods of deploying camera traps and interpretation of results to determine how best to use remote cameras to provide rigorous data on species detectability and species richness and density.

Aims

- Investigate methodologies for the use of camera traps to examine the temporal and spatial occurrence of native and introduced mammal species in the south-west of Western Australia.
- Investigate and assess methods of data capture and data storage, including emerging automated species recognition technologies.
- Develop analytical tools and methodologies for the interrogation and interpretation of camera trap imagery data.
- Undertake comparative trials on new models of cameras and trapping array designs to assess effectiveness and suitability for monitoring and survey programs.
- Provide analysis of trends and occurrence for critical weight range mammals and introduced predators at landscape scales within targeted reserves.

Progress

- A project investigating the impact of repeated Eradicat® baiting, to control feral cats, on the activity levels of the red-tailed phascogale using tree-mounted cameras was completed, demonstrating a low risk to the phascogales.
- A paper has been submitted to *Wildlife Research* focusing on the potential risk of Eradicat® baiting on red-tailed phascogales as per above.

Management Implications

- Tree-mounted cameras proved to be an effective and efficient method to monitor red-tailed phascogales.
- To maximise camera detections, the optimal time for monitoring red-tailed phascogales is during autumn, prior to male die-off.
- Integrating the application of Eradicat® to control feral cats with existing fox control in conservation reserves that support populations of red-tailed phascogales is likely to pose minimal risk to the species.

Future Directions

- This project will be complete with finalisation of the publication.

Monitoring of threatened birds on Dirk Hartog Island

SP-2013-21

A Burbidge

Context

This project was designed to develop and implement a monitoring program for the three naturally remaining threatened bird species on Dirk Hartog Island (DHI): DHI southern emu-wren, DHI rufous field-wren, and DHI white-winged fairy-wren. This project is part of the broader Dirk Hartog Island National Park Ecological Restoration Project. The intent is to allow assessment of the distribution, status and population trends of the threatened bird species and enable monitoring of change in relation to management actions aimed at restoring plant and animal communities of the island to a state similar to that which existed before pastoralism and the introduction of exotic weeds, herbivores and carnivores.

Aims

- Determine historical and contemporary occurrence of threatened bird species across Dirk Hartog Island.
- Model and map the occurrence of each species across the island in relation to vegetation characteristics.
- Develop a robust monitoring program.
- Clarify the conservation status of each of the threatened bird taxa.

Progress

- A manuscript on modelled species distribution and population sizes on the island has been submitted for publication, and is currently being revised following reviewer comments.

Management Implications

- As all three threatened taxa are more abundant and widespread on the island than previously thought, localised management actions will have limited impacts, and monitoring will not need to be undertaken as frequently or as intensively as previously anticipated.

Future Directions

- Finalise publication of accounts of species distribution modelling across the island and population estimates of the species.
- Finalise development of an optimal monitoring design for each species across the island.

Barrow Island threatened and priority fauna species translocation program

SP-2012-25

L Gibson, A Burbidge, J Angus, S Garretson, C Sims

Context

Barrow Island Nature Reserve is one of Australia's most important conservation reserves, particularly for mammal and marine turtle conservation. It has also been the site of a producing oil field since 1964. In 2003, the Western Australian Government approved the development of the Gorgon gas field off the north west of Barrow Island and associated LNG plant on Barrow Island subject to several environmental offset conditions. One of these offsets was the threatened and priority fauna translocation program that provided for the translocation of selected Barrow Island fauna species to other secure island and mainland sites. This will assist in improving the conservation status of these species and allow the reconstruction of the fauna in some areas. It also provides an opportunity to examine the factors affecting translocation success and improve these where necessary. Targeted species are the golden bandicoot, brushtail possum, spectacled hare-wallaby, boodie, black and white fairy-wren, and spinifex bird.

Aims

- Translocate mammal and bird species from Barrow Island to other secure island and mainland sites.
- Reconstruct fauna in areas where these species have become locally extinct.
- Develop and refine protocols for fauna translocation and monitoring.

Progress

- In association with the Rangelands Restoration Project, animals translocated from Barrow Island to Matuwa Kurrara Kurrara National Park continued to be monitored.
- Introduced predator control and associated monitoring continued at Cape Range National Park.
- Monitoring of animals translocated to the Montebello Islands under this project has been completed, with final reports pending.

Management Implications

- Arid zone rangelands fauna reconstruction and conservation techniques developed by this project will have broad State and national application.
- This project has contributed to an improvement in the conservation status of several threatened fauna taxa by establishing additional populations on islands and the mainland as the result of successful translocations.

Future Directions

- Continue the monitoring of translocated populations at Matuwa Kurrara Kurrara National Park.
- Continue integrated fox and feral cat control at Cape Range.
- Prepare final reports describing the monitoring of birds and mammals on the Montebello Islands.

Conservation and management of the bilby in the Pilbara

SP-2012-35

H Moore, T Harrison, D Bohorquez Fandino, L Gibson

Context

The bilby (*Macrotis lagotis*) is listed as vulnerable under the *Biodiversity Conservation Act 2016* and the Commonwealth EPBC Act. Increases in threats, including pressure from mining activities across the Pilbara mean that a greater understanding of the distribution, abundance and ecology of the bilby is necessary to ensure appropriate conservation and management measures are implemented. This project aims to increase our knowledge of the bilby in the Pilbara bioregion of Western Australia, and develop a regional survey and monitoring program. The current focus is to determine the distribution of the bilby in the Pilbara and to establish appropriate survey and monitoring techniques, including genetic approaches.

Aims

- Improve understanding of the distribution and demographics of bilbies in the Pilbara.
- Provide information to environmental regulators, resource development companies and contractors that will allow appropriate management to ensure the long-term persistence of the greater bilby in the Pilbara.
- Design, establish and implement a long-term monitoring program for bilbies in the Pilbara.

Progress

- Bilby abundance monitoring near the Warralong community in the Pilbara continued in conjunction with Eradicat® feral cat baiting. Planning is underway to expand the area baited. Ongoing monitoring will help determine if baiting is effective in reducing feral cat activity, and leads to a positive effect on bilby abundance.
- Preliminary results from an analysis investigating the influence of fire attributes on bilby occurrence in the Pilbara suggested that bilby occupancy decreases with increasing spatial extent of recently burnt habitat in the surrounding landscape, and increases with diversity of fire ages.
- Analysis of 2 hectare sign plot surveys conducted on the Dampier Peninsula in the Kimberley, published in *Wildlife Research,* showed that bilby occupancy increased with increasing spatial extent of surrounding long unburnt habitat (greater than 3 years old), while feral cat occupancy declined. Similarly, frequent fires tended to deter bilbies but not feral cats.

- A review of the bilby research program was published in *Australian Mammalogy*, identifying future research directions and management actions.

Management Implications

- Recent findings further highlight the importance of appropriately managing fire to benefit bilby populations.
- Improved understanding of the effectiveness of threat mitigation will help inform ongoing conservation management of the bilby across its range.
- Ongoing surveys for bilbies across the Pilbara will improve our understanding of their conservation status in this region and assist assessments of development proposals.

Future Directions

- Continue the monitoring at Warralong to assess the effectiveness of threat management.
- Continue investigating the role of fire in improving bilby habitat across their current range, as well as how fire may interact with other threats (predation).
- Develop a strategy to commence implementation of the research priorities identified in the review.

Conservation of south coast threatened birds

SP-2012-22

A Burbidge, G McGrath

Context

Identifying the conservation requirements of threatened south coast birds, such as the critically endangered western ground parrot, endangered noisy scrub-bird, vulnerable western bristlebird, western subspecies of the western whipbird and the endangered Australasian bittern, will aid *in situ* management of these taxa. Understanding of responses to fire and hydrological changes, biological and behavioural characteristics, such as vulnerability to predation, and nesting site requirements is essential knowledge for the conservation of these birds, some of which are endemic to the south-west, and the development of management programs.

Aims

- Develop an understanding of the biological and ecological factors that limit the distribution and numbers of south coast threatened birds, including interactions with predators, habitat requirements and response to fire.
- Increase the survival chances of south coast threatened birds and increase their total population size through the creation of management prescriptions that will benefit all threatened south coast animals.
- Investigation of life history characteristics and ecological processes impacting recruitment in the Australasian bittern.
- Survey and monitor Australasian bittern population and habitat trends.

Progress

- Contributed to CSIRO-led project to sequence the genome of both western and eastern ground parrots; sequences now published on GenBank.
- Collaborated on contributions to innovative monitoring approaches, particularly through acoustic methods.
- Commenced an investigation into the diet of the western ground parrot using innovative indirect methods.
- A report was published on the management approach for the captive population of western ground parrot.
- Four collaborative presentations were given at workshops and conferences.
- Contributed to a Structured Decision Making (SDM) workshop for the western ground parrot, the outcomes of which are currently being finalised.

Management Implications

- Current analyses of genomic data will clarify the relationship between eastern and western ground parrots. Resolution of this will indicate the feasibility of genetic rescue for the critically endangered

western birds.

- Improved acoustic monitoring methods will allow timely management response to changes in population trend, and evaluation of translocation success.
- The SDM workshop outcomes will indicate the relative efficacy of different management options for the western ground parrot.
- Wetland surveys will improve understanding of habitat quality for the Australasian bittern and co-occurring species.

Future Directions

- Contribute to finalisation of genetic analyses for the ground parrot, and their publication.
- Contribute to on-going improvement of acoustic survey methods specifically for the western ground parrot.
- Finalise and report on management implications from the western ground parrot SDM workshop.
- Contribute to supervision of the Australasian bittern/wetland project on the south coast.

Genetic assessment for conservation of rare and threatened fauna

SP-2012-34

K Ottewell, M Byrne, B Huntley, L Umbrello, R Sun, M Millar

Context

Genetic analysis of threatened species can provide important information to support and guide conservation management. Genetic information can aid resolution of the taxonomic identity of species and sub-species to determine whether they have appropriate conservation listing. At a population level, analysis of the genetic diversity present, and its distribution across extant populations, provides information on the genetic 'health' of threatened species. Concurrent analysis of some of the proximal drivers of genetic change can identify appropriate management responses for declining populations to improve conservation outcomes. Further, emerging genomic technologies enable novel monitoring approaches, expanding the available toolbox for threatened species monitoring.

Aims

- Assess the genetic diversity and genetic structure of target species.
- Use genetic approaches to assist in resolving taxonomic boundaries of target species.
- Undertake genetic monitoring of translocated and natural populations of target species.
- Use novel genetic technologies to assist and/or inform conservation management of target species.

Progress

- A manuscript on population genomic analysis of island and mainland golden bandicoots has been published in *Heredity*.
- Population genomic analysis of black-flanked rock wallaby has been incorporated into a population management strategy. A SNP array for scat monitoring has been developed and is undergoing validation across multiple populations.
- Bilby faecal DNA monitoring is continuing on Pilbara and northern WA projects. A manuscript on the bilby SNP array has been published in *Nature Ecology & Evolution* as well as a review of future research directions in *Australian Mammalogy*.
- Statistical analyses of wild, translocated and historical populations of Gilbert's potoroo have been completed, including development of a SNP array for genetic monitoring. Genetic analyses were incorporated into a population management strategy.
- Genomic analyses of hairy marron individuals for the Perth Zoo breeding program has been completed and breeding recommendations provided.

Management Implications

- Genomic analysis of remnant golden bandicoot populations indicated the Kimberley as the most genetically-diverse population and informs future translocations of the species.
- Genomic analysis of black-flanked rock wallaby populations in the Wheatbelt indicated Nangeen Hill has lower diversity and would benefit from genetic supplementation.

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- Bilby scat monitoring methods enable estimates of abundance and inter-annual survivorship, informing effectiveness of population and habitat management strategies, including fire and feral cat management.
- Genomic analysis of Gilbert's potoroo has informed supplementation strategies for the species.
- Genomic analysis of Margaret River hairy marron confirmed the non-hybrid status of individuals brought to Perth Zoo for captive breeding and has informed mate pairings.

Future Directions

- Update black-flanked rock wallaby analyses with additional samples from recent monitoring and translocation events.
- Finalise validation of black-flanked rock wallaby SNP array.
- Provide bilby, black-flanked rock wallaby and Gilbert's potoroo SNP genotyping as required for genetic monitoring projects.
- Develop SNP array for hairy marron pedigree management if required by Perth Zoo. Contribute to development of hairy marron eDNA monitoring techniques.

Rangelands restoration: reintroduction of native mammals to Matuwa (Lorna Glen)

SP-2012-24

C Lohr, B Pittway, D Cummins, L Gibson

Context

Operation Rangelands Restoration commenced in 2000 with the acquisition of Lorna Glen (Matuwa) and Earaheedy (Kurrara Kurrara) ex-pastoral leases by the WA Government, that were made a National Park in 2023. We are working in collaboration with the Traditional Owners, Tarlka Matuwa Piarku Aboriginal Corporation (TMPAC), who were granted exclusive Native Title over the area in 2014, to restore ecosystem function and biodiversity in the rangelands. Matuwa once supported many mammal species, that have suffered large declines. This project seeks to reintroduce 11 arid zone mammal species following the successful suppression of feral cats and foxes. Mammal reconstruction will also contribute to the restoration of rangeland ecosystems through re-establishment of ecosystem services such as digging, grazing/browsing of vegetation and seed dispersal. The first mammal reintroductions commenced in August 2007 with the release of bilby (*Macrotis lagotis*) and brushtail possums (*Trichosurus vulpecula*). Between 2010-2012, mala (*Lagorchestes hirsutus*), Shark Bay mice (*Pseudomys fieldi*), boodies (*Bettongia lesueur*) and golden bandicoots (*Isoodon auratus*) were translocated into a 1100 hectare introduced predator-free fenced enclosure. The enclosure is intended to provide species with an opportunity to acclimatise to the desert environment. The ultimate goal is to release animals outside the enclosure and establish free-ranging, self sustaining populations of these species.

Aims

- Refine effective feral cat control and monitoring techniques in a rangeland environment.
- Continue to reintroduce native mammal species to Matuwa, and contribute to an improved conservation status for these species.
- Re-establish ecosystem processes and improve the condition of a rangeland conservation reserve.
- Develop and refine protocols for fauna translocation and monitoring.
- Participate in two-way science with TMPAC and Wiluna Rangers.

Progress

- The Matuwa Kurrara Kurrara Interim Joint Management Board approved seven science projects for Matuwa.
- Introduced predator control via aerial baiting with Eradicat continued with the track activity index indicating successful suppression of feral cats.
- A two-way gate design that may allow boodies to disperse out of the introduced predator-free fenced area into the wider landscape, while preventing entry of feral cats, was tested.
- The utility of LiDAR to detect malleefowl mounds was investigated.
- Monitoring of bilbies was undertaken and abundance from scat DNA was estimated.
- Refining methods of estimating genetic diversity and abundance of mala from scat DNA continued.
- A manuscript discussing the efficacy of various lures for camera-traps used to monitor feral cats was published in *Biological Invasions*.

- A manuscript describing the impact of fenced reserves on mulgara was published in *Australian Mammalogy*.
- A manuscript describing the genomic diversity in golden bandicoots was published in *Heredity*.
- A manuscript describing genetic relationships among boodies has been accepted by *Australian Mammalogy*.
- A manuscript describing threatened fauna behaviour near prescribed burns was submitted to A*nimal Behaviour*.

Management Implications

- A strategic approach to feral cat control using annual aerial baiting plus additional control activities to remove bait-shy individuals has proved to be effective in suppressing feral cat activity.
- Bilbies can thrive outside fenced enclosures in the presence of a sustained and effective feral cat control program.
- The ability to identify feral cats on camera, and hence estimate their abundance, has been improved through the use of cat urine lures.
- The capacity to monitor fauna translocated to Matuwa has been improved by involvement of Traditional Owner rangers and associated training.
- Successful translocations to Matuwa have enabled this location to become a source site for other translocations.
- Non-invasive monitoring approaches such as scat DNA have improved the department's ability to monitor species that are difficult to detect using other methods, such as live trapping, and thereby increases capacity to measure translocation outcomes.

Future Directions

- Investigate new methods of re-establishing native mammals outside a fenced enclosure.
- Develop and refine management protocols for other introduced vertebrate pests.
- Verify potential malleefowl mounds identified by LiDAR analysis.
- Improve monitoring techniques for cryptic species such as mala.
- Continue to participate in two-way science with TMPAC and Wiluna Rangers and provide training opportunities for Wiluna Rangers and community members.
- Complete publications on the ecology of boodies, and the impact of baiting on golden bandicoots.

Ecology and management of the northern quoll in the Pilbara

SP-2011-5

H Moore, T Harrison, D Bohorquez Fandino, L Gibson

Context

The northern quoll (*Dasyurus hallucatus*) is listed as an endangered species under the *Biodiversity Conservation Act, 2016*. Funding from mining offset conditions is being used to gain a better understanding of quoll distribution, ecology, demographics and management requirements in the Pilbara. The two major components of the project are monitoring and ecological research. Survey and monitoring of Pilbara northern quoll populations over 10+ years will provide a regional context for understanding population dynamics. Researching northern quoll ecology will provide information related to impacts, such as loss of known or potential habitat critical to the survival of the species, loss of known or potential foraging/dispersal habitat, and barriers restricting dispersal opportunities and genetic flow.

Aims

- Develop appropriate and standardised survey and monitoring methods for northern quoll.
- Define areas of critical habitat and better understand how disturbance affects habitat quality.
- Improve understanding of population dynamics.
- Better understand the key threats and interactions between these threats.
- Determine whether the northern quoll will colonise restored/rehabilitated areas and artificial habitat.

Progress

- Pilbara-wide monitoring of northern quoll occupancy and abundance continues to be implemented annually.

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- Research published in *Austral Ecology* documented northern quoll temporal activity patterns across their northern Australian range.
- Research published in *Movement Ecology* indicated northern quolls avoid areas affected by mining during the breeding season.
- Analysis is underway to assess the efficacy of conditioned taste aversion baits deployed in the Kimberley as a method to protect northern quolls against invading cane toads.

Management Implications

- The camera monitoring program that will effectively track population trends can assist in identifying potential drivers of shifts in quoll occupancy, and can allow for timely responses to any significant declines or changes.
- Identification of the importance of topographically rugged habitat, as well as linear features, such as creek beds for northern quolls, informs management strategies that protect these preferred habitats and provide benefits to the species.
- Engaging local stakeholders strengthens DBCA's capacity to monitor northern quolls effectively at scale in the Pilbara, and has increased the capacity of Aboriginal ranger groups to undertake their own monitoring of other culturally significant fauna.

Future Directions

- Further refine the northern quoll regional monitoring program, including the addition of sites and building capacity within Aboriginal Country managers and Regional staff.
- Improve understanding of how interacting threats such as introduced predators, fire, and herbivore grazing influence northern quoll populations in the Pilbara.
- Further investigation of how other threats such as mining associated activities and the impending cane toad invasion can be best mitigated.

Impact of cane toads on biodiversity in the Kimberley

SP-2006-4

D Pearson

Context

The invasion of cane toads is impacting the biodiversity of the Kimberley, and no technique has been developed to prevent their spread across the landscape. Earlier research has identified that predators, such as northern quolls (*Dasyurus hallucatus*) and goannas, are especially vulnerable to poisoning by toads and that it is possible to train some native predators to avoid eating cane toads. A taste aversion bait to prevent quolls eating toads has been developed and is being trialled during this project. Monitoring of northern quoll and reptile populations on Adolphus Island and mainland sites is required to understand how these species are likely to respond to the arrival of toads on islands.

Aims

- Test taste aversion baits and the use of 'teacher toads' (metamorphs too small to be lethal) to induce an effective conditioned taste aversion (CTA) response by native species threatened by toads.
- Develop operational techniques to roll out taste aversion training across Kimberley landscapes.
- Monitor populations of susceptible species behind the toad front, including those where taste aversion training took place and at control sites.
- Investigate where and how toads survive in seasonally dry habitats to better understand their colonisation of islands and their potential to spread into the Pilbara region.

Progress

- Fieldwork is complete. Work is now focused on examining a large number of still and video images collected during trials of taste aversion sausages with northern quolls.
- Draft paper prepared on the impact of the arrival of cane toads on Adolphus Island on susceptible species (quolls and goannas).
- Advice provided to the Cane Toad Program and associates.

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Management Implications

- Trials of DBCA conditioned taste aversion baits resulted in equivocal results, with small numbers of quolls persisting on both control and treatment sites after the arrival of cane toads. The differences are being carefully assessed using video and camera footage to understand how quolls interact with the baits.
- CTA baits were found to be effective at inducing quoll avoidance of the baits and toad legs. Results from this work and research by others suggests that quolls do not remember their taste aversion experience for a long period (weeks). Therefore, it is important that aerial drops of CTA baits occur both early, and at other times in the wet season, so that quolls have likely encountered a CTA bait a short time before they meet their first toad.

Future Directions

- Finalise data analysis and publication of conditioned taste aversion trials on wild and captive quoll populations with recommendations on how baits could be better employed to protect mainland and island northern quoll populations.
- Publication of information on the impact of cane toads on various other taxa.

Development of effective broad-scale aerial baiting strategies for the control of feral cats

SP-2003-5

D Algar, N Hamilton, M Onus

Context

The effective control of feral cats is one of the most important native fauna conservation issues in Australia. Development of an effective landscape-scale baiting technique, and the incorporation of a suitable toxin for feral cats, is cited as a high priority in the various iterations of the national *Threat abatement plan for predation of feral cats*, as it is most likely to yield a practical, effective, and cost-efficient method to control feral cat numbers in strategic areas and promote the recovery of threatened fauna.

Aims

- Design and develop a bait medium that is readily consumed by feral cats.
- Examine baiting strategies to provide long-term and sustained effective control.
- Assess the potential impact of baiting programs on non-target species and devise methods to reduce potential risks where possible.
- Provide a technique for the reliable estimation of cat abundance.
- Refine the feral cat trapping technique to effectively collect information on population parameters relevant to control strategies, while minimising risk to non-target species. Assess the utility of trapping as a follow-up measure post-baiting where eradication of cats is required or to provide additional control effort.

Progress

- Following improved uptake of digest coated *Probaits* by foxes, the consumption of digest coated *Eradicat* baits by cats was examined. Initial trials indicated a significant preference for the coated bait medium. New methods of producing the bait medium to improve bait quality and integrity are also being tested.
- Feral cat patterns of movement through the landscape are being analysed from several sites using GPS data-logger radio-collars. These results will enable development of more targeted and strategic baiting programs based on habitat preferences, home range, distribution patterns and likely bait encounter rates.
- Field trials examining cat urine as an olfactory lure for camera traps indicated cats were more responsive to this lure than other common attractants and resulted in more cameras recording cat images, cats reacting positively with the lure and greater ease of individual identification.
- Investigations into the efficacy of other potential control techniques continued with assessment of 'Felixers' with the toxin PAPP. The trial was terminated when the Animal Ethics Committee protocol requiring greater than 80% success rate could not be achieved.

Management Implications

- Effective landscape-scale baiting methods, based on cat activity and movement patterns, across climatic regions will assist in fine-tuning techniques to provide optimal control efficiency and

effectiveness of field operations to target this pest species at strategic locations across mainland Western Australia and lead to significant conservation benefits.

- Development of an accurate, reliable and repeatable statewide feral cat monitoring technique also a trapping methodology that minimises risk to non-target species, will complement the control toolkit and improve ability to collect data relevant to management options.

Future Directions

- Conduct further refinement of the bait medium and manufacturing method to improve bait palatability, quality and integrity.
- Investigate cat activity and movement patterns across climatic regions to better target this pest species at strategic locations.
- Continue investigation of attractants that could prove utility as a suitable lure for the reliable and accurate monitoring of feral cat populations.
- Continue joint investigations into the efficacy of other potential control techniques.

Biodiversity Information Office

Program Leader: Robert Cechner

The Biodiversity Information Office (BIO) has been established as custodian and manager of the Biodiversity Data Repository for the biodiversity data collected and used by the Western Australian community. BIO will mobilise biodiversity data from all environment-related sectors, including government, industry, and community organisations, promoting a culture of collaboration and seamless data sharing across government, industry, research and the community. Greater access to biodiversity data will increase knowledge of our biodiversity and support informed decision making. BIO enhances the capability of the WA public sector to deliver services to a diverse range of stakeholders, leading to the delivery of sound policy outcomes and evidence-based decision-making. BIO is a core component of the WA digital transformation initiative, delivering data services for digital transformation of environmental assessment and approvals system (Environment Online) that is led by the Department of Water and Environmental Regulation (DWER). BIO will provide seamless integration with Environment Online to ensure access to the best available information to inform decision making. BIO is part of the partnership between WA and the Commonwealth Department of Climate Change, Energy, the Environment and Water (DCCEEW) to deliver the Digital Environmental Assessment Program as an integrated digital environmental assessment system and biodiversity data repository.
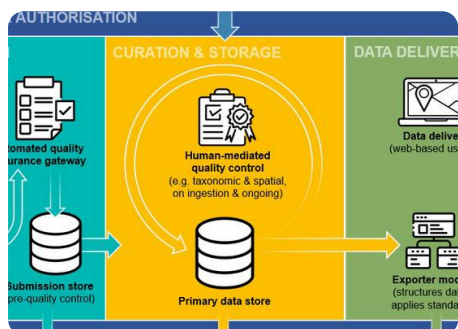
BIO biodiversity data platform

CF-2021-44

R Cechner, N Panine, D Murphy, Z Huq, A Barker, C Piper, K Grogan, S Marcus, H Pichette

Context

The Biodiversity Information Office (BIO) has developed Dandjoo, a central platform that makes Western Australian biodiversity data more easily discoverable, searchable, and accessible. Dandjoo was launched in mid-2022 and has been enhanced with a range of new features and refinements during 2022-23 and 2023-24. Dandjoo is designed to mobilise biodiversity data from all environment-related sectors, including industry, government and community organisations, and to support seamless data sharing across the public, private and research sectors and the broader community.

This work will drive improved regulatory decision-making, providing data for the State's forthcoming Environment Online portal to support digital transformation of environmental assessment and approval, and support other State agencies' evidence-based decision-making for better environmental outcomes. It also facilitates the automated exchange of biodiversity data between Western Australia and the Commonwealth to support decision-making at a national level.

Aims
- Allow users to easily discover, search, and access a range of Western Australian biodiversity data via a single platform.

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- Provide streamlined access to biodiversity data for government agencies, including regulators, to enhance the quality and timeliness of decision-making.
- Develop a model that can be deployed in other states and territories to automate the contribution of biodiversity data to an Australia-wide repository.

Progress
- Implemented methodology consistent with national Restricted Access Species Data (RASD) principles to allow users to access reduced-precision conservation-listed species data.
- Implemented a wide range of enhancements and new features throughout 2023-24 based on feedback from BIO's stakeholders, including expansion of search functionality, system and user interface performance enhancements, capability to display more complex data types, and ability to export unique species lists.
- Collaboration continued with the Western Australian Museum, Western Australian Herbarium and DBCA experts to ensure data in the platform remains up-to-date and robustly curated.

Management Implications
- Increased data availability for industry and government will support environmental impact assessments and facilitate transparent and evidence-based ecological decisions.
- Access to a broader range of high-quality biodiversity data will expand research opportunities and enhance the quality of research outputs.
- Biodiversity conservation outcomes will be enhanced by more information on the geographic distribution of species in Western Australia, supporting conservation programs' effectiveness and identifying knowledge gaps that will inform priorities for future data collection efforts.

Future Directions
- Finalise rollout of enhanced functionality to ingest and visualise systematic survey data allowing public users to access more data than was previously available.
- Ongoing development of Dandjoo to provide additional functionality, including incorporation of new data fields, PDF species list export and enhancement of location lookup to include an expanded list of national and regional parks and mining tenements.
- Ongoing consultation with data users and data custodians across all sectors to prioritise future enhancements and refinements of the platform now and for future years.
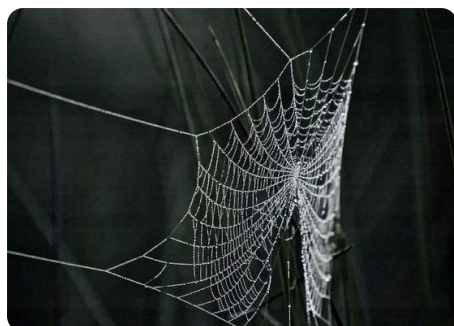
BIO data collation program

CF-2021-45

R Cechner, N Panine, D Murphy, Z Huq, A Barker, C Piper, S Marcus, H Pichette, K Grogan

Context

The data collation program of the Biodiversity Information Office (BIO) brings together data from a range of data sources and providers across industry, government, the public, research sectors and community organisations. BIO is initially focusing on high volume, high quality datasets, particularly those that are not easily accessible at present, driving a step-change in the availability of biodiversity data in Western Australia. The data is ingested into the platform after passing automated quality assurance checks, where it is mapped to the Darwin Core biodiversity data standard and undergoes human-mediated quality control before being released to users.

The initial datasets ingested into BIO's Dandjoo biodiversity data sharing platform have been sourced directly from industry, DBCA repositories, the Western Australian Museum, Department of Water and Environmental Regulation (DWER) and other regulators. New data will continually be ingested, through future automated delivery from regulators and BIO's rolling program to identify and source other valuable datasets. This data collation program will involve outreach to data custodians across all sectors, exploration of technologies to unlock data in pre-digital documents and ongoing monitoring of existing data to identify temporal and spatial gaps.

Aims
- Provide users with access to a rich collection of high-quality datasets.
- Ingest new and up-to-date data over time.

- Enable access to previously undiscoverable and inaccessible datasets held by government and other sectors.

Progress

- BIO curators have ingested over 3.1 million biodiversity records into Dandjoo. Curatorial work on these records is driving a State-wide uplift in data quality, as many have not undergone curation since they were first collected.
- Progressed acquisition of Western Australian biodiversity records from a range of international, state and territory collections so they can be made available to Western Australian data users.
- Reinitiated discussions with DWER on ingesting historical environmental assessment data and re-engineering regulatory processes to allow for the automated ingestion of new data into Dandjoo.

Management Implications

- Access to a greater range of high-quality biodiversity data, including datasets that have not been available in the past, will support better-informed research and decision-making.
- Availability of up-to-date environmental assessment data, mapped to common standards and validated via the curation process, will ensure that environmental decisions are based on current and accurate information.

Future Directions

- Continue to ingest high-quality datasets from within DBCA, the Western Australian Museum and DWER, and connect with data providers across all sectors to secure new data sets.
- Implementation of systematic survey data visualisation and ingestion functionality, ingestion of DWER historical environmental assessment data, and increasing scope of available data for use by government, industry, and community.
- Continue to co-design environmental assessment processes with DWER to embed data ingestion into the BIO platform including through pre-planning and application workflows for industry proponents.

Ecosystem Science

Program Leader: Adrian Pinder

Applied research undertaken by the Ecosystem Science Program seeks to understand the environmental, ecological and biogeographical processes that determine the conservation values, health and productivity of the lands and inland waters managed by the department. The program's research examines the spatial and temporal distribution of the State's biodiversity, and how ecosystems function and respond to threatening processes and management.

Biogeographic studies provide information on the composition of communities and distribution of the State's flora and fauna at scales relevant to management questions. Survey data provide the foundation for a range of management activities, including conservation estate planning, assessing the conservation status of species and communities and predicting the impacts of other land uses and threats.

The program investigates how ecosystems function and respond to water and land resource management practices, including forest management, and to broadscale threats including salinity, altered hydrology, climate change and habitat fragmentation. Projects include investigations into the nature of threats and monitoring associated ecological responses and effectiveness of mitigation strategies. The program also investigates genetic diversity, evolutionary history and ecological plasticity of plant populations to guide vegetation management.

The program collaborates with other parts of the department, museums and herbaria, universities, cooperative research centres, natural resource management groups, CSIRO and other research providers. Partnerships also exist with traditional owners, resource companies and the environmental consulting industry.

Evaluating the application of eDNA and metabarcoding as biodiversity and monitoring tools

SP-2020-68

A Wills, K Fernandes, J Hyde, L Dugal, R Hortin

Context

Ecological monitoring is a key element of adaptive conservation management, but can be resource intensive. In recent years, techniques such as camera traps, audio recorders and satellite tracking have improved effectiveness of monitoring programs. Metabarcoding and environmental DNA (eDNA) are emerging technologies that may be used to enhance environmental monitoring. While no single tool can provide all the information necessary for monitoring, eDNA has some advantages over other methods in some situations. For example, significant taxonomic expertise is often required to identify taxa, especially invertebrates, but such expertise can be difficult to obtain. Additionally, some existing methods are not ideal for detecting elusive or poorly known taxa and can be laborious. eDNA may overcome some of

these limitations, and this project examines how eDNA can be effectively used as a monitoring tool, complementing existing methods and projects for biodiversity conservation.

Aims

- Apply eDNA and metabarcoding methods to a range of survey and monitoring projects to evaluate whether they can effectively replace or complement traditional ecological sampling.

Progress

- Wetlands eDNA kits were tested at two Ramsar wetlands and barcoding of invertebrates has progressed, with Sanger sequencing about to be completed.
- Samples of zooplankton from the Pilbara have been sequenced and bioinformatic analyses have been completed. Data analyses and manuscript preparation are underway.
- Sequence data was analysed from soil microbial samples collected in the Yarragil experimental thinning catchments. Shotgun data is undergoing bioinformatic analysis and a manuscript is in preparation.
- eDNA samples are being analysed on an ongoing basis to track the movement of cane toads in the Kimberley, as part of a collaboration with the Cane Toad management group.
- Samples of dry wetland sediment from the Badimia Conservation Reserves were collected to detect microinvertebrate resting egg banks. Laboratory protocol optimisation of DNA extractions is ongoing.
- Samples of soil, water and sediment were collected from three fire dams in the Perth Hills to assess the ability of eDNA metabarcoding to recover signatures of vertebrate taxa visiting the dams.

Management Implications

- Results of these projects will help inform how eDNA can be applied to enhance the efficiency and scope of ecological monitoring.
- Adoption of standard protocols for eDNA collection, extraction and sequencing will facilitate comparison of survey results from different projects and potentially other organisations.
- The development of reference barcode libraries will improve species discovery, knowledge of species' ranges and ecological requirements and provide greater understanding of ecosystem conservation values and trends.
- Thinning of stand density in the Yarrigil catchments does not affect soil microbiome composition below and between trees, suggesting that range of jarrah forest soil processes may not be affected by thinning, but the open space microbiome will expand as the canopy opens.
- eDNA has been added to the cane toad detection toolkit and is being used at the invasion front.

Future Directions

- Continue to add to the barcode libraries as opportunities arise.
- Synthesise the results of the freshwater eDNA projects and produce guides for use in management.
- Progress a manuscript on the responses of soil microbiomes to ecological thinning.
- Contribute to a paper on the impacts of redclaw crayfish on Pilbara river pools.
- Analyse sequence data and commence a manuscript on the utility of soil eDNA as a forest vertebrate fauna monitoring tool.

Lifeplan: A planetary inventory of life

SP-2020-9

A Pinder, A Barrett, K Quinlan, R Glowicki

Context

Lifeplan is a global biodiversity survey project funded by the European Research Council and led by the University of Helsinki. As a fundamental data platform, Lifeplan will generate standardised, global data on a range of species groups, allowing quantification of variation in ecological communities at spatial scales from 0.1 km to 10,000 km across hundreds of thousands of species. This project is establishing 100 sites globally, with additional denser sampling in the Nordic countries and in Madagascar. Each of the 100+ global sites will consist of paired urban and natural locations. Perth has been selected as one of the global sites, with plots located in woodlands dominated by *Banksia* and *Casuarina* in Lowlands Nature Reserve and Kings Park. In addition to investigating global patterns in biodiversity, the project aims to scale up the use of efficient biodiversity monitoring tools (machine learning analysis of ecoacoustics and camera trapping data,

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and metabarcoding of aerial spores, soil fungi and flying insects). The project will be carried out over six years, with sampling alternating between the Lowlands and Kings Park locations.

Aims

- Gain an understanding of the application and effectiveness of novel biodiversity survey methods through participation in a global project.
- Survey and contrast the biodiversity values of a large semi-rural nature reserve and a large urban bushland with similar dominant overstorey vegetation.
- Improve understanding of the broader biodiversity values of a Threatened Ecological Community (*Banksia* woodlands of the Swan Coastal Plain).

Progress

- The second year of sampling was completed at Lowlands Nature Reserve.
- The second year of sampling at Kings Park commenced.
- Samples of spores from the cyclone sampler and soil were sent to the Swedish University of Agricultural Sciences and insect samples to University of Guelph in Canada.
- Audio and camera trap imagery are being transferred to the project headquarters in Helsinki.
- The project team continued to identify call samples from the Kings Park and Lowlands sites to contribute to machine learning.
- The Perth project team contributed to a paper on global patterns in bird vocalizations that has been submitted to *Nature*.

Management Implications

- Involvement with this global project will provide an improved understanding of the capacity of newer technologies to be employed for efficient survey and monitoring of biodiversity.
- The monitoring will provide insights into threatening processes such as urbanisation, feral animals and fire. In particular, it will provide an understanding of how management of Kings Park has allowed retention of biodiversity inhabiting *Banksia*/*Casuarina* dominated woodlands on the Swan Coastal Plain.
- Information collected add to an understanding of temporal patterns in biodiversity values of the banksia woodlands of the Swan Coastal Plain threatened ecological community, which can be used to design monitoring programs and management actions.

Future Directions

- Continue monitoring at Kings Park and Lowlands Nature Reserve.
- Compile reference libraries of faunal images and assist with providing training data for machine learning of bird calls.
- Undertake botanical surveys at the Lowlands and Kings Park sites to add to the information base for these sites and add context to analyses.

Tracking the condition of Ramsar wetlands in Western Australia

SP-2020-7

M Venarsky, A Barrett, B Huntley, G McGrath, A Pinder

Context

The management of Ramsar wetlands on Western Australia's conservation estate is the responsibility of DBCA, in partnership with external organisations. The department coordinates documentation on the wetlands' condition and reports to the Commonwealth Government for reporting to the Ramsar Secretariat. Like many wetlands globally, Western Australia's Ramsar wetlands are threatened or currently being affected by various factors. These include water resource development, agriculture and urban development, invasive species, mining, plant diseases, salinisation, and climate change. This project aims to undertake monitoring of the State's Ramsar wetlands to improve reporting capabilities and determine efficient monitoring techniques for adaptive management programs.

Aims

- Undertake monitoring of Ramsar wetlands to enable effective management and reporting on their condition.

- Understand spatial and temporal patterns in wetland hydrology, water quality and vegetation structure as primary drivers of wetland biodiversity.

Progress

- Two papers documenting salinity vs water level relationships and how they can inform lake management were prepared based upon data from the Southwest Wetlands Monitoring Program, including lakes in the Muir-Byenup and Toolibin systems.
- Conducted remotely piloted aircraft flights to develop baseline vegetation monitoring data for Muir-Byenup system.
- Conducted waterbird surveys at Thompsons and Forestdale Lakes, Ord River Floodplain (Parry Lagoon) and Lakes Argyle and Kununurra Ramsar site (Lake Kununurra).
- Completed processing of aquatic invertebrate samples for Muir-Byenup wetlands. Results contributed to management effectiveness reporting for the Perup Nature Reserves.
- Completed a final round of sampling for a baseline survey of aquatic invertebrate of the Peel-Yalgorup system.
- Secured funding to outfit Lake Wheatfield with remote telemetry systems for water quality monitoring.
- Reported on trends in water chemistry, aquatic invertebrates and waterbirds of Toolibin Lake, and used results to populate a new format of Ramsar Information Sheet.
- Provided data and advice into multiple Ramsar wetland management and reporting frameworks.
- Implemented a water quality sampling program for the Ord River Floodplain Ramsar site.

Management Implications

- Direct measurements of habitat quality and quantity as surrogate indicators of broader wetland health and biodiversity values will improve the ability to report on limits of acceptable change in the Ecological Character Descriptions.
- Monitoring of waterbird populations will provide consistent data on which to base assessments of ecological character and limits of acceptable change.
- Site specific monitoring and research will provide local managers with information to assist with adaptive management of Ramsar wetlands.
- Data collected for this project contributes to the department's ability to report on ecological character of Ramsar sites.

Future Directions

- Processing of the Muir-Byenup data will continue.
- Resubmit papersdescribing salinity vs water level relationships.
- Install remote telemetry equipment in Lake Wheatfield.
- Work with South Coast NRM and South West NRM to commence a new phase of ecological monitoring of the Lake Gore and muir-Byenup Ramsar sites with National Landcare Program funding.
- Complete processing of Peel-Yalgorup aquatic invertebrate samples and write a paper describing diversity and spatial patterning.
- Continue routine monitoring at other Ramsar wetlands.
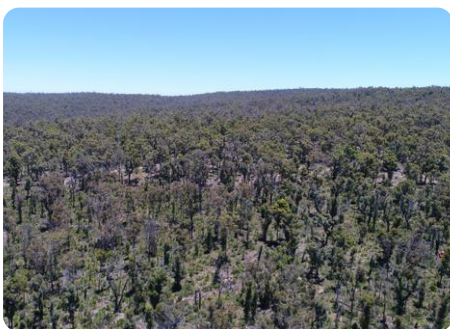
Investigating the causes of change in forest condition

SP-2019-48

K Ruthrof, R Van Dongen

Context

A decline in vegetation density in the north-east of the Forest Management Plan area was noted in *mid-term review of performance of the Forest Management Plan 2014-2023*. The decline is broadly consistent with climate change predictions, although other factors may be contributing. Previous research suggests that *Eucalyptus wandoo* has been undergoing a series of declines associated with drought and increasing temperatures, and a buprestid beetle (*Cisseis fascigera*). *Eucalyptus marginata* and *Corymbia calophylla* have been reported to be vulnerable to acute drought and heatwave events at water-shedding sites with shallow soils, as well as frost events.

More information is needed about the landscape, site and stand characteristics that predispose forests to decline. This project will build on the information available and investigate the contributing factors. Project

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results will provide a greater understanding of the vulnerability of the forest to climate change and assist in developing evidence-based management interventions.

Aims

- Investigate the cause of decline in vegetation density in south-west forests by understanding the interactions of contributing factors.

Progress

- A manuscript on the long-term decline in the north-east of the Forest Management Plan area is being finalised.
- Sites affected by the recent extensive die-off across the southwest are being investigated.
- Data are being collated and will help improve the accuracy of the thresholds used to describe die-off from satellite images.

Management Implications

- Techniques used to map die-off in different types of vegetation type, the thresholds of mortality vegetation communities during drought and heatwaves, and their responses, will help map vegetation health, and manage vegetation communities. For example, knowing where and when jarrah forest experiences die-off will assist in creating vulnerability maps and help planning for where and when ecological thinning could increase forest resistance and resilience.

Future Directions

- Continue fieldwork to validate satellite maps, and report on the die-off event of 2024.
- Publish the manuscript describing the decline in the north-east of the Forest Management Plan area over 30 years.

Understanding the implications of a drying climate on forest ecosystem function to inform and improve climate change adaptation

SP-2019-68

K Ruthrof, G McGrath, R Van Dongen, W Veber

Context

Little is known about the effects of climate change on our forest ecosystems. A broader understanding of the range of effects that climate change has on forest ecology and functioning is required to predict how forest ecosystems will respond to a future climate and extreme weather events. By increasing our understanding, management intervention techniques may be explored that could reduce the severity of changes to forest ecosystems. The Forest Management Plan 2024-2033 specifies that research to address knowledge gaps related to forest conservation, forest health and forest management for climate adaptation will be prioritised. Responding to current impacts of climate change on forest biodiversity and resilience, and forecasting future impacts, will be underpinned by knowledge and understanding of mitigation and adaptation actions.

Aims

- Understand the impacts of climate change and extreme events on structure, composition, and functioning of forest ecosystems in southwestern Australia.
- Investigate responses to ecological thinning in forest ecosystems.

Progress

- A manuscript quantifying the geophysical characteristics and tree structure at drought research sites was published in *Ecohydrology*.
- A manuscript on the effects of drought and wildfire, and the combination of drought and wildfire, on soil microbial communities, was published in *Science of the Total Environment*.
- Fieldwork was undertaken to monitor the impacts of thinning at the Hamilton Block, including establishing permanent survey plots, coarse and fine woody debris, and forest canopy.
- Soil analysis was undertaken at the Munro ecological thinning demonstration site to quantify changes in nutrients with different types of thinning.

- A report on the collaborative fire severity study with the Department of Fire and Emergency Services was written.
- Microclimatic data, including temperature and wind speed has been collected across the different treatment types at the Munro ecological thinning demonstration site.

Management Implications

- The high density of resprouting from stumps at the Hamilton Block thinning trial, indicated that stem control will be needed in the future.
- Soil nutrient analysis, for example, the level of organic carbon in the soil, will help us understand how soil characteristics may be affected by different thinning treatments.
- Microclimatic data, such as temperature and wind speed collected in the different treatment types at Munro will contribute to calculating potential fire behaviour for each treatment, which may influence the type of ecological thinning undertaken in certain locations.

Future Directions

- Given the extensive die-off across the southwest in Autumn 2024, work will be undertaken to determine the impact on vegetation and any interacting factors (such as harvesting and fire histories). This information will help determine vulnerabilities and inform climate change adaptation, such as intervention techniques.

Hydrological function of critical ecosystems

SP-2016-5

J Rutherford, B Huntley, G McGrath

Context

Biodiversity conservation requires an understanding of ecological processes that include balances and fluxes of water, energy and biogeochemistry. These processes are considered in a number of coarse scale ecological assessment and management frameworks but these are difficult to apply at finer or local scales, where an appreciation of hydrological variation is important. To increase confidence in applying coarse scale management frameworks at finer scales, they need to be verified by results from targeted, critical, local scale ecosystem investigations. Critical ecosystem sites are selected where dominant processes driving their behaviour are complex but not unique, so that frameworks for ecosystems with similar hydrological function and response to change can be assessed. The project will investigate the hydrological function of local scale critical water dependent ecosystems, determine and improve our understanding of dominant hydrological processes controlling their physico-chemical sensitivity and responses to change, and feed the results back into coarser scale ecosystem management frameworks. Local scale sites will be selected where ecohydrological data can be collected and integrated with existing biophysical datasets and information to optimise the transferability of hydrological results and outcomes to other areas.

Aims

- Assess and determine the scales and dimensions of data required to map hydrological features being researched and measure change important for interpretation and management.
- Build suitable conceptual hydrological models within the bounds of available data and application requirements.
- Explore critical hydrological parameter and system sensitivities to resolve potential ecohydrological management zones.
- Construct conceptual hydrological models and review the need and uncertainties associated with numerical models.

Progress

- A paper on "Changing processes flooding a salt marsh in a microtidal estuary with a drying climate" was published in *Estuarine, Coastal and Shelf Science*.
- A hydrological monitoring program was established in and around Lake, Mammoth and Calgardup caves of the Leeuwin-Naturalist Ridge for the purposes of evaluating the hydrological response following the December 2021 Boranup fire. The project aims to monitor cave pool and groundwater water levels and water quality.

- The paper to elucidate spring sources in arid NW Australia using geophysical and hydrochemical approaches was submitted to S*cience of the Total Environment*.
- In the Great Brixton Street Wetlands, a monitoring program was designed to trial passive sensors to collect data on metals, organic contaminants and viruses in surface water and groundwater.

Management Implications

- The hydrological monitoring, data analyses and modelling from the Ashfield Flats hydrological study indicate that rising sea levels are increasingly dominating the flooding at Ashfield Flats and this is expected to lead to an increase in the frequency of flooding and vegetation change that should be considered in management planning for the site.
- Methodology to investigate arid zone springs has been developed and can be exported to other arid zone evaporite basins and most coastlines in northwestern Australia to map potential springs and groundwater dependent vegetation and assess their resilience to changed water availability.
- Understanding the fate of contaminants in the Brixton Street wetlands will increase our understanding of hydrological processes and reduce uncertainty in diagnosing changes in vegetation condition.

Future Directions

- Hydrological monitoring of the caves will continue through 2024 with the assistance of local DBCA staff, and staff from the other caves managed by the Margaret River-Busselton Tourist Association.
- Work with DBCA West Kimberley District staff to interpret and publish local-scale hydrological data collected in the Walyarta organic springs between 2019 and 2022.
- Implement Greater Brixton Street Wetlands passive sampler trial.

Responses of terrestrial vertebrates to management in the jarrah forest

SP-2012-38

A Wayne, C Ward, M Maxwell

Context

Understanding the impacts of management activities, such as timber harvesting and fire, on the terrestrial vertebrates of the jarrah forest is necessary for biodiversity conservation and development of ecologically sustainable forest management. This project began in 1994 and uses a before-after, control-impact study design to intensively investigate biodiversity responses to, and ecological consequences of disturbance by forest management.

Aims

- Investigate the effects of management activities on terrestrial vertebrates in jarrah forest ecosystems.
- Provide information that helps improve ecologically sustainable management and biodiversity conservation in the jarrah forest.

Progress

- Vehicle based spotlight monitoring of mammals on three standardised transects was conducted in Spring 2023 and Autumn 2024 (3 repeat surveys per transect per season). These surveys occurred after a gum leaf skeletoniser outbreak that impacted approximately 100,000 hectares of the Upper Warren region during the summer of 2022-23, including the areas surrounding the three long-term monitoring transects in Greater Kingston. While no substantial declines were observed in the detection rates of the critically endangered ngwayir (western ringtail possum) or koomal (brushtail possum), it is possible that significant declines may be observed in the coming year.
- A pedestrian-based spotlight survey involving 110km of transects across one of the long-term monitoring sites was conducted in April 2024, resulting in 59 and 438 independent detections of ngwayir and koomal respectively.
- Analyses of both datasets are underway.

Management Implications

- Identification of decline in ngwayir numbers in the Upper Warren region (including greater Kingston area) contributed significantly to the recent elevation of its conservation status to critically endangered.

- Information on the effects of the gum leaf skeletoniser outbreak, forest management and other environmental factors on terrestrial vertebrates and the factors responsible for changes in populations will lead to improved ecologically sustainable forest management practices and the conservation of biodiversity.

Future Directions

- Publication of results in a peer-reviewed paper.

Western Australian flora surveys

SP-2012-5

M Lyons, A Markey, M Langley, A Barrett, R Binks

Context

Flora surveys of targeted areas provide knowledge of floristics and vegetation pattern and structure for a variety of purposes, including provision of baseline biodiversity data, monitoring of management effectiveness, understanding distributions of threatened taxa, defining threatened and priority communities, determining suitability of vegetation for fauna translocation and conservation operations such as fencing and stock control. Recent surveys have included flora and vegetation surveys in the West and Central Kimberly and targeted flora surveys in Karijini National park.

Aims

- Undertake targeted surveys to provide specific management advice, monitor long-term change in vegetation at specific sites and specific communities, or fill specific knowledge gaps.

Progress

- A survey of wetlands on jointly managed Badimia lands was conducted with Midwest Region staff in August 2023 to further sample wetland flora following limited rains. Collected specimens, including several priority flora species have been identified. Further progress is dependant on there being substantial rains in the area.
- An aerial and ground based survey to identify occurrences and document the floristics of rainforest patches in Wunaamin Conservation Park was completed with traditional owners and staff from DBCA West Kimberly District. A report has been completed and the occurrence data will contribute to ongoing fire management planning for the reserve.
- A project to re-analyse floristic community data for the Swan Coastal Plain continued. The analysis is now complete and the resultant classification is under review by staff with expertise in the floristics of the Swan Coastal Plain.
- The genetic identification of unknown Kimberley *Typhonium* specimens is ongoing as a collaboration between DBCA and Department of Primary Industries and Regional Development, with the third round of identifications currently underway.
- The second stage of sequencing for the Pilbara barcoding project is now complete, adding another 400 chloroplast genomes to the existing database of Pilbara plant species.

Management Implications

- Genetic identifications improve understanding of the distribution and abundance of threatened *Typhonium* species in the Kimberley to inform conservation and land management practices in the region.
- The generation of a database of genomic data for Pilbara plant species will provide barcoding opportunities for cost-effective survey and monitoring practices throughout the Pilbara.
- Identification of Rainforest patches in Wunaamin CP will enable planning of fuel reduction burning operations to avoid impacting these fire sensitive plant communities.
- The updated analysis of the Swan Coastal Plain floristic data will provide a more comprehensive and robust suite of Floristic Community type definitions for the Swan Coastal plan as a basis for ongoing conservation planning in the region.

Future Directions

- Expand floristic sampling at Badimia wetlands depending on adequate rainfall.

- Complete floristic community type descriptions for the Swan Coastal Plain.

Long-term stand dynamics of regrowth forest in relation to site productivity and climate

SP-2011-20

R Mazanec

Context

This project provides information to underpin the management of karri and jarrah regrowth stands in the immature stage of development (25-120 years old). Regenerated stands have important values for biodiversity conservation and as a store of terrestrial carbon. Immature karri stands that regenerated following timber harvesting and bushfire comprise more than 50,000 hectares and represent around one third of the area of karri forest managed by the department. Large parts of the jarrah forest are also comprised of predominantly even-aged regrowth. There are a number of experiments that investigate the dynamics of naturally regenerated and planted stands managed at a range of densities. These experiments span a range of site productivity and climatic gradients and have been measured repeatedly over several decades, providing important information to support and improve management practices.

This project addresses emerging issues for the next decade of forest management, including climate change and declining groundwater levels, interactions with pests and pathogens and increased recognition of the role of forests in maintaining global carbon cycles. The scope of this project has been broadened to include thinning response of even-aged jarrah stands, with all thinning experiments now covered by this project.

Aims

- Quantify the response of immature karri and jarrah stands to management practices that manipulate stand density at establishment or through intervention by thinning. Responses will be measured by tree and stand growth, tree health and other indicators as appropriate (for example, leaf water potential and leaf area index).

Progress

- A paper on the effect of stand density on growth and allometry of marri was published in T*he Journal of the Royal Society of Western Australia.*

Management Implications

- Analysis of stand density demonstrated that thinning is a useful tool for promoting growth on retained trees and has potential for use in water catchment management, timber production and wildlife conservation. Large trees resulting from thinning are likely to produce higher quality habitat and food resources for arboreal and avifauna.

Future Directions

- This project is complete.

Western Australian wetland fauna surveys

SP-2011-18

A Pinder, K Quinlan, D Cale, A Barrett

Context

Regional biological surveys provide analyses of biodiversity patterning for conservation planning at broader scales but sites in these projects are usually too sparse for use at a more local scale, such as individual

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reserves, catchments or wetland complexes. This project is designed to fill gaps within and between regional surveys by providing aquatic invertebrate biodiversity data and analyses at finer scales. Recent examples of such projects are wetland surveys in the Upper Fortescue catchment in the Pilbara, Lake Carnegie and Kimberley Mound Springs.

Aims

- Provide an understanding of aquatic biodiversity patterning at the scale of individual wetlands to wetland complexes, catchments or regions to inform local conservation planning and as baselines for future monitoring.
- Provide better data on the distribution, ecological tolerances and conservation status of aquatic fauna species and communities.

Progress

- A report was completed on a second survey of wetland invertebrates inhabiting wetlands of Kurriji Pa Yajula Nature Reserve and adjacent soaks on Karajarri Indigenous Protected Area in the Great Sandy Desert.
- A report on aquatic invertebrates of Deefor Road wetland in the Wandoo National Park was completed. Samples from two associated wetlands were processed for the same project.
- Identifications of aquatic invertebrates for a project to examine impacts of redclaw crayfish in the Pilbara have been completed. Metabarcoding of plankton samples is underway for comparison with morphologically derived diversity data.
- Identifications of macroinvertebrates inhabiting 17 wetlands across the Wheatbelt were completed. These were collected in 2021 to examine the extent to which wetland invertebrate communities of the area recovered in a wet year, after previous analyses showed declines in alpha and gamma diversity over 16 years (1997 to 2012) of declining rainfall.
- Specimen data on a reference collection database were incorporated into a larger aquatic fauna database creating a more efficient system for tracking and maintaining identifications.

Management Implications

- New knowledge of the biodiversity values of arid zone wetlands will assist with assessing the conservation status of species and communities and environmental impacts of mining and pastoralism.
- Species level invertebrate data can assist in understanding the conservation significance of individual species and in refining descriptions of threatened ecological communities.
- Wetland survey work is providing information to understand the threats posed by redclaw crayfish in the Pilbara and inform actions to minimise its spread.

Future Directions

- Analyse invertebrate data to understand impacts of redclaw crayfish on Pilbara river pool communities
- Analyse invertebrate data to understand resilience of Wheatbelt wetland communities to a prolonged decline in rainfall.
- Undertake surveys of wetlands on Badimia lands in the MidWest Region and Ngadju lands in the Goldfields Region. These will fill two significant gaps in understanding of the diversity and distribution of aquatic fauna in WA arid zones and provide benchmark data for assessing impacts of resource development and effectiveness of management.
- Publish a review of diversity and distribution of aquatic invertebrate communities within vegetated clay-based wetlands of south-western Australia.

FORESTCHECK: Integrated site-based monitoring of the effects of timber harvesting and silviculture in the jarrah forest

SP-2006-3

A Pinder, A Wills, G McGrath, J Hyde, K Ruthrof, L Dugal

Context

FORESTCHECK has been a long-term monitoring program and results have been used by forest managers to report against Montreal Process criteria and indicators for ecologically sustainable forest management. Initiated as a Ministerial condition on the *Forest Management Plan 1994-2003*, FORESTCHECK was incorporated in the *Forest Management Plan 2014-2023* as a strategy for increasing knowledge on the

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maintenance of biodiversity and management effectiveness in Western Australian forests.

Aims

- Quantify the effects of timber harvesting and silvicultural practices in the jarrah forest (gap creation, shelterwood, post-harvest burning) on forest structural attributes, soil and foliar nutrients, soil compaction and the composition of the major biodiversity groups including: macrofungi, cryptogams, vascular plants, invertebrates, terrestrial vertebrates and birds.

Progress

- A paper analysing biotic responses to harvesting and fire in 16 FORESTCHECK sites sampled from 2013, in the Donnelly South and Sandy Basins jarrah forest ecosystems, has been published in *Forest Ecology and Management*. Analyses showed harvesting had minimal impacts on biotic richness but some effect on fungal composition. Time since fire was associated with increased invertebrate diversity and slightly reduced diversity of vertebrates and fungi. Community composition was associated with time since fire, especially for plants and invertebrates.
- A manuscript is in preparation showing that soil eDNA may complement rather than replicate invertebrate pitfall trapping.
- A second round of sampling of soil DNA extractions from FORESTCHECK sites was completed, with this round of sampling also including burrows and hollows. These samples are being sequenced with three vertebrate-specific primer sets to examine detections of local fauna.
- Vertebrate barcoding using specimens from a variety of sources, including the Western Australian Museum, is continuing.
- Data are being prepared for lodgement in an international repository and associated data papers are being prepared.

Management Implications

- FORESTCHECK has provided a systematic framework for evaluating the effects of silvicultural practices in jarrah forests and provided a sound basis for adaptive management.
- The project has demonstrated that harvesting had no impact on richness of most biological groups. Richness of cryptogams was higher in unharvested sites in the first monitoring round and richness of ground-dwelling vertebrates was higher in harvested sites in rounds one and two, but not for the later 16 sites. Harvesting did not affect the composition of most biological assemblages, except that bird and cryptogam communities differed between unharvested and some harvested sites in the original 48 sites, and harvesting was a small but statistically significant influence on fungal composition in the more recently sampled 16 sites.
- Findings from the project will continue to inform a variety of forest management policies and practices and contributed to development of the Forest Management Plan 2024-2033.
- The network of FORESTCHECK grids will remain in place and provide locations with known characteristics and history that will be useful for future forest research and monitoring. Some will be included in a new forest health monitoring program.
- eDNA may provide an efficient tool for monitoring forest biodiversity and health.

Future Directions

- Archive remaining FORESTCHECK project data in suitable repositories and ensure integrity of the grid sites. Publish data papers promoting the value and use of FORESTCHECK data and the site network.
- Investigate further analyses of FORESTCHECK data, such as for biogeographic patterning across the jarrah forest.
- Continue the analyses and write up of a manuscript on the soil microbiome of the jarrah forest.
- Complete current eDNA based monitoring projects, including the analysis of vertebrate sequence data originating from soil, hollow and burrow samples collected throughout the jarrah forest

Hydrological response to timber harvesting and associated silviculture in the intermediate rainfall zone of the northern jarrah forest

SP-2000-3

G McGrath, B Huntley, R Van Dongen

Context

This long-term experiment was established in 1999 to address a Ministerial Condition attached to the *Forest Management Plan 1994-2003* to monitor and report on the status and effectiveness of silvicultural measures in the intermediate rainfall zone (900-1100mm/yr) of the jarrah forest to protect water quality. The project, focused on the Yarrigil thinning trial site near Dwellingup, evaluated groundwater and streamflow responses to a 1983 thinning trail and currently the responses to a re-thinning the catchment in 2019.

Aims

- Investigate the hydrological impacts of timber harvesting and associated silvicultural treatments in the intermediate rainfall zone of the jarrah forest in a changing hydroclimate.

Progress

- LiDAR data was captured along transects at 4L and the nearby catchment 4X via a remote piloted aircraft (RPA). Raw data was post-processed and post-processed data is undergoing further analysis by project partners.
- Continuous hydrological monitoring of groundwater levels and streamflow was conducted.
- Vegetation monitoring was undertaken with basal area transects. Stem samples were collected every two months for water isotopes.

Management Implications

- Re-thinning of Yarragil 4L provides an opportunity to examine the effects of the silvicultural treatments on the groundwater and surface water hydrology, biodiversity, and vegetation structure and composition of the catchment. The experimental catchments at Yarragil provide the only continuous long-term record of the hydrological response of the headwaters of the jarrah forest to climate change and forest management practices enabling managers to better assess how thinning impacts forest and riparian zone health.

Future Directions

- Long-term changes to groundwater and streamflow from the 2019 thinning at 4L will continue to be monitored. This project will be completed in 2025, with data transferred to and some activities continuing under a new project.

Genetic analysis for the development of vegetation services and sustainable environmental management

SP-1998-7

M Byrne, M Millar, R Binks, N Delnevo

Context

Understanding the genetic structure and function of plants is important for their effective utilisation for revegetation, mine-site rehabilitation and provision of ecosystem services, such as hydrological balance, pollination and habitat connectivity.

Aims

- Provide genetic information for the conservation and utilisation of plant species for revegetation and rehabilitation. Current work aims to identify seed collection zones for species used in rehabilitation of mine sites in the Pilbara.

Progress

- The final data paper for this project has now been published. Analyses of genetic diversity in *Senna glutinosa* subsp. *glutinosa* found very high levels of clonality within populations, and further analysis of seedlings revealed many of them to have identical genotypes as their mother plant, confirming apomixis as the dominant reproductive strategy, although some sexual reproduction was evident. Apomictic clones were distributed across the Pilbara landscape with no particular geographic pattern. This evidence of long-distance seed dispersal is likely driven by water movement following cyclonic activity. These results have been published in the *Journal of Biogeography*.
- A synthesis manuscript is being prepared that summarises broad genetic patterns in the eleven Pilbara species studied to date, focusing on seed collection and provenancing strategies for mine site

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restoration.

Management Implications

- Understanding patterns of genetic diversity provides information for seed collection strategies in restoration and revegetation. Analysis of a range of species in the Pilbara provides species-specific information to support effective mine site restoration.
- The low level of population differentiation across the range of *S. glutinosa* subsp*. glutinosa* indicates that seed resources for land rehabilitation and mine site revegetation programs for this species can be selected from a wide distributional range within the Pilbara.

Future Directions

- Finalise the synthesis paper to summarise the major genetic patterns seen across the Pilbara flora to inform broad recommendations for seed sourcing strategies used in mine site restoration.

Fire Science

Program Leader: Ben Miller

The Fire Science Program seeks to inform fire management and biodiversity conservation on lands managed by the department, including state forests, national parks and other conservation reserves. The strategic goal of the program is to ensure that the best available scientific information is used for integrated fire management to protect communities and natural values. Key themes for the program include developing and validating decision support tools for fire management, and understanding the effects of fire regimes on species, ecosystems and landscapes and how these interact with threatening processes including weeds, introduced predators and climate change. Monitoring and learning from the outcomes of prescribed burns and bushfire incidents is also an important activity for the program. Strong collaborative linkages exist with universities, cooperative research centres, CSIRO, the Bureau of Meteorology, other government agencies and private sector research providers.
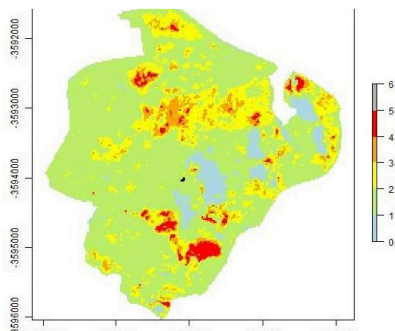
Development of a systematic approach to monitoring and reporting on the outcomes of prescribed burns and bushfires

SP-2018-134

V Densmore, K Zdunic

Context

Fire severity describes the amount of biomass removed, reduced or substantially altered (for example, charred) by either unplanned bushfire or planned burning. Severity relates to fire intensity but extends consideration beyond fire behaviour to incorporate ecological effects and structural changes. Thus, fire severity represents a valuable approach to gauge how planned burning or unplanned fire has impacted future fire hazards and the persistence of habitat for flora and fauna. A systematic tool to assess fire severity supports the objective evaluation of the outcomes of decision making, the methods used to apply planned burns, and assists in meeting statutory reporting obligations including fire management performance indicators and potential impacts on listed flora and fauna.

Aims

- Develop a framework for a systematic approach to assessing and reporting the outcomes of prescribed burns and bushfires based on remote sensing and field surveys.
- Develop and test a variety of reporting tools and metrics related to environmental outcomes.

Progress

- Burn severity mapping workflow was established to the satisfaction of the Burn Severity Monitoring Working Group.
- A paper relating key fauna habitat variables to burn severity classes has been submitted and is currently under review at *Australian Forestry*.

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- Fauna habitat look-up tables have been drafted for severity classes within forested districts in south-western WA.
- Severity mapping being utilised in a case study examining the effectiveness of prescribed burning to reduce the extent of multiple bushfires ignited in Perth Hills on a single day in Nov 2023.
- Severity models and historic severity mapping supported a successful 3-year Commonwealth Disaster Ready Fund grant application to investigate severity models for heath/shrublands, interactions between severity and fuel accumulation, additional historical mapping, vegetation mapping and development of knowledge-sharing platforms.

Management Implications

- Severity maps are being used to report actual area burned and impact of prescribed burns and bushfires to Government.
- Fire managers are adjusting burn objectives and success criteria within burn prescriptions to incorporate data provided by severity mapping. This represents a substantial change to specific and measurable metrics, such as percentage area within a target severity class, increasing accountability for decisions made regarding burn implementation, thus supporting adaptive fire management.
- Historical severity maps are being used to improve the accuracy of fire history records, helping to improve confidence in fire management by DBCA.
- Historical severity maps assist in fire management planning by enabling comparison of consecutive fire events, evaluation of the role of prior severity in mitigating severity of subsequent fire events and monitoring changes to fire regimes as climate changes.

Future Directions

- Pending publication of the manuscript under review at *Australian Forestry*, which relates key fauna habitat variables to burn severity classes, the project is complete.

Evaluation of synergies among fire and weed management in urban biodiversity and fire management

SP-2018-46

B Miller, R Miller

Context

The social and conservation values of remnant natural ecosystems in urban and peri-urban environments can be significant, particularly where they include threatened species and communities, such as the nationally listed 'Banksia woodlands of the Swan Coastal Plain ecological community'. Fire management of these systems is particularly complex as they are often: very close to homes, businesses and infrastructure; exposed to high ignition likelihoods; fragmented; subject to a wide range of other threats and disturbances; and susceptible to invasion or already supporting a number of pest plant and animal species. The spread of grassy weeds, in particular, can be enhanced by fire and promotes changes in fire regime. Knowledge of interactions between fire regimes and weed invasion will provide a basis for synergies in fire and weed management that may deliver beneficial outcomes. The study design and replication, and fuel, plant species and community response data, provide valuable research infrastructure that associated student projects and other studies can use (for example, soil properties and invertebrate responses).

Aims

- Assess outcomes for prescribed and wild fire management, weed management and persistence of native plant species in urban and peri-urban areas by testing a range of fire and weed management approaches.

Progress

- Weed management was continued at the Kings Park, Bold Park and Yangebup sites.
- Comprehensive floristic surveys were conducted at Kings Park, including confirming previous records and improving data quality.
- Analysis of fuels data is in the final stages, and a manuscript is being prepared for submission to scientific journal.
- Cleaning of floristic data is in the final stages and will soon be ready for final analyses.
- A planned burn at the Bold Park site was postponed this year due to unsafe burn conditions during autumn 2024 drought conditions. The burn has been re-planned for 2025.

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- Presentations and site visits were held with a variety of internal (BGPA) and external stakeholders, including local councils and local community groups, to share findings and demonstrate management implications.

Management Implications

- Identification of optimal combinations of weed and fire management treatments will provide a basis for recommendations for the management of peri-urban and urban bushlands.
- Burning without weed management results in increased grass weed cover and poor recovery of native species.
- Post-burn weed management is effective in maintaining low levels of weed cover at pre-burn levels (or lower) and beneficial for native community regeneration.

Future Directions

- Ongoing implementation of weed management treatments and floristic and fuel surveys in all sites where required.
- Re-initiate planning for experimental burn in the Bold Park site.
- Complete analyses of fire-grassy weeds interactions and submit manuscript for publication.
- Complete cleaning of floristics data, and progress analyses of floristic response to burn and weed treatments across all sites.

Long term response of jarrah forest understorey and tree health to fire regimes

SP-2012-29

V Densmore, S Samson

Context

This study is a long term strategic research project to better understand the effects of fire regimes, including prescribed fire, on the floristic composition of jarrah forests. This knowledge is essential for developing and implementing ecologically appropriate fire regimes and managing fire to reduce risk to the community, biodiversity and other environmental values.

Aims

- Understand and quantify the long-term effects of fire regimes on the floristic composition of jarrah forests.
- Determine the long-term effects of various fire regimes on tree health and growth rates.
- Utilise the established plots to compare fire behaviour outputs, drivers and ecological responses between prescribed burning and Indigenous-led Cultural Burning approaches.
- Monitor potential interactions between climate change and fire regimes and their impacts on floristic composition and fire behaviour in jarrah forests.

Progress

- Burning regimes continued at sites with planned burn treatments at Perup (plots 2 and 10).
- Collected leaf litter samples and purchased equipment for undertaking leaf litter decomposition surveys.
- Purchased five Kestrels to undertake weather monitoring at plots during spring 2024 and summer and autumn 2025.
- Explored steps that may enable Indigenous-led cultural burning to be included as treatments within plots at both the Perup and McCorkhill sites.

Management Implications

- Being one of a few long-term studies of its kind around the world, the findings of this study are important for guiding fire management policy and planning for community protection and biodiversity conservation.
- Knowledge and understanding gained from this long-term study have been incorporated into a fire ecology training program that is delivered to employees involved in fire management planning and operations.

- Within the fire frequency and intensity ranges investigated in this study, there was flexibility in the application of prescribed fire to achieve management goals without loss of plant diversity.

Future Directions

- Continue current burning regimes with the next burn treatments planned at McCorkhill (plots 6 & 10).
- Measure leaf litter decomposition rates and monitor weather conditions across treatments at the McCorkhill and Perup plots.
- Maintain the integrity of the study sites for ongoing monitoring in the longer term.
- Investigate potential for establishing new burning regime in "burnt once only" plots (2 per site) and 2 "spare" plots at the McCorkhill site.
- Implement new monitoring and a review of floristic change data.

North Kimberley Landscape Conservation Initiative: monitoring and evaluation

SP-2012-27

I Radford

Context

This project is a biodiversity monitoring and evaluation program to inform adaptive management of fire and cattle in the north Kimberley. The adaptive management program that forms the Landscape Conservation Initiative of the *Kimberley Science and Conservation Strategy* commenced in 2011 in response to perceived threats by cattle and fire to biodiversity conservation in the North Kimberley. This initiative is based on the hypothesis that large numbers of introduced herbivores and the impacts of current fire regimes are associated with declines of critical weight range mammals, contraction and degradation of rainforest patches, and degradation of vegetation structure and habitat condition in savannas. This monitoring and evaluation program will provide a report card on performance of landscape management initiatives in the north Kimberley, particularly prescribed burning and cattle culling, in maintaining and improving biodiversity status.

Aims

- Inform management of biodiversity status in representative areas after prescribed burning and cattle control programs have been applied.
- Provide warning when landscape ecological thresholds have been reached, for example, decline of mammals to below 2 percent capture rate, or decline of mean shrub ground cover to less than 2 percent.
- Compare biodiversity outcomes in intensively managed and unmanaged areas to evaluate the effectiveness of management interventions in maintaining and improving conservation values.
- Investigate cane toad and predator interactions that may influence mammal abundance.
- Elucidate influence of different burning approaches to threatened plant taxa in the North Kimberley.
- Investigate interactions between fire and weed invasion.

Progress

- Five live-trapping surveys were undertaken, including the fifth survey of Orchid Creek in Drysdale River National Park (DRNP), the tenth and eleventh survey of Dulundi and Mount Hart in Wunaamin Miliwundi Range Conservation Park (WMRCP), and the eighth survey of Cascade Creek in Prince Regent National Park (PRNP).
- The fifth camera trap and obligate seeder helicopter-based survey of remote PRNP fire-plots was undertaken.
- Three journal articles from theproject were published in *Forest Ecology and Management*, *Biological Conservation* and *Wildlife Research*, with DNA samples collected contributing to two others.
- A second year of vegetation survey and herbicide-burning treatment applications was conducted at six experimental plots at WMRCP. Data analysis is underway.
- Monitoring near Mt Hart recorded the first brushtail possums since 2011.

Management Implications

- The project continues to provide annual, real-time feedback into adaptive fire and feral herbivore management.

- Reduced extent of late dry season wildfire, increased effectiveness of herbivore management and resulting increase in grass cover (>10%), has allowed threatened mammals at Orchid Creek DRNP to attain their highest abundance and species richness since 2013. This emphasises the importance of reducing wildfire extent via prescribed burning and feral herbivore control.
- Extensive fires in previously long unburnt vegetation at Mt Hart in 2023 led to the lowest mammal abundance and species richness since 2011. Careful fire management is needed to compartmentalise highly flammable, but preferred, long unburnt vegetation, to prevent this from happening in the future.
- More strategic application of burn mosaics to retain larger patches of long unburnt vegetation resulted in increases in mammal abundance and species richness as Cascade Creek in remote areas of PRNP.

Future Directions

- Annual monitoring surveys and reporting will continue as part of the evidence-based evaluation of Kimberley adaptive management effectiveness.
- Survey newly established remote sites in WMRCP, FRCP, DRNP and PNP.
- Resurvey sites to include additional priority flora and fire-sensitive obligate seeder species.

Fire regimes and impacts in transitional woodlands and shrublands

SP-2010-11

C Gosper

Context

The Great Western Woodlands (GWW) is an internationally significant area with great biological and cultural richness. This 16 million hectare region of south-western Australia contains the world's largest and most intact area of contiguous temperate woodland. The GWW Conservation Strategy and a review conducted by a wide range of scientific experts identified inappropriate fire regimes as a threat to the woodlands and emphasised the need for a science-based fire management regime for the area. Critical gaps in the knowledge of fire ecology for GWW ecosystems are a hindrance to ecological fire management in the region. The GWW supports eucalypt woodlands at very low mean annual rainfall (250-350mm). Many of the woodland eucalypt species are killed by fire (obligate-seeders), and eucalypt recruitment is stimulated by fire but individuals are slow growing. In recent decades a large part of the GWW has been burnt and concern has been expressed over the ecological impacts of this. Fire ecology research already undertaken in eastern Wheatbelt nature reserves will help resolve ecological fire management issues for mallee and mallee-heath communities in the GWW but similar information for the dominant eucalypt woodlands is needed.

Aims

- Develop a method to robustly estimate stand time since fire in gimlet (*Eucalyptus salubris*) woodlands that have not been burnt during the period covered by remotely-sensed imagery, allowing the scale of recent extensive wildfires to be placed in a historical context.
- Investigate the effects of time since fire on the assembly and recovery of gimlet woodlands, including on plant and animal community composition, development of ecosystem structure and changes in carbon dynamics.
- Produce a spatially explicit representation of long-unburnt woodlands through linkage of plot data on vegetation structure with remotely-sensed imagery.

Progress

- Analysis of on-ground vegetation structure measurements of tree allometry in combination with plot-scale high-resolution remotely piloted aircraft LiDAR, landscape-scale medium-resolution airborne LiDAR and global coarse-resolution GEDI satellite LiDAR demonstrated that woodland age classes can be reliably distinguished based on their 3D canopy structure and supported delineation of vegetation structural features and LiDAR metrics that scale robustly across platforms. This research has supported development of a spatially explicit map of woodland age classes across the whole GWW, and has been published in papers in *Remote Sensing of Environment* and *Remote Sensing in Ecology and Conservation*.
- Vegetation structure and biomass data from the *E. salubris* chronosequence was used to calculate changes in woodland carbon stocks with time since fire and prior fire interval, finding that biomass carbon is greater in long-unburnt woodlands and carbon losses due to fire are buffered by a long prior fire interval. This work has been published in the *International Journal of Wildland Fire* and is being used to calculate carbon stocks in eucalypt woodlands across the GWW, in collaboration with CSIRO

Environment and supported by Woodside Energy.

- Understanding derived from documenting fire response, reproduction and seed dispersal traits of plant species on the *E. salubris* chronosequence informed development of intuitive names, a clear scope and explicit description of plant traits for the AusTraits Plant Dictionary, with this resource covering over 500 traits available online and published in *Scientific Data*.
- An overview of the effect of time since fire and prior fire interval on the response of flora, ants, birds, fuel and vegetation structure from the *E. salubris* chronosequence was published in the *Journal of Ecology and Environment*, forming one of three plot networks associated with the broader ecosystem monitoring infrastructure of the Great Western Woodlands TERN (Terrestrial Ecosystem Research Network) SuperSite.
- Similarities in structure, function and threatening processes has allowed the development of a structured framework for generalised state-and-transition models to inform recovery planning for threatened eucalypt woodland communities across southern Australia. This work has been accepted for publication in the *Journal of Applied Ecology*. Obligate-seeder eucalypt woodlands were one of six woodland subtypes under the 'Eucalypt woodland' umbrella class for which state and transition models of community response to disturbance were derived from expert option and published as part of the *Australian Ecosystem Models Framework*.

Management Implications

- National-scale syntheses of temperate eucalypt woodland responses to disturbance revealed that many Western Australian woodlands are uniquely dominated by taxa that are obligate seeding, and have vegetation dynamics driven by rare, stand-replacing disturbances. These characteristics illustrate a putative vulnerability to decreases in intervals between bushfires and increases in bushfire extent, with large changes in vegetation composition and structure and losses of carbon stocks after woodlands are burnt and especially with short prior fire intervals. This information contributes to understanding ecological and functional responses of obligate-seeder eucalypt woodlands to fire.
- Post-fire succession in vegetation composition and structure, which in turn determines successional patterns in animals, occurs over multi-century timescales, demonstrating the value of avoiding fire in mature woodlands to maximise future fire management options.
- A spatial map of multi-century GWW woodland age classes provides the basis for departmental, Department of Fire and Emergency Services, local government and Indigenous fire managers to plan fire mitigation and suppression activities to minimise loss of mature woodlands in bushfires.
- Models of biomass carbon stocks in woodlands, and their response to time since fire and prior fire interval, supports testing of the economic and implementation feasibility of a fire management carbon methodology for obligate-seeder eucalypt woodlands.

Future Directions

- Expand models of carbon stocks in eucalypt woodlands to be applicable across the geographic extent of the GWW through consideration of climate gradients and different woodland types.
- Continue development of using LiDAR metrics to track woodland structural characteristics over space and time.
- Provide data to underpin investigations of the potential for a fire management-based carbon accounting method in GWW eucalypt woodlands, accounting for carbon fluxes with fire and woodland growth.

Kings Park Science

Program Leader: Jason Stevens

Kings Park Science undertakes research in native plant biology, underpinning the conservation and ecological restoration of Western Australia's unique biodiversity and biodiversity generally. Research focuses on the key areas of restoration ecology and ecophysiology, seed science, conservation genetics, conservation biotechnology, ecosystem ecology, fire ecology and systematics. Research is prioritised to enhance practical outcomes in conservation and management, and sustainable development of the State's unique natural resources. The Program delivers science capacity underpinning the State's botanic garden and the lands managed by the Botanic Gardens and Parks Authority, and the horticultural development of the Western Australian flora. The Program has a long history of successful postgraduate student supervision in collaboration with Western Australian universities, and contributes to undergraduate teaching, predominantly in conservation biology and restoration ecology.

Conservation biotechnology

CF-2018-48

B Funnekotter, K Elder

Context

Research into *in vitro* and cryogenic science streams is essential to progress and enhance the *ex situ* conservation and germplasm storage options for threatened plant species, where other forms of germplasm storage are not possible. The micropropagation of threatened taxa also provides a source of greenstock for plant translocation studies in cases where normal propagation is not possible. A range of species are kept in liquid nitrogen storage for conservation and research purposes, including many rare and threatened vascular plant taxa and seeds and mycorrhizal fungi of many native orchid species, including a number of rare taxa.

Aims
- Develop micropropagation for plants requiring translocation and for living collections.
- Develop cryopreservation protocols for *ex situ* long-term storage of germplasm of selected species.

Progress
- An overview document has been created documenting the stage of each species in the active tissue culture and cryogenic collections, and what future research is needed on that species. This provides a clear purpose for each species in the collection.
- In total five new species were added to the tissue culture collection. Two *Syzygium* species and one *Eugenia* species were added to the collection due to their known myrtle rust sensitivity. Six accessions of *Cephalotus follicularis* was added into the active collection received from Plantrite. Five accessions of *Androcalva perlaria* were raised from cryostorage to provide additional material as insufficient vials

were cryopreserved for each accession.
- Four species were added into cryo-storage, with a focus on *Philotheca basistyla* where 9 accessions consisting of 115 vials were cryopreserved.

Management Implications

- *In vitro* propagation provides *ex situ* germplasm material for threatened species where cutting propagation or seed is unavailable. This approach provides biosecure storage in culture collections or cool storage for selected genetic material of endangered plants. This material can be accessed to provide plants for future translocations if required.
- Cryopreservation provides very long-term biosecure storage of shoot tips, protocorms, seeds and other material of threatened plant species, which can be revived and utilised to produce plants for restoration purposes.

Future Directions

- Develop protocols to initiate new species of interest into tissue culture, including *Acacia volubilis*, and four species relevant to a new industry partnership with Alcoa (*Lomandra, Lepidosperma, Netrostylis* & *Tetrarrhena* species).
- Explore new innovations to improve tissue culture performance of challenging species, with a focus on new technologies (i.e. temporary immersion and bioreactor systems), reaching out to international experts to understand limitations and applications.
- Continue research to understand the effects of cryopreservation on the metabolism of plant germplasm.
- Develop cryopreservation protocols for 'exceptional' species that may possess recalcitrant seeds and/or may be threatened by myrtle rust in the future.
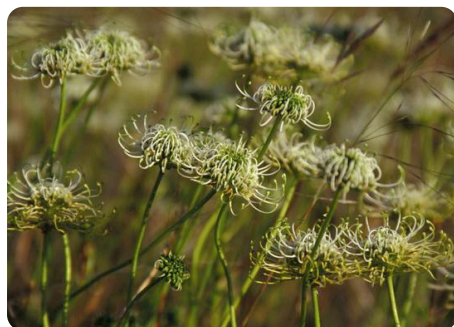
Conservation genetics

CF-2018-68

S Krauss, C Elliott, N Maher, J Anthony

Context

The conservation, restoration and horticultural development of Western Australia's unique biodiversity is informed by understanding of patterns of genetic diversity at multiple hierarchical levels (individuals, populations, species, communities), as well as the key ecological and evolutionary drivers of this genetic diversity, such as adaptation, mating and dispersal. Research into conservation genetics seeks to understand the impacts on genetic diversity and the key drivers of this diversity from environmental stressors, such as habitat fragmentation, mining, climate change and introduced species, and identify solutions based on genetic data and theory.

Aims

- Experimentally assess seed sourcing strategies for restored plant communities that are resilient to changing climate and altered substrates.
- Engage in two-way learning with traditional owners for improved restoration of seagrass in Shark Bay.
- Assess reproductive functionality in restored and impacted plant communities.
- Conduct experimental molecular and ecological studies of pollination by birds and mammals on banksias.
- Establish multi-species provenance trials in the northern jarrah forest and Pilbara for an assessment of climate adjusted seed sourcing strategies for ecological restoration.
- Commence a multi-year study on the genetic and biochemical basis for flower colour in kangaroo paws.
- Assess the pollination biology of *Aluta quadrata.*

Progress

- Assessment of survival and growth of 32,000 seedlings in multi-species provenance trials established at 8 sites across the Swan Coastal Plain continued three years post-establishment.
- Two way learning between scientists and traditional owners from Gathaagudu (Shark Bay) has resulted in re-connection of community with country and seagrass restoration benefits.
- Equivalent mating system parameters in post-mining and undisturbed native plant populations confirms restitution of bird-pollinator function in rehabilitated kwongan vegetation.

- Birds, non-flying mammals, and European honeybees were all found to contribute to the pollination of *Banksia catoglypta* (Proteaceae).
- Provenance trials were established in the Pilbara and jarrah forest.
- The kangaroo paw genome has been sequenced.
- Mating system and pollination biology continue to be assessed across multiple populations of *Aluta quadrata.*

Management Implications

- Provenance trial results to date suggest little effect of provenance for restoration seed sourcing of Banksia woodland on the Swan Coastal Plain.
- Knowledge of the genetic and biochemical basis for flower colour is assisting efficient breeding of native plants for horticultural markets.
- Ecological genetic analysis is a powerful tool for assessing and managing impacts from mining on rare species as it can be used to detect changes in key population processes such as pollination and mating that influence plant reproduction and fitness, providing options for management intervention.

Future Directions

- On-going assessment of large-scale provenance trials, glasshouse trials, and seed germination trials for key species from banksia woodlands to test seed sourcing strategies for restoration that is resilient to climate change.
- Assessment of genomic data and reciprocal transplant trials with polyploid and diploid seagrass in Shark Bay continues.
- Continue experimental molecular and ecological studies of pollination by birds and mammals on banksias.
- Monitor multi-species provenance trials in the northern Jarrah Forest and Pilbara for an assessment of climate adjusted seed sourcing strategies for ecological restoration.
- Continue a multi-year studies on the genetic and biochemical basis for flower colour in kangaroo paws.
- Continue a multi-year studies on the pollination biology of *Aluta quadrata.*
- Continue research on the pollination biology of banksia woodlands.
- Commence a study on the population genetics and pollination biology of *Quoya zonalis.*
- Commence a study on the pollination biology and breeding system of *Synostemon hammersleyensis.*
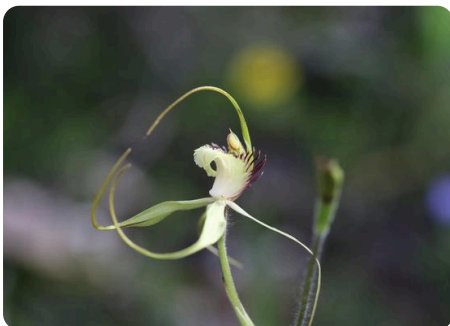
Orchid conservation and recovery

CF-2018-60

J Stevens, B Davis

Context

Western Australia is an orchid biodiversity hotspot of worldwide significance, with 413 named species of orchid, of which 95% are endemic. There are 44 Western Australia orchid taxa listed as threatened, with the key threatening processes being habitat loss due to land clearance, fragmentation, pollinator loss, weed invasion, illegal collection and habitat degradation. Orchids represent a conservation challenge as they have complex and highly specific ecological interactions with pollinators above ground and their mycorrhizal partners below ground. Overlaying the immediate needs of the orchid are the independent requirements of the pollinator (nectar sources, brood sites) and the mycorrhizal partner (nutrient sources, soil attributes). *Ex situ* conservation of Western Australia's orchids is undertaken through maintaining a large living collection of orchids, seed banking and maintaining an orchid mycorrhizal library in long term cryostorage. Scientific research into pollination, orchid ecology, translocation, propagation and mycorrhizal function underpins successful species recovery in the Orchidaceae.

Aims

- Determine and prioritise those orchid species most at threat and undertake *ex situ* conservation actions leading to supplementation of natural populations, to ensure their ongoing persistence.
- Continue maintenance and growth of the *ex situ* living collection, seed and fungal collections.
- Conduct integrated conservation research to provide management solutions to improve the conservation status of threatened orchid taxa.
- Make collections of seed and fungi from threatened and priority listed species available to investigate the potential for supplementation of wild populations.

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- Maintain and build *ex situ* seed and fungal banks of the orchid flora of Western Australia for conservation and research purposes.

Progress

- Continued a collaborative project with the aim of restoring the critically endangered species, *Caladenia busselliana* in partnership with the Australian Seed Bank Partnership, WWF Australia, Woolworths and Botanica Airwick. Translocations of *C. busselliana* sites were assessed for survival, flowering, seed set with recruitment also being observed in two of the three sites.
- Long term monitoring of tagged individuals of *Caladenia lodgeana, Caladenia leucochila* and *Caladenia busselliana* continued across natural populations.
- An intensive pollinator mark recapture experiment took place for *Caladenia procera* and pollinator baiting surveys for *Caladenia lodgeana* occurred to inform site choice for a translocation and the compilation of a translocation proposal for the species.
- Propagative *ex situ* material (seed and fungi) was collected from 19 species of orchid and incorporated into the cryostorage collection.
- Successful germination protocol established for the endangered, *Caladenia hopperiana*.
- Comprehensive fungal collections were made for *Thelymitra variegata* from the largest remaining population.

Management Implications

- Development of germination protocols for threatened orchid species provides conservation support in the form of *ex situ* living collections, advances the possibility of translocations as a conservation tool and informs *ex situ* collection practices for functionally similar species.
- Growing *ex situ* collections of threatened orchids provides essential conservation support for species with critically low wild plant numbers or single populations. The provision of plant material to undertake pollinator research and site selection for translocations is critical to species recovery efforts.
- Pollinator identification, pollination syndrome, abundance of pollinators and distribution across habitat types inform regional conservation management of habitat remnants, selection of potential translocation sites and whether reproductive management of the orchid species may be necessary.
- Long term demographic monitoring data for orchids is rare but vital to perform population viability analysis and provide an understanding of orchid life stages, recruitment, reproduction and life span to inform species management and recovery.

Future Directions

- Undertake research and population viability analyses to inform regional planning and management of threatened and conservation listed orchid species.
- Make targeted seed and fungal collections available to supplement *ex situ* orchid collections in line with the *ex situ* conservation program.
- Investigate orchid, pollinator and mycorrhizal ecology as they relate to species recovery efforts and *in situ* management of populations.

Restoration science

CF-2018-77

J Stevens, S Krauss, W Lewandrowski, C Elliott

Context

Restoration science is a multidisciplinary approach to provide a comprehensive scientific basis for restoration actions across the State. Overall, the research includes seed science, provenance, ecohydrology, ecophysiology, soil science, community ecology and plant-enabling technologies. Restoration science works across diverse systems including Pilbara grassland and savanna, mid-west shrublands, Swan Coastal Plain banksia woodlands and shrublands, jarrah forest, marine seagrass meadows, and arid coastal communities, through collaboration with a variety of stakeholders. Restoration science is well placed to provide the applied scientific solutions required for all plant community restoration activities.

Aims

- Establish targets and criteria for restoration success.

- Determine appropriate sourcing of biological materials for restoration.
- Optimise establishment of plants in restoration.
- Determine factors influencing growth and survival of plants in restoration.
- Determine factors influencing resilience, sustainability and landscape integration.

Progress
- Continued to study the ecophysiological, pollination and reproduction biology of the endangered *Aluta quadrata* in the Pilbara.
- Commenced research to examine the species biology of the rare Pilbara plant species *Quoya zonalis.* This project will understand seed germination requirements as well as population genetic processes for the species to inform conservation decision making.
- Several strategic projects continued through the CRC Transformations in Mining Economies, connecting the department's climate research and seed science capability with Australia's mining sector.
- Established a tree health monitoring program in managed parkland and bushland systems at Kings Park using novel whole tree ecophysiological monitoring tools.
- Extended the collaborative program with DPIRD to understand biodiversity values of Kimberley grassland grazing systems. Small scale plots were established in Perth to determine seed farming constraints for priority grasses.
- Using initial species distribution modelling, study sites for ecophysiological monitoring were established for the rare *Tetratheca butcheriana* on Mt. Brockman Range. Development of remote sensing methodologies, as well as initial population monitoring have commenced.
- Continued research partnership with Hanson Construction Materials delivering Banksia Woodland restoration solutions for practitioners, focussing on assessing post-pine restoration activities and long-term Banksia Woodland restoration trajectories.

Management Implications
- Critical insights into plant habitat, substrate and niche interactions underpinning species distribution, as well as environmental conditions driving persistence and ecophysiological functioning will help monitoring approaches and management actions within the mining sector.
- Maximising seed usage will assist in creating resilient biodiverse systems and sourcing seeds for restoring mined lands under future climate scenarios.
- Monitoring and understanding tree health and decline in response to seasonal changes in rainfall, nutrient deficiencies informs changes in management initiatives (irrigation, acidifying of bore water).

Future Directions
- Continue a multi-year study on the pollination and reproductive biology of the rare *Aluta quadrata* in the Pilbara.
- Commence developing a guiding document to inform on the restoration of *Melaleuca argentea* in the Pilbara.
- Continue research that examines the species biology of the rare *Quoya zonalis* in the Pilbara.

Seed science

CF-2018-85

D Merritt

Context

Seed science projects focus on supporting plant species conservation and ecosystem restoration. Research themes include seed storage behaviour, the physiology and ecology of seed dormancy and germination, the interactions of seeds and seedlings with the soil environment, and the development of seed technologies to enhance seedling establishment in threatened species translocation and broad-scale restoration settings. Seed science is integrated with the conservation seed banking functions of DBCA to support and enhance the capacity for long-term storage of germplasm of Western Australia's flora.

Aims

- Support and enhance the curation of *ex situ* germplasm collections through characterising seed storage behaviour and longevity, developing methods for assessing seed viability and quality, and predicting

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seed storage life.
- Develop reliable methods for seed-based propagation through determining seed dormancy break and germination requirements.
- Develop seed enhancement technologies that improve seedling establishment for ecological restoration.
- Improve mechanised direct seeding systems to support biodiverse ecological restoration.
- Inform the management of Western Australia's flora through the study of seed ecology in the natural environment.

Progress
- Completed projects on mechanisms of seed longevity, quantifying effects of oxygen on seed ageing and examining RNA integrity as a measure of seed viability decline.
- Continued studies characterising seed storage behaviour and germination biology of species of the Kimberley to support *ex situ* conservation.
- Contributed to a national review of seed collections of the Australian Seed Bank Partnership to identify their representativeness, functionality, and value.
- Commenced a project to develop seed propagation techniques for the threatened species *Quoya zonalis*.
- Continued a 5-year project developing direct seeding machinery for mine site restoration, implementing field trials in the southwest to optimise seed metering systems and soil engaging tools, and establishing trials in a rain-out shelter in the Pilbara testing seed priming and pelleting.
- Continued a project studying mechanisms of seed protection and release in *Banksia*, sampling cones monthly through their developmental stages for imaging and material properties analyses.
- Completed a 3-year project studying how germination traits and the soil micro-environment influence spatial patterns of annual species of the York gum woodlands.

Management Implications
- Research findings on seed storage behaviour have been incorporated into a series of training workshops to improve seed banking practices, and are informing a Living Collections Policy.
- Analyses of Australian Seed Bank Partnerships collections data will inform future collections priorities and research needs for effective national programs of *ex situ* conservation.
- New seed processing equipment, direct seeding machinery and seed technologies are being adopted by industry to improve the efficiency of seed use in broad-scale minesite restoration.

Future Directions
- Develop knowledge of seed storage behaviour for species of the Kimberley to respond to myrtle rust.
- Examine potentially short-lived seeds and seed tolerance to heat and drought stress.

Marine Science

Program Leader: Thomas Holmes

The broad goal of the Marine Science Program is to ensure the department's marine biodiversity conservation and management programs are based on best practice science. Specifically, the program promotes and undertakes marine research and monitoring to improve the scientific basis for the conservation and management of Western Australia's State-wide system of marine protected areas, threatened marine fauna and marine biodiversity generally. The program also coordinates and manages external marine research programs, such as the current investigation into the bio-physical, social and cultural values of the Kimberley that is undertaken as part of the Western Australian Marine Science Institution (WAMSI). The research and monitoring programs undertaken by the Marine Science Program are based around the research and monitoring strategies identified in protected area management plans and threatened species recovery and management plans, ensuring that all activities are linked to departmental priorities and programs.

Benefits of marine parks for marine fishes in a changing climate

SP-2021-40

J Goetze, T Holmes, C Ross, W Robbins

Context

To conserve WA's marine biodiversity, a network of marine parks has been established under the principles of being comprehensive, adequate and representative. These principles require knowledge of ecological assets over a statewide scale and are complicated by a changing environment. Finfish have been identified as a key ecological asset due to their high ecological and social values. Anthropogenic pressures are leading to shifts in the composition of fish assemblages, and it is unclear how well the current network of marine parks represents fish diversity. This project will combine DBCA finfish monitoring data with information collected by external collaborators to assess fish biodiversity inside and outside of WA marine parks over the last decade. This dataset will be used to describe statewide spatial and temporal patterns of finfish composition and distribution in relation to key pressures, to enable adaptive management and guide marine park planning.

Aims

- Collate a statewide finfish dataset with key collaborators to enable biodiversity assessments of fish inside and outside of marine parks, over the last decade.
- Develop conversion factors that will enable the synthesis of DBCA finfish data (diver operated video, DOV) with legacy datasets (underwater visual census, UVC) and emerging methods (remotely operated vehicle, ROV).
- Compare the composition, biodiversity and productivity of fish assemblages among marine parks relative to non-reserved locations.
- Assess if the composition, biodiversity and productivity of finfish assemblages within marine parks has changed over time and if any changes correspond with climatic events or are due to fishing pressure.

- Determine if these changes persist through time and whether patterns of change differ among parks located along the WA coast.

Progress

- Finfish data spanning two decades and ten marine parks has been cleaned and collated.
- A paper comparing the behavioural responses of fishes to ROVs and diver-based sampling methods was published in *Estuarine, Coastal and Shelf Science*. The results show that while ROVs and diver based methods sample broadly comparable fish assemblages, fish are less wary of ROVs.

Management Implications

- Cleaning and collation of a State-wide finfish dataset has facilitated more accurate and streamlined marine park reporting to inform adaptive management across WAs marine parks.
- The method comparison facilitated a transition to ROVs, which provide comparable data to diver-based methods. ROVs eliminate the safety risks associated with diving and provide a more cost-effective approach to the provision of monitoring data for adaptive marine park management.

Future Directions

- Progress preparation of manuscripts on key ecological factors affecting finfish.
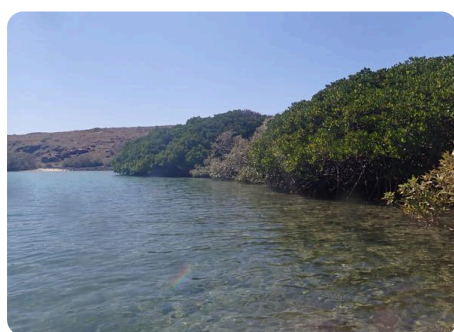
Primary productivity and energy transfer between marine ecosystems.

SP-2020-2

M Moustaka, R Evans, K Murray

Context

Primary productivity provides energy that fuels food webs and is recognised as an important driver of local diversity and secondary production. Hence conservation planning often aims to identify where primary production is high; what systems, including their spatial arrangement, are most productive and how efficiently productivity from these producers is transferred to other systems or consumers. While marine productivity is largely attributable to oceanic phytoplankton, productivity from benthic macrophytes becomes increasingly important in coastal food webs. However, the link between benthic productivity by vascular plants and algae and secondary production remains equivocal. Moreover, local variations in hydrology are likely to influence the supply of nutrients, temperature and light (caused by turbidity), all of which are fundamental determinants of primary productivity. This project will investigate rates of primary productivity and energy transfer in the shallow, turbid waters of the Dampier Archipelago.

Aims

- Develop an updated coarse benthic habitat map for the Dampier Archipelago and fine resolution benthic habitat maps for up to 16 sites.
- Develop fine scale oceanographic modelling of the Dampier Archipelago to provide water flow and retention data for interpreting spatial differences in productivity.
- Measure water quality parameters (total soluble solids, salinity, nutrients, Chlorophyll A) and assess how they vary spatially and temporally.
- Measure primary productivity in different marine habitats (mangroves, seagrass, seaweed and coral reef) and assess how rates vary among locations and between seasons in the Dampier Archipelago area.
- Measure abundance, diversity and growth rates of fish and benthic communities and assess how these relate to spatial variation in primary productivity.
- Measure abundandance and diversity of macroalgal epifauna and sediment infauna and assess how these relate to spatial variation in primary productivity.
- Measure stable isotopes of primary producers and secondary consumers, and use isotopic signatures to assess the extent of transfer from different primary producers to secondary consumer tissues and between different habitats.

Progress

- Completed two field trips to the Dampier Archipelago, including collection of data on juvenile fish abundance and diversity, and costal ecosystem (macroalgae, seagrass, mangrove, coral) structure and productivity.

- Post-bleaching surveys were conducted at 14 coral sites following the 2023 summer bleaching event.
- Analysis of three years of stereo diver operated video footage was completed.
- Completed laboratory processing of second season of algal epifauna samples and laboratory preparation and stable isotope analysis for *Acropora* spp. fragments from 4 sites
- Individual coral colony growth (photogrammertry-based) and density measurements were collected.
- Completed analysis of 130 eDNA samples.
- Analysis of final water quality samples (6 temporal samples total) was completed.
- Hydrodynamic modelling was finalised and outputs are being used in ecological studies.
- Three manuscripts on juvenile fish distributions, macroalgal nursery function, and cross-habitat trophic subsidies for fish have been submitted for publication.

Management Implications

- Identification of high productivity locations may be used in spatial planning within the Dampier Archipelago and improve scientific advice relating to development projects in the area. Results will be transferable to planning in other locations with similar environmental conditions, by assessing which environmental factors correlate with high productivity.
- An increased understanding of the factors influencing the nursery function of macroalgal meadows across the study region for the valuable fishery species *Lethrinus punctulatus* is important for future spatial planning and fisheries management.
- Quantifying the extent to which different primary producers underpin the productivity of juvenile and adult fishes increases our understanding of ecosystem function in the region, which in turn informs environmental decision making.
- Juvenile fish distributions were strongly influenced by hydrodynamic conditions and to a lesser extent seascape configuration and local habitat composition. This increases our understanding of factors influencing recruitment dynamics and hence potential community recovery following disturbance, which is important for future spatial planning and fisheries management.

Future Directions

- Finalise the hydrodynamic model and prepare resulting publications.
- Estimate mangrove densities for productivity calculations.
- Continue analysing epifauna, coral, productivity and eDNA data and writing scientific publications.
- Collect fourth and final mangrove estimates of mangrove productivity.

Do marine reserves adequately represent high diversity cryptobenthic fish assemblages in a changing climate?

SP-2019-31

J Goetze

Context

Small-bodied fish (<5cm) typically account for ~40% of all described fish species on coral reefs and therefore are expected to represent a substantial proportion of fish diversity in the State marine reserves. Short life spans of these small fish also suggest they are important conduits of energy transfer in marine food webs and will respond more rapidly to environmental change and stressors than larger-bodied counterparts. This is especially pertinent along the WA coastline, where marine heatwaves have dramatically impacted habitat, and fishing may have reduced the abundance of small fish predators. Standard visual methods of surveying fish are not suitable for monitoring these small cryptobenthic fish (CRF). This project will investigate whether environmental DNA (eDNA) from water and sediment samples is a viable alternative to collecting with poison (clove oil) and visual approaches for assessing CRF assemblages. By collecting data from different habitats and management zones within marine parks, the project will also assess how effectively different techniques detect a change in CRF due to spatial variation in environment or management.

Aims

- Develop appropriate methods for measuring and monitoring CRF assemblages.
- Compare CRF assemblages collected inside and outside of no-take sanctuary zones.
- Compare CRF assemblages across a gradient of reef (habitat) types from high coral cover and complexity to reefs dominated by macroalgae with low complexity.

Progress

- A manuscript describing and comparing fish assemblages from the different survey techniques has been published in *Limnology and Oceanography: Methods*.

Management Implications

- eDNA collected from water detects the most cryptobenthic species and is therefore an efficient tool for rapidly assessing biodiversity, but extractive techniques may still be required for biological and monitoring studies, and when combined with eDNA sampling provides the most comprehensive assessment of cryptobenthic fishes.

Future Directions

- The project has now been completed.

Understanding the key ecosystem services provided by the seagrass meadows of Western Australia

SP-2018-136

S Strydom, I Leal, K Murray, B Huntley, T Holmes

Context

Seagrasses are foundation species that support important ecosystem services and processes. Seagrass meadows are declining globally and anthropogenic pressures such as terrestrial run-off, anchor damage and dredging threaten the ecological, economic and social services that seagrass meadows provide. Some of the world's largest and most diverse seagrass meadows occur in Western Australia and support many commercially, recreationally and culturally important fauna. As the condition of seagrass meadows responds readily to pressures, they are used as indicators for the overall effectiveness of management across marine reserves managed by the department. Across-region comparisons and thorough temporal assessments of seagrass condition will provide a broader appreciation of seagrass health among the State's network of marine reserves. Furthermore, a greater understanding of how climate change related pressures of increased seawater temperature and extreme events impact seagrass meadows and the ecosystem services they provide, is needed. This is particularly the case in vulnerable regions like Shark Bay, Western Australia's largest World Heritage Area, where the full extent of seagrass loss since the 2010-11 marine heatwave was until recently, not well understood.

Aims

- Describe seagrass distribution and condition over time across the sub-tropical and temperate WA marine reserves.
- Establish appropriate methods for surveying and monitoring faunal communities in seagrass meadows.
- Assess faunal communities in different types of seagrass meadows across the seascape to inform how key ecosystem services are affected by pressures that impact seagrass condition.

Progress

- Analysis of spatiotemporal trends in seagrass condition has identified significant drivers of seagrass decline across four WA reserves. Key results showed that seagrass condition differed among regions, with increased mean summer temperatures being a strong driver of declines in Cockburn Sound and Marmion. Shoot density was highest in the Ngari Capes, highlighting the area's importance as a climate change refuge.
- Data from trawls and underwater remote video were analysed to provide a wholistic view of assemblages among seagrass meadows and investigate the implications of habitat quality reduction on fish assemblages in Shark Bay.
- This research demonstrates that faunal communities differ across seagrass meadows with varying degrees of seascape metrics and meadow type (*Posidonia* vs *Amphibolis*). Invertebrate assemblages between seagrass genera were assessed. Updated seagrass extent maps were completed to seagrass genera level for the Monkey Mia region.

Management Implications

- Relationships between predictor variables and seagrass condition in marine reserves, highlights the importance of tailoring management actions to specific stressors. For example, turbidity was found to be a driver of decline in Jurien Bay and Marmion Marine Parks, and actions to reduce turbidity should be

prioritised to maintain seagrass condition at such locations.

- Seascape metrics provide further detail of the quality of habitat for fish and invertebrate communities, and highlighted the superior value of *Amphibolis* seagrass meadows compared to *Posidonia* meadows, which therefore warrants higher conservation focus.
- Mapping products have been used for internal and Ministerial advice, for research projects and for site selection in externally-led ecological restoration initiatives.

Future Directions

- Prepare papers on seagrass distribution and condition over time and submit for publication.
- Include seagrass genus level mapping into a manuscript on fragmentation of seagrass meadows and its influence on fish communities in Shark Bay. Further analyse invertebrate assemblage data and prepare a manuscript for publication.
- Finalise the updated Shark Bay seagrass habitat maps and quantify spatial and temporal shifts in seagrass extent between 2016 and 2023.

Distribution and abundance estimate of Australian snubfin dolphins at a key site in the Kimberley region, Western Australia

SP-2014-18

H Raudino, K Waples

Context

The lack of knowledge of the Australian snubfin dolphin (*Orcaella heinsohni*) meant that its conservation status could not be adequately assessed due to insufficient information on population dynamics and distribution. This species is known from tropical coastal waters of Australia and New Guinea, but individuals tend to be evasive and difficult to study. As there has been little locally based research on this species and the limited data collected remains unpublished, this project will compile existing data on snubfin dolphins across the Kimberley to better understand their habitat use and distribution. The collation of data into a single database will also facilitate the study of population structure and demographics based on recognised individual animals.

Aims

- Provide a quantitative abundance estimate of snubfin dolphins for Roebuck Bay in Western Australia that will be used as a baseline for this population component and enable comparison with abundance estimates of the species from sites at Cleveland Bay (Qld) and Port Essington (NT).
- Compare methods for abundance estimation (mark-recapture versus distance sampling) and assess the suitability of these methods for abundance estimation of this species.
- Map the extent of occurrence and area of occupancy of snubfin dolphins in the Kimberley by combining traditional knowledge and dolphin sightings from Aboriginal sea rangers and scientific survey sightings.
- Refine and populate a purpose built and standardised database that will support long term data collection and curation in Western Australia and facilitate data-sharing between jurisdictions.

Progress

- The collaborative monitoring activity was co-presented with Yawuru with joint managers at the Australian Marine Science Association Conference.
- A new 2024 edition of the Finbook Yawuru Nagulagun,an identification catalogue of dolphins in Roebuck Bay, containing photographs of individual dorsal fins, sighting history information and species identification, was published and distributed to commercial tour operators, Bush Cadet leaders, Dolphin Watch volunteers and is accessible to the public online.
- A presentation on research findings was delivered at the Bush Cadet conference in Broome and incursions focused on snubfin dolphins were delivered to Broome schools.

Management Implications

- Collation of scientific and traditional knowledge of a poorly understood marine mammal of high conservation value will help to address the key performance indicators related to maintaining abundance and diversity of dolphin species in Yawru Nagulagun Roebuck Bay Marine Park (YNRBMP).
- Establishment of a database for all dolphin research and monitoring where survey and photo-identification data is collected, ensures that standardised data is available for assessing population abundance and distribution. It also provides the capacity to develop sighting histories for individual

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animals, thus providing a better understanding of population demographics and life history. These data were used to inform the nominations of Commonwealth Biologically Important Areas for snubfin dolphins in the Kimberley.

- The broad-scale collation of information and modelling has provided relevant information on area of occupancy and extent of occurrence that can be used to assess the conservation status of snubfin dolphins more accurately. These data have been used to inform the nomination for listing the species as vulnerable under the *Environment Protection and Biodiversity Conservation Act 1999.*
- The research has established partnerships with Aboriginal sea ranger groups to develop survey methodologies, data storage and reporting structures consistent with Healthy Country and marine park management plans.
- The Marine Fauna Sighting app and Finbook photo-identification guide will support ongoing monitoring of the snubfin dolphin population in YNRBMP.
- A monitoring program for dolphins in YNRBMP will inform ongoing management of dolphins using the marine park and surrounds.
- Understanding the population structure and genetic connectivity of coastal dolphin populations will inform conservation management by identifying populations more vulnerable to anthropogenic impacts.

Future Directions

- Publish the results of the genetic analyses of tissue samples collected from snubfin dolphins in Prince Regent River.
- Complete the biennial snubfin survey in Lalang-gaddam Marine Park, Malandoon (Prince Regent River).
- Complete the 3 yearly snubfin census in YNRBMP.

Habitat use, distribution and abundance of coastal dolphin species in the Pilbara

SP-2014-21

K Waples, H Raudino

Context

Australian snubfin (*Orcaella heinsohni*), Australian humpback (*Sousa sahulensis*) and Indo-Pacific bottlenose (*Tursiops aduncus*) dolphins inhabit Australia's north-western coastal waters, but little is known about the population sizes, distribution and residency patterns of these species. Current knowledge of these dolphin species in the Pilbara is poor and is limited to a dedicated study of humpback dolphins in Ningaloo Marine Park and Exmouth Gulf, opportunistic surveys and anecdotal sightings throughout the region. Although the presence of several coastal dolphin species is expected in nearshore Pilbara waters (including humpback, snubfin and bottlenose dolphins), very little is currently known of their residency and habitat use patterns.

Human pressures on these species are increasing in the Pilbara through activities associated with expansion of the resources sector, including oil and gas exploration and production, coastal infrastructure development and shipping. While these are key factors that proponents are required to address to secure State and Commonwealth environmental approvals, impact assessments for these species are complicated by the lack of best practice protocols and standards for survey design and data collection, which limits the comparison of different studies and study sites. This project will provide a better understanding of these species and their spatial and temporal use of Pilbara coastal waters, leading to greater certainty in assessing and managing impacts related to industrial developments. This project was designed to meet this priority need under the Wheatstone Offset C program.

Aims

- Determine habitat use, distribution, abundance, residency and movement patterns of dolphins in coastal Pilbara waters.
- Identify the characteristics of habitats used by coastal dolphins, such as water depth, benthic substrate and a range of environmental variables.

Progress

- A paper was published in *Frontiers in Ecology and Evolution* using density surface modelling of aerial survey data to visualise and estimate abundance and distribution of coastal dolphins at a regional scale in the Pilbara. Abundance estimates are in the low thousands for both Indo-pacific bottlenose dolphin and Australian humpback dolphin, with humpback dolphins apparently less abundant than bottlenose dolphins.

Management Implications

- The maps derived from these data depicting dolphin distribution and habitat use in the Pilbara region have informed environmental impact assessments in Exmouth Gulf, Onslow, Thevenard Island and Dampier Archipelago.
- The information produced from this project directly informed a nomination of humpback dolphin for listing as vulnerable under the *Environment Protection and Biodiversity Conservation Act 1999*.
- The sighting data and associated behavioural data have been used to nominate Biologically Important Areas to the Commonwealth government, which if supported, will be important considerations in environmental impact assessments and have associated statutory requirements.

Future Directions

- Undertake genetic analyses of the tissue samples collected from two species of dolphin at the Montebello Islands Marine Park.
- Develop a spatial risk assessment of pressures at a regional scale and assess how these overlap with dolphin distribution and abundance, using the data outputs from this project as the response variable in that modelling approach.

The influence of macroalgal fields on coral reef fish

SP-2013-6

T Holmes, J Goetze

Context

Macroalgae are a prominent component of tropical benthic communities along the north-west coast of Australia. Within Ningaloo Marine Park, large fields of macroalgae are a distinct feature of the lagoon, covering approximately 2000 hectares. These macroalgal fields are important habitats for fish targeted by recreational fishers and are a focal area for boating activity within the park. Moreover, large seasonal shifts in algal biomass on these and other tropical reefs suggest macroalgae play an important role in nutrient fluxes in Ningaloo and similar systems. Work at Ningaloo has quantitatively assessed seasonal variation in biomass and diversity of macroalgal communities. This project will build on the information gained from those initial studies to improve understanding of how macroalgae are distributed across the Ningaloo lagoon and better define the role of macroalgal fields as habitat for fish recruits and adults.

Aims

- Quantify spatial variance in macroalgal fields at Ningaloo Marine Park and determine the relative importance of physical and biological drivers of algal abundance and diversity.
- Identify attributes of macroalgal fields favoured by juvenile fish and examine the relative importance of habitat quality and predation on juvenile abundance.
- Assess the influence of juvenile fish on replenishment and future adult abundance.

Progress

- An additional field trip was conducted to collect additional data on fish recruit abundance, adult lethrinid abundance and macroalgal dynamics and structure.
- Data continued to be collected at long term sites within the Ningaloo Marine Park.
- Potential new sites along the central and eastern margins of Exmouth Gulf were investigated and preliminary data on macroalgae and reef structures were collected at an additional eight sites within the gulf, with the intention of incorporating these data into long-term monitoring.
- A paper winvestigating whether recruitment can predict the future abundance of large-bodied reef fish was published in *Marine Environmental Research*.

Management Implications

- Data collected form this project continues to inform our knowledge of fish recruitment dynamics along the Ningaloo reef. As this is a key driver of recovery following disturbance and recreational fishing, it is important to understand for informing adaptive management.
- The work continues to build our understanding of the importance of macroalgae as a part of tropical shallow water ecosystems, which has implications for spatial management and conservation priorisation.

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- Knowledge generated by the project is beginning to inform understanding of the role of tropical macroalgae in carbon cycles and storage in shallow water ecosystems, which is relevant to broader policy and socio-economic onsideration.

Future Directions

- The project will continue to expand into Exmouth Gulf.
- The number of sites in Ningaloo Marine Park will be scaled back, with the view to using those sites for regional comparison with Exmouth Gulf and a focus on temporal, rather than finer scale spatial variability.

Understanding movements and identifying important habitats of sea turtles in Western Australia

SP-2013-2

S Whiting, S Fossette-Halot, T Tucker

Context

This project uses satellite telemetry to track turtles that are released to the wild with minimal and extensive rehabilitation. In addition, turtles are tracked to identify connectivity between different habitats in their life stages. Commonly, turtles are tracked from nesting beaches to identify habitat, migration routes and resident foraging grounds. The tracking results identify the geographic range and preferred habitats and provide insight into the viability and survivorship of healthy and rehabilitated turtles in the wild. The identification of preferred habitat allows pressures to be identified and prioritised for different size classes. Broadcasting live tracking data on the internet provides a direct link between the department's science activities and the community. The genetic information derived from samples collected routinely across a range of projects, will provide another layer of information that helps to describe the spatial range of sea turtles in Western Australia.

Aims

- Determine the distribution and movement of sea turtles and investigate how components of sea turtle biology (including genetics) influence turtle distribution, preferred sites, movement and foraging ranges.
- Investigate how environmental drivers, such as oceanographic factors, influence turtle distribution, preferred sites, movement and foraging ranges.
- Investigate the viability and survivorship of rehabilitated turtles.
- Investigate connectivity of turtles between habitats across their life stages.

Progress

- A manuscript describing the flatback turtle satellite tracks has been published in *Ecosphere*. For this study, information from 280 turtles has been combined from multiple research partners to develop one of the world's largest animal tracking data sets.
- Additional transmitters were applied to reproductively mature male turtles to fill knowledge gaps relating to the location of mating areas.
- Analysis revealed that flatbacks spent 99.5% of their time in Australian waters, where they are provided with a very high level of spatial protection during the inter-nesting phase of their life cycle, with up to 85.6% overlap between marine reserves and their foraging range.
- These results will help guide several future research projects and management strategies for this species.

Management Implications

- The results are being used to inform the new boundaries of Biologically Important Areas for flatback turtles in Western Australia.
- The tracking data for flatback turtles in Roebuck Bay Marine Park is being used to inform Marine Park management and port development planning.
- The next step for management is to identify threats and pressures overlapping with newly identified important foraging areas for this species in order to prioritise mitigation and conservation actions

Future Directions

- Investigating movements and distribution of male flatbacks and describing mating areas.

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- Investigating movements and distributions of juvenile flatbacks turtles in Roebuck Bay.
- Investigating how seasonal environmental drivers influence turtle distribution and foraging ecology.
- Investigating connectivity of turtles between nesting beaches and foraging grounds using both tracking and stable isotopes data.

Marine monitoring program

SP-2012-8

T Holmes, R Evans, C Ross, S Strydom, K Murray, W Robbins, J Goetze, K Crook, K Carter, I Leal, H Raudino

Context

A statewide system of marine protected areas has been established and regularly updated in Western Australia as part of Australia's National Representative System of Marine Protected Areas. Long-term monitoring of the condition of ecological values and the pressures acting on them is seen as an integral aspect of adaptive management. The department's marine monitoring program is a long-term monitoring, evaluation and reporting program that is designed to increase the efficiency and effectiveness of marine reserve and threatened marine fauna conservation and management across Western Australia.

Aims

- Implement a long-term monitoring program of key ecological values and the pressures acting on them in Western Australia's marine parks and reserves.
- Develop and implement a long-term monitoring program of threatened and protected marine fauna and the pressures acting on them in State waters.
- Report results and findings of the monitoring program to departmental managers, joint management partners, the Conservation and Parks Commission, public, peers and other key stakeholders to facilitate effective management and conservation of Western Australia's marine values.
- Continually evaluate and review monitoring and reporting programs to ensure that best practice science is adopted and that communication methods are appropriate for the intended target audiences.

Progress

- Updated monitoring data was collected by DBCA or collated from collaborators for fish, coral, seagrass, mangroves, macroalgae, subtidal invertebrates, little penguins, intertidal invertebrates, dugongs, seals, sea lions and water quality during field work conducted across 15 marine reserves from Walpole and Nornalup Inlets Marine Park in the south to North Kimberley Marine Park in the north.
- Updated results and findings from the monitoring program were communicated to Marine Park managers via the annual Marine Park Performance Assessment process, written advice, and opportunistic presentations. This information included more detailed management advice and data interpretation for the Jurien Bay, Lalang Gaddam marine parks.
- Six scientific papers incorporating departmental monitoring data or examining developments in monitoring methodologies and indicators were published in *Science of the Total Environment*, *Landscape Ecology*, *Estuarine and Coastal Shelf Science* (x2), *Limnology and Oceanography: Methods* and *Marine Environmental Research*.
- Scientific advice was provided for the ongoing planning process for South Coast, Marmion and Exmouth Gulf marine parks, through internal planning discussions, risk assessments, management plan revisions and through community engagement forums associated with the South Coast planning processes.
- Conducted marine monitoring prioritisation workshops with Yawuru, Bardi Jawi, Mayala, Balanggarra, Nyangumarta, and Dambeemangarddee traditional owners.

Management Implications

- The marine monitoring program provides data that informs evidence-based adaptive management of Western Australia's marine parks and reserves and threatened and specially protected marine fauna.
- Monitoring data is collected on key ecological values, and the pressures acting on those values to guide management responses. Performance assessment and adaptive management allow conservation managers to respond appropriately to changes as they become apparent and refine approaches to managing ecological values based on rigorous scientific evidence collected as part of a strategic statewide framework.

Future Directions

- Continue development of the online monitoring dashboard application.
- Continue the implementation and periodic review of ecological value monitoring across the marine reserve system, including planning and prioritising of monitoring activities in the proposed South Coast and Exmouth Gulf marine reserves.
- Development of new long-term monitoring programs in the Kimberley, including those focussed on seagrass and water quality.
- Continue science support and build capacity for traditional owner-led dugong monitoring in the Kimberley.

North West Shelf Flatback Turtle Conservation Program

CF-2011-118

S Whiting, S Fossette-Halot, T Tucker

Context

The Northwest Shelf Flatback Turtle Conservation Program (NWSFTCP) is one of four additional environmental undertakings for the Gorgon Gas project at Barrow Island. The purpose of the program is to increase the conservation and protection of the Northwest Shelf flatback turtle population through surveying, monitoring and research, reducing interference to key breeding and feeding locations and establishing information and education programs. This project coordinates the planning and implementation of works required for the NWSFTCP and coordinates general research and monitoring of marine turtles in Western Australia. The NWSFTCP has a range of governance arrangements that include an advisory committee and a scientific panel.

Aims

- Implement the scientific management and communication strategies of the NWSFTCP Strategic Plan.

Progress

- Several workshops were held to develop and run prioritisation tools to inform the next NWSFTCP strategic plan.
- Foraging flatback turtles continued to be monitored and studied in Roebuck Bay in close collaboration with Yawuru Traditional owners.
- Index nesting beaches continued to be monitored. Long-term datasets are currently being analysed.
- Multiple education and communication products have been produced to raise awareness about marine turtle conservation.
- On-ground actions have been undertaken at three flatback rookeries (Mundabullagna, Port Hedland and Onslow) to help mitigate multiple threats including feral predation, erosion, artificial lights and coastal development.
- Aboriginal engagement activities including employment, community visits and active research collaboration continued at several sites.
- A Traditional Custodian Collaboration Strategy and a Communication Strategy for the NWSFCTP have been finalised.

Management Implications

- A review of Biologically Important Areas for flatback turtles in Western Australia will provide better information for environmental decision making.
- Monitoring has informed mitigation of multiple threats, including artificial lights and fox predation at multiple flatback rookeries at Cemetery Beach, Mundabullangana and Barrow Island.
- A review of the monitoring program for the Cable beach flatback rookery supports closure of the beach to vehicles.
- Program outputs are incorporated in the Dampier Archipelago Island Reserves joint management plan.

Future Directions

- A new NWSFTCP website will be launched.
- The Communication Strategic Plan and Traditional Custodian Strategy will be published.
- New Strategic Conservation Plan will be finalised.

- A monitoring plan will be developed, taking into account the outcomes of analyses of long-term monitoring datasets.
- On-ground actions to mitigate threats continue.
- Communication and education actions and products will be diversified.

Spatial and temporal patterns in benthic invertebrate communities of the Walpole and Nornalup Inlets Marine Park

SP-2009-13

I Leal

Context

Walpole and Nornalup Inlets Marine Park (WNIMP) was created in 2009 to include the entrance channel, Walpole and Nornalup inlet basins and the tidal extent of the Frankland, Deep and Walpole rivers. Invertebrates are recognised as a significant ecological value of the marine park and a key performance indicator (KPI) of management effectiveness. Additionally, benthic invertebrates are a key food source for a range of fish species in WNIMP. The benthic invertebrate community of the inlets was initially described from surveys conducted in 1984 and 1987. The fauna was relatively diverse compared with most estuaries in the south-west of Western Australia because of the predominantly marine conditions that are sustained in the inlets. Few subsequent studies have examined this fauna, and the current knowledge of benthic invertebrates in the system is considered to be inadequate for marine reserve management. Furthermore, as there are strong recreational fishing values associated with the region, understanding trophic links between benthic invertebrates and fish in the estuary is important for management of the marine park.

Aims

- Determine spatial patterns and temporal variation in the WNIMP benthic invertebrate community.
- Assist in developing long-term monitoring methods for benthic invertebrates in WNIMP and more broadly across temperate estuarine marine protected areas.
- Determine whether there are spatial and temporal differences in community structure (species composition, abundance, age class) in WNIMP.

Progress

- In collaboration with Edith Cowan University (ECU) the annual monitoring survey of the WNIMP was undertaken to collect data on bivalve communities.
- Reported on the condition of bivalve communities as part of the annual Marine Park Performance Assessment process.
- A paper describing the environmental drivers of diversity and abundance of infaunal assemblages in WNIMP was prepared for submission to *Biodiversity and Conservation*.

Management Implications

- This project aligns with the Management Plan strategic goal to monitor key ecological values at risk and human usage to provide a basis to adapt and improve management of the marine park.
- Project outputs contribute to annual Marine Park performance assessments by addressing one of the Key Performance Indicators for WNIMP, the condition of benthic invertebrate communities.
- Project outputs inform where areas of high diversity are located in the Marine Park, informing targeted management actions to reduce pressures on these communities (such as, fishing and anchoring).

Future Directions

- Publications associated with the long-term dataset collected with ECU will be progressed and finalised.
- Future sampling of infaunal communities in the marine park will revert to every 2-3 years and become incorporated into DBCA's long-term monitoring program.

Spatial and temporal patterns in the structure of intertidal reef communities in the marine parks of south-western Australia

SP-2009-2

I Leal

Context

Jurien Bay Marine Park (JBMP), Marmion Marine Park (MMP) and Shoalwater Islands Marine Park (SIMP) are located on the north and south Perth metropolitan coast, while Ngari Capes Marine Park (NCMP) is in Western Australia's south-west. These marine parks support a diverse range of marine conservation values ranging from various marine habitats to threatened marine fauna, and are dominated by sub-tidal and emergent limestone reefs and shallow sandy embayments. The marine parks are subject to high levels of recreational and commercial human activity due to their proximity to population centres. Significant areas of intertidal reef platform occur on mainland and island shores and as isolated offshore patch reefs. While a number of local studies of intertidal communities provide a significant regional knowledge base, the broad spatial patterns of intertidal biodiversity across MMP, SIMP and NCMP are not adequately understood. Particular gaps exist in our knowledge of the intertidal communities of offshore platform reefs. This study will determine spatial and temporal patterns in the distribution of intertidal reef organisms in Western Australia's temperate marine reserves. Relationships between the composition of these communities and the physical structure and location of the reefs will also be examined.

Aims

- Determine spatial and temporal patterns in the composition of intertidal reef communities in the JBMP, MMP, SIMP and NCMP, including the proposed northern extension to MMP.
- Determine if the intertidal reef communities in management zones protected from extractive activities differ from the intertidal reef communities of otherwise comparable reefs.
- Assist in the development of methods for long-term monitoring of intertidal communities in temperate marine reserves.

Progress

- Conducted intertidal surveys in the Ngari Capes Marine Park in collaboration with volunteers and University of Western Australia researchers. Historical survey data from these Marine Parks were cleanned and analysed with contemporary data from this project.
- A metadata report on monitoring of intertidal communities in limestone platforms across the Ngari Capes Marine Park was produced.

Management Implications

- Project results contribute to annual Marine Park Performance Assessments of the condition of intertidal communities, one of the parks' Key Performance Indicators.

Future Directions

- Intertidal surveys are planned for Jurien Bay, Marmion and Ngari Capes Marine Park.
- A paper comparing offshore/inshore reefs within temperate marine parks will be prepared.

Perth Zoo Science

Program Leader: Harriet Mills

Perth Zoo Science Program undertakes targeted research to support the breed-for-release of seven threatened species. It also addresses knowledge gaps in our understanding of behaviour, reproductive biology and conservation medicine for the species in the Zoo's collection and smaller number of species in the wild. The research program involves projects dealing with environmental communication and socio-ecology.

Anstisia frog breed and rear for release program

SP-2018-102

H Mills

Context

There are two species of *Anstisia* (formerly *Geocrinia*) frogs, white-bellied frogs (*Anstisia alba)* and orange-bellied frogs (*A. vitellina)*, that have a restricted distribution in south-west Western Australia and are listed as critically endangered and vulnerable, respectively. Whilst these frogs lay large clutches of eggs, the survival rate to adult frogs is low. Captive rearing of eggs to metamorphs is an effective means of overcoming this constraint and providing supplementation of animals into the populations. Egg clutches of both species are collected from the wild and metamorphs are raised and subsequently released to the wild. Additionally, there is ongoing research and husbandry management to achieve regular and reliable captive breeding in both species.

Aims

- Breed and rear white-bellied and orange-bellied frogs for release to sites to maintain or increase the current extent and viability of populations of these species.

Progress

- Ten egg masses from white-bellied frogs were collected from the wild, yielding 94 metamorphs in 2023.
- Three clutches of white-bellied frog eggs were produced by the captive breeding colony, producing 27 metamorphs.
- 118 white-bellied frogs were released to the wild in September 2023.
- 67 orange-bellied frogs were released to the wild in September 2023.

Management Implications

- The husbandry protocols that have been developed over the last few years continue to be refined, but are working well at Perth Zoo, with another cohort of captive-bred frogs being produced.
- The releases of the zoo-reared and zoo-bred frogs into the wild continues to supplement existing populations, in accordance with actions of the recovery plan.

Future Directions
- Continue to rear and breed metamorph frogs for release to supplement the threatened populations.
- Investigate options for genetic testing of the captive and wild populations to inform future management.
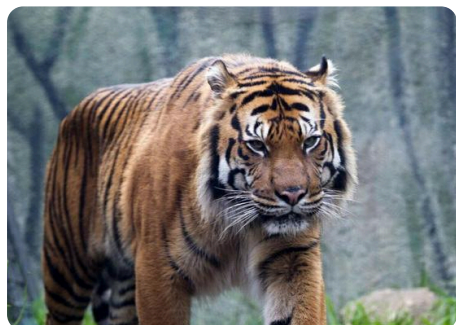
Behavioural observations of Perth Zoo collection animals for animal welfare purposes and establishment of baseline data

CF-2018-115

E Polla

Context

Maintaining or improving animal welfare is a key consideration in operations at Perth Zoo, and behavioural observations of collection animals ensures effective management approaches. Many observational studies conducted on Perth Zoo collection animals in the past have provided staff with insight into animal behaviour and generated recommendations on how to improve quality of life through specific enrichment, modifications to enclosures or husbandry practices, as well as data to allow comparisons to be made for individual animals over time.

Aims
- Determine what behaviours are exhibited by certain individuals or species of Perth Zoo's animal collection, and at what frequency.
- Compare current data with past studies to see if animal behaviour has changed over time.
- Observe the effects of the current behavioural enrichment programs on behaviour in Perth Zoo's collection animals.
- Observe the effects of Perth Zoo visitors on the behaviour of Perth Zoo's collection animals.

Progress
- Social interactions of co-housed numbats were observed.
- Emus' behaviour was monitored during nearby construction.
- Feathertail glider observations improved understanding of their activity patterns.
- General behaviour and food choice in relation to beak growth of female Baudin's cockatoos was monitored.
- A male Baudin's cockatoo has been monitored in relation to his individual behaviours and social interactions.
- Lions' interactions with visitors through viewing windows was monitored.
- Animal interactions, including between turtles, lizards and fish, were monitored in the mixed species billabong exhibit.
- Review off CCTV footage of the estuarine crocodile provided an informed understanding of his diurnal and nocturnal behaviours.

Management Implications
- Baseline data and observations are necessary for monitoring the welfare outcomes for all species in Perth Zoo.
- Empirical behavioural data gathered through this project allows Perth Zoo staff to make informed decisions about animal welfare changes as animals age and respond to new or altered dietary regimes, monitor animals during introductions of new exhibit mates or breeding animals, validate the benefits of enrichment programs, quantify animal use of exhibits before and after redesign and measure visitor interaction with exhibited animals

Future Directions
- Use the data to recommend animal welfare improvements.
- Provide empirical data to support accreditation processes for a broader range of species.

Dibbler breed for release program

CF-2018-99

H Mills

Context

Dibblers (*Parantechinus apicalis*) are listed as endangered and were formerly widely distributed along the west and southern coasts of Australia but now have a limited area of occupancy in the south-west and on islands off the midwest coast. Establishing new populations entirely with wild caught dibblers is not feasible and captive breeding provides a source of animals for supplementation of wild populations and establishment of new populations. Dibblers are one of the species identified for reintroduction to Dirk Hartog Island following cat and goat eradication, and this is being achieved through captive breeding of animals sourced from the midwest islands.

Aims

- Maintain a captive breeding colony of dibblers to produce stock for translocation.
- Translocate captive bred animals to establish further self-sustaining populations.
- Carry out genetic monitoring and management of reintroduced populations.

Progress

- The dibbler breeding program at Perth Zoo, which began in 1997, was closed in 2023 after a final two releases of 66 dibblers to Dirk Hartog Island, bringing the total number of dibblers released onto the island to 203.
- The overall number of zoo-bred dibblers released is 1173. These were been translocated to establish new populations on Escape Island, Gunton Island and Dirk Hartog Island. Releases to mainland sites (Peniup Nature Reserve, Stirling Range National Park, Waychinicup and Whiteman Park) were unsuccessful, although dibblers may persist in low numbers at Peniup Nature Reserve.
- In addition to breeding animals for release, the program has provided an excellent opportunity for research, supporting six PhDs, one Masters by Research, eight Honours projects and two Postgraduate Diplomas focused on dibbler biology and ecology.

Management Implications

- The breeding program provided important information on reproductive biology and genetics of the populations, which has been used to assist management decisions.
- The department will continue to monitor populations in the wild, both extant and translocated, to ensure they persist, and manage threats such as feral predators and fire.

Future Directions

This project is complete.

Memory of recent actions in large-brained mammals (*Elephas maximus*)

CF-2018-118

C Holland, E Polla

Context

Animals' survival depends on good and timely solutions to the problems being experienced. Sometimes problems are widely spaced in time so a problem solving strategy that is not retained in their memory does not provide a substantial cognitive economy to the individual. Among terrestrial mammals, elephants, along with humans and great apes, have large brains, are long-lived and have offspring that require long periods

of dependency. Studying the memory of an Asian elephant may allow greater insights into the evolution of cognitive abilities in large brained animals.

Aims

- Determine if an Asian elephant is capable of understanding an abstract rule such as the 'repeat' command.
- Determine if an Asian elephant is capable of discriminating and identifying past actions and performing responses that clearly reveal the extent to which past actions were identified and remembered.
- Determine the ability of an Asian elephant to represent its own recently performed behaviours in working memory.
- Determine the ability of such representations to affect future behaviours.

Progress

- The 'repeat' cue and the 'mark' cue abstract rules will be used in trials approved by the Perth Zoo Animal Ethics Committee via an amendment to the original application.
- The new trials will include a delay between the completion of a behaviour and the request for the abstract rule. This is to test the elephants' ability to encode abstract rules in memory.

Management Implications

- Determining the extent of an Asian elephant's memory and the capacity to apply abstract rules will inform the types of training and enrichment that can be applied to this species in a zoo environment, which can contribute to improving their welfare.

Future Directions

- Publish a paper reporting the results.

Numbat breed for release program

CF-2018-98

H Mills

Context

Numbats (*Myrmecobius fasciatus*) are listed as endangered, and occur in only two natural populations at very low densities. Establishing new populations entirely with wild caught numbats is not feasible and captive breeding provides a source of animals for supplementation of wild populations and establishment of new populations. A captive breeding program for numbats at Perth Zoo has been in place since 1992. Captive bred numbats have enabled new populations to be established at Boyagin Nature Reserve, Batalling Forest and fenced reserves at Dryandra National Park, Mount Gibson Sanctuary in Western Australia, Yookamurra Sanctuary and Secret Rocks Mallee Refuge (South Australia), and Scotia Sanctuary and Mallee Cliffs National Park (New South Wales).

Aims

- Produce yearling numbats in sufficient quantity to support proposed reintroductions to wild sites.

Progress

- In December 2023, thirteen numbats were transferred from Perth Zoo for release at Mallee Refuge (Secret Rocks) in South Australia.
- One female and one male numbat from the Upper Warren Region were added to the breeding program to improve genetic diversity.
- In the 2024 breeding season, fourteen pouch young were produced.
- Numbats at Perth Zoo were photographed for a UWA Masters by Research project investigating the functional significance of stripes.

Management Implications

- The breeding program continues to produce numbats to supplement existing populations and to establish new populations across the former range.

- Numbats at Perth Zoo continue to provide opportunities for research to inform conservation management and recovery.

Future Directions

- Maintain the breeding colony at 5-6 pairs to provide numbats for translocations.
- Continue to engage with students and researchers on projects to improve the conservation status of the species.

Western ground parrot husbandry

SP-2018-137

H Mills

Context

The western ground parrot (*Pezoporus flaviventris*) is listed as critically endangered and is now restricted to a single population around Cape Arid. Less than 150 birds remain in the wild, and these are threatened by foxes and feral cats. Habitat critical to the species' survival has been threatened by extensive wildfires in recent years. In July 2014, seven western ground parrots were transferred from departmental aviary facilities near Albany to Perth Zoo in a successful attempt to establish a captive insurance population and to investigate the potential for future breeding for release.

Aims

- To determine if the western ground parrot can successfully breed in captivity.
- To develop and document captive breeding techniques that maximise reproductive output for western ground parrots, while also taking the opportunity to learn as much as possible about the biology and behaviour of the species.

Progress

- New work exploring semen viability and morphology was undertaken with collaborators in Germany. The first semen samples were collected from three males and artificial insemination was undertaken with one female.
- A total of three eggs were laid, one of which was laid after the artificial insemination procedure. None of the eggs were viable and failed to develop.
- In consultation with veterinarians, changes to the diet have been made incorporating a portion of parrot pellets to trial whether this will improve egg quality.

Management Implications

- Relatively little is known about this highly cryptic species and the information collected is valuable to those working with the species in the field and for recovery planning.
- The successful breeding of western ground parrots in captivity will provide an insurance population from which birds can be used to supplement the extant population in Cape Arid National Park and provide a source of birds for reintroduction to former populations and localities in the Fitzgerald River National Park and areas west of Albany.

Future Directions

- Continue to attempt to breed in captivity, including further trials using artificial insemination if the opportunity arises.
- Progress the stable isotope analysis to understand differences between wild and captive diets.
- Use bone density scanning technology available through partnerships to better understand the health of the birds.

Western swamp tortoise breed for release program

CF-2018-101

H Mills

Context

Western swamp tortoises (*Pseudemydura umbrina*) are listed as critically endangered and occur in only two natural populations at very low numbers. Establishing new populations entirely with wild caught tortoises is not feasible and captive breeding provides a source of animals for supplementation of wild populations and establishment of new populations. Captive bred tortoises have enabled new populations to be established at Moore River Nature Reserve and Mogumber Nature Reserve, with trial assisted colonisation sites on the south-west coast of Western Australia. Two additional captive insurance populations have been established at Adelaide Zoo and Monarto Zoo (South Australia).

Aims

- Produce a minimum of 30 hatchling tortoises (>30 days of age) each year for release into wild sites.

Progress

- 52 tortoise hatchlings were produced, 8 were late-emergers from ground nests in July 2023 and the remainder hatched in 2024. Hatchlings were from both artificially incubated eggs and eggs left in-situ in ground nests.
- There was no release of any tortoises in 2023-24, as monitoring at the translocation sites continued.
- Research was initiated to quantify the impact of incubation method (artificial incubation or ground nest incubation) on shell morphology and locomotory performance.

Management Implications

- Research into optimum incubation methods will provide recommendations that will be used to improve the fitness of hatchlings and juveniles for release to the wild in accordance with the recovery plan for the species

Future Directions

- Breeding plans for 2024 have been adjusted to manage the increased size in the captive population as a result of no translocations in 2023-24.
- Assess the genetics of the current captive population to provide an accurate pedigree and to better manage translocations.
- Investigate possible egg translocation trials.

Plant Science and Herbarium

Program Leader: Carl Gosper

Applied flora conservation research seeks to understand the factors and processes that are critical for the conservation of Western Australia's native plant diversity. Major objectives include ensuring the persistence of rare and threatened species, understanding key threats such as Phytophthora dieback and weeds, and improving the understanding of genetic and ecological factors that are vital for the long-term viability of plant species. Strong collaborative linkages exist with universities, cooperative research centres, CSIRO, other research providers such as the National Environmental Science Program and the corporate sector.The program includes the Western Australian Herbarium that houses the State collection of scientific specimens of plants, algae and fungi. Information in the collection underpins the conservation of Western Australian flora. The Herbarium is responsible for: documenting and understanding the diversity of Western Australia's plants, algae and fungi; maintaining a research and archive collection of specimens of all species in these groups from throughout their range in Western Australia; helping the community, industry and researchers understand and identify plants, algae and fungi; contributing to, supporting and servicing the research, conservation and decision-making activities of government; contributing to taxonomic research by the Australian and the international scientific community; providing authoritative information to government, industry and the community via the FloraBase website and the Herbarium's information management systems.

A digital Flora of Western Australia – a guide to the State's botanical species diversity

SP-2023-17

J Wege, C Ely, B Richardson

Context

Western Australia has an evolutionarily remarkable flora that is not only the richest and most diverse of any Australian State but is of immense global scientific interest. There are more than 13,000 native and introduced plant species, many of which are threatened or otherwise significant for conservation management, and new species are regularly discovered through surveys, taxonomic assessment of herbarium collections and phylogenetic studies. Although new Western Australian plant species continue to be described at globally significant rates, the State lacks an overarching Flora with up-to-date descriptive, distributional and ecological data for all species and associated images and identification guides. Descriptive data and keys are currently held across disparate sources including historical literature, out-of-print field guides and a broad range of journals. For many species, no up-to-date or accessible description exists.

Aims

- Develop an approach for producing a digital Flora of Western Australia.

- Develop best-practice workflows for online delivery of high-quality taxonomic content through pilot projects on Myrtaceae and Stylidiaceae, groups for which taxonomic content is actively being prepared for the Flora of Australia, and additional plant groups as capacity allows.
- Plan updates to IT infrastructure that will enable taxonomic content on the WA flora to be seamlessly delivered to stakeholders.

Progress

- A treatment of *Hypocalymma* (33 spp.) was completed and published in the Flora of Australia.
- Typification issues for species in *Malleostemon*, *Micromyrtus*, *Scholtzia* and *Thryptomene* were resolved and published in *Nuytsia* to inform the Flora treatments of these genera. A paper describing novel taxa in *Thryptomene* was also prepared and submitted for publication.
- A Flora treatment of *Micromyrtus* (50 spp.) was compiled and edited.
- A Flora treatment of Stylidiaceae was substantially progressed.

Management Implications

By improving access to information on Western Australia's flora, this project will enhance the accuracy and efficiency of plant identifications (including of rarities, novelties and environmental weeds), assist research projects across a broad range of disciplines, and improve conservation outcomes.

Future Directions

- Compile taxonomic treatments of select genera for Flora of Australia, providing editorial assistance as required.
- Mobilise hard copies of Western Australia's regional Floras via the Biodiversity Heritage Library and populate Imagebank with vouchered photographs.
- Document potential workflows and IT needs for a digital Flora of Western Australia.

Molecular characterisation of stinking passionflower (*Passiflora foetida*)

SP-2018-41

M Byrne

Context

Stinking passionflower (*Passiflora foetida*), a perennial vine native to South and Central America, is a highly invasive weed in the Pilbara and Kimberley regions of Western Australia and other parts of the world. In the Pilbara, the weed is rapidly expanding its abundance in areas with slightly higher moisture availability than the surrounding landscape, including coastal reserves and riparian habitats. Options for effective management of the weed in these areas are limited and biological control is being investigated as a potential management strategy in collaboration with CSIRO. Limited knowledge of the biology and life history of stinking passionflower is a significant impediment to implementing effective weed management strategies, including biological control. Ecological and genetic characterisation is required to understand the invasion ecology of the species and to guide the search for suitable biological control agents from the native range.

Aims

- Use molecular analysis of Australian collections in the context of samples from the native range and other regions and countries where *P. foetida* is introduced, to identify and characterise the genetic entity(ies) present in Australia.
- Elucidate whether there are multiple origins for the Pilbara invasions.
- Confirm the level of relatedness of the invasive *P. foetida* to *Passiflora* species native to Australia and to commercial varieties.
- Characterise Pilbara populations relative to less invasive populations to identify any signal of adaption.

Progress

- Genomic analysis of samples across the introduced range in Australia showed low diversity and confirmed the expansion of one of the introduced lineages from Ecuador across northern Australia from the location of introduction in Queensland.
- A manuscript on genetic diversity across the distribution has been prepared.

- Design of a whole genome sequence data approach to analysis of environmental adaptation has been undertaken with scientists from Monash University.

Management Implications

- Information on the potential taxonomic entities and origin of *P. foetida* in the Pilbara will inform the identification of, and guide the search for, putative control agents from the natural range.
- Information on local adaptation within invasive populations provides a basis for understanding the dynamics of invasion and determining the effectiveness of potential control agents.

Future Directions

- Finalise manuscript on the population genetic analysis of collections from the invaded range in Australia.
- Progress whole sequence analysis to determine environmental adaptation, considering the low diversity that has been found in populations in Australia.

Herbarium collections management

CF-2011-105

S James, J Huisman, S Coffey, M Hislop, K Sadgrove, E Wood-Ward, C Parker, J Percy-Bower, S Sinha, R Gugiatti, W Pettenon

Context

The Western Australian Herbarium houses the State's botanical physical and digital collections, the core resource for knowledge of the State's plants, algae, fungi, and slime moulds. The collection is growing constantly and consistently through accessions of specimens from internal and external sources. New taxa are documented as voucher specimens and digital records. The collections are maintained to the highest standard utilising international natural science collections and archival best practice, and provide the department and the community with the fundamental resource that provides knowledge of the diversity, temporal and spatial distribution, and abundance of the flora throughout Western Australia.

Aims

- Document and audit the diversity of Western Australia's plants, algae, fungi, and slime moulds.
- Maintain, in perpetuity, a comprehensive and representative research and reference collection of specimens of all taxa in groups occurring in, and adjacent to, Western Australia.
- Contribute to, support and service the biodiversity research, conservation and decision-making activities of the department and stakeholders.
- Contribute to, support and service taxonomic and other research by the local, national and international scientific community.
- Provide digital resources enabling open access to the botanical collections.

Progress

- The Western Australian Herbarium added 10,644 specimens to collections, including 1024 specimens of priority taxa, 123 specimens of threatened taxa and three specimens of presumed extinct taxa, increasing the size of the collection to 853,647 catalogued items representing more than 18,454 taxa. More than 65 new type specimens were added to the collection (9678 items).
- The Western Australian Herbarium shared specimens with eight national and three international institutions and shipped 574 specimens in 16 loans for scientific research. A total of 3177 exchange specimens were sent to collaborating institutions, and 16 requests for 236 tissue samples from herbarium specimens were processed for molecular and other scientific analyses.
- Major activities within the collections included a substantial and targeted reduction in unprocessed specimens, incorporation of specimens returned to the Western Australian Herbarium from Manjimup (958 specimens), processing and incorporation of Herbarium Lowerianum (1071 specimens), Bush Blitz expedition collections (453 specimens), M.D. Barrett collections (1120 specimens), and the TERN Ecosystem Research Infrastructure collections (493 specimens).
- The rearrangement and expansion of the historical collection, containing specimens dating prior to 1896 (the year of the first official herbarium in the State) was initiated (currently 560 specimens).
- Specimens and data were cited in more than 130 publications during the past year. The collection and associated data have been cited 3229 times since the early 1900s.
- A collection of Type specimen photographs continues to be developed (currently >1600 items), increasing the space within the Types Vault and improving care of the physical (true) Type specimens.

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Biodiversity and
Conservation
Science

The Type collection is being reorganised to allow for the continued expansion of the collection.

- Volunteer participation continues to be a significant and invaluable resource, totaling 2588 hours, equivalent to approximately 1.6 full time employees. The Herbarium was assisted by 39 regular volunteers and 14 Research Associates. With the assistance of volunteers, 6605 specimens were mounted.
- The Reference Herbarium was accessed 2260 times by visitors, volunteers and industry consultants for plant identifications and other scientific purposes.
- The Research Collection was accessed 1484 times by visitors for the study and identification of taxa.
- The Herbarium Identification Program provided identifications to a range of clients, including departmental staff, other government agencies, environmental consultancies, regional herbaria and the public. More than 3987 specimen identifications in 413 transactions were undertaken for stakeholders.
- Educational programs consisted of 20 herbarium tours and monthly induction sessions for departmental staff, tertiary institutions, environmental consultancies, community groups and the media (approximately 350 participants). A display in the Atrium is regularly updated to highlight the work of the Western Australian Herbarium. The Herbarium also trained one UWA Work Integrated Learning intern, and two UWA McCusker interns.
- The Western Australian Herbarium Facebook page, with more than 7800 followers, shares a monthly 'Plant of the Month' and other interesting botanical announcements.
- The herbarium currently has an estimated 42,244 uncatalogued specimens dating back to 2015.
- Herbarium collections activities include the creation and curation of digital data (CF-2011-110) and management of plant names (CF-2011-111).

Management Implications

- Maintenance and curation of the Western Australian Herbarium botanical collections provides an authoritative inventory of the biodiversity of Western Australia, which underpins flora conservation and State, national, and international biodiversity research programs.
- The collections are accessed constantly by DBCA staff, consultants and policy makers to validate specimen records from biological surveys, environmental impact assessments, assess the conservation status of native taxa and document the introduction of new and invasive species.
- Both the physical and the curated collections data are heavily utilised resources for systematic and taxonomic research, collections management, environmental assessment, ecological and other scientific research, restoration and remediation projects, biosecurity management and planning, educational uses, and citizen science.

Future Directions

- Continue to significantly reduce and make available the currently unprocessed and uncatalogued specimens in storage. Accept research quality specimens from DBCA and stakeholder collection activities to continue to build a geographically and temporally diverse collection for Western Australia, and participate in federally funded Bush Blitz expeditions.
- Support implementation of a new collections management system (Specify) that will increase scope for the extended specimen initiative and improve efficiency in management and data delivery.
- Focus on the imaging of biosecurity-relevant specimens, algae (for specimen conservation purposes), conservation listed taxa, and taxa not represented in the Reference Herbarium. Imaging of the research collection will continue systematically through the Herbarium vaults by engaged volunteers.

Taxonomy of selected families including legumes, grasses and lilies

SP-2011-1

T Macfarlane

Context

Successful conservation of flora requires that conservation units equate to properly defined, described and named taxa. There are numerous known and suspected unnamed taxa in the grass, legume and 'lily' (now Asparagaceae and Hemerocallidaceae) families, and numerous cases where keying problems or anomalous distributions indicate that taxonomic review is required. The main current focus is on *Thysanotus*, *Wurmbea*, *Caesia*, *Lomandra*, *Amphipogon* and *Trithuria*.

Aims

- Identify plant groups for which taxonomic issues need to be resolved, including apparently new species to be described and unsatisfactory taxonomy that requires clarification.
- Carry out taxonomic revisions using field work, herbarium collections and laboratory work, resulting in published journal articles.

Progress

- A conservation genetics project on *Wurmbea dioica* is nearing completion.
- *Thysanotus* was studied in field and herbarium with one paper (containing 3 new species) published and a second one submitted.
- A molecular phylogeny of *Lomandra* was published.
- A paper on *Alyogyne* (Malvaceae), including recognition of a new species, was published.
- *Caesia* research was limited by seasonal conditions but a conference paper was presented on the project.
- Participated in a published international phylogenetic study of the Flowering Plants (Angiosperms).
- Poaceae studies included a species re-classification from *Brachiaria* to *Cynodon* (submitted), contributing to an international molecular phylogenetic study of the grass family (in review) and resolution of questions concerning *Amphipogon* (in preparation).
- Participated in a team reviewing classification of the *Pultenaea* group of legumes (Fabaceae) (in review).
- Collaborative papers on photosynthetic pathways in *Neurachne* (Poaceae) and *Tribulus* (Zygophyllaceae) have been submitted for publication.
- Contributed taxonomic, identification and scientific name advice on priority conservation species and surveyed poorly known species.

Management Implications

- Identification of species known or suspected to have restricted distributions enables re-assessment of conservation status and improved management effectiveness.
- Improved identification tools enable more effective and reliable identification of species and subsequent assessment of their conservation status.
- Better knowledge of plant relationships adds to the appreciation of the global significance of the Western Australian flora and facilitates its appropriate representation in a wide range of research.

Future Directions

- Finalise papers describing new species, especially in genera of Asparagaceae, Poaceae and Fabaceae.
- Continue revision of *Thysanotus* and *Wurmbea*.
- Conduct field searches for species or populations of relevant families that are insufficiently known.
- Complete draft Landscope articles about research on *Thysanotus* and *Wurmbea* for general audiences.
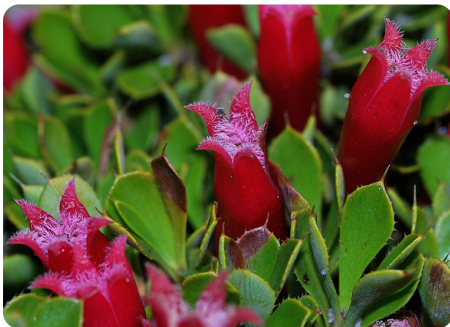
Taxonomy of undescribed taxa in the Ericaceae subfamily Styphelioideae, with an emphasis on those of conservation concern

SP-2011-15

M Hislop

Context

Recent phylogenetic studies have resulted in significant changes to the classification of the epacrids at the generic level. The circumscription of the genus *Styphelia* has now been expanded to include all taxa previously in *Astroloma*, *Coleanthera* and *Croninia*, and a large percentage of those in *Leucopogon*. A recent publication formalising these changes has opened the way to the process of describing the many phrase name taxa of *Styphelia* (in the newly expanded sense) that are currently listed under *Leucopogon*. A significant number of these are short range endemics of conservation significance. In addition, there is still much taxonomic work remaining in *Leucopogon s. str.* and new taxa in all epacrid genera continue to come to light with some regularity.

Aims

- Publish new taxa from the tribes *Styphelieae* and *Oligarrheneae*, prioritising those of high conservation significance.

- Continue a taxonomic assessment of species boundaries across the tribe *Stphelieae* (mainly in *Leucopogon* and *Stphelia*) with a view to identifying previously unrecognised taxa, especially those that may be geographically restricted.

Progress

- Two papers were published in *Nuytsia, desribing* the taxonomy of the *Stphelia corynocarpa* subgroup (Ericaceae: Epacridoideae: Stphelieae), comprising four species descriptions, three of which are new; and three new species of *Stphelia* (Ericaceae: Epacridoideae: Stphelieae) from the central south coast of Western Australia.
- A paper on four new species of Western Australian *Stphelia* (Ericaceae: Epacridoideae: Stphelieae) from the *S. marginata* subgroup, comprising five species descriptions, including four that are new was published in *Swainsona*.
- A short paper, in which a new, and probably rare species of *Leucopogon* is described, has been accepted by *Nuytsia*.
- A new phrase-name, *Leucopogon* sp. Banovich Road is added to Western Australia's plant census.

Management Implications

- Among the epacrids of Western Australia a high percentage of taxa have narrow and/or very sporadic distributions and are hence of conservation concern. Illustrative of this is that of 48 new Western Australian epacrids published in the last five years, 36 (75%) of them have been assessed as priority or threatened flora.

Future Directions

The process of documenting the drupaceous epacrids continues with two large *Stphelia* papers underway, one of which is nearing completion.

The Western Australian Herbarium specimen database

CF-2011-110

S James, J Percy-Bower, E Wood-Ward, S Coffey, S Sinha, R Gugiatti, W Pettenon, R Gillen, K Parker

Context

The Western Australian Herbarium collection management system (WAHerb) allows staff at the Herbarium to manage, maintain and share the Herbarium's botanical specimen metadata. It also allows the transactional management of the collections (loans, exchange and sampling). It provides core data on the distribution, ecology and morphology of taxa for the department and the community, through *Florabase* and other biodiversity data aggregators. Data from the collections database is provided to researchers, consultants and community members on request, and to the Australasian Virtual Herbarium (AVH), Atlas of Living Australia (ALA), Global Biodiversity Information Facility (GBIF), and Dandjoo (Biodiversity Information Office) on a regular basis.

Aims

- Capture, maintain and validate taxonomic, spatial, phenological, population and habitat data for the Herbarium botanical collections, enabling curation of the collection and providing core data for biodiversity data providers and departmental decision support systems and research.

Progress

- The Western Australian Herbarium added 10,644 specimen records in 2023-24.
- The metadata of more than 567,900 specimen records were edited ensuring the Herbarium collection and data are scientifically valid, accurate, up-to-date, and the taxonomy aligned with the department's conservation designations.
- Customised specimen data reports (species lists and label data) were provided to departmental officers, researchers and the public regularly upon request.
- The Integrated Publishing Toolkit, established in 2022, enables streamlined delivery of a Darwin Core Archive of the Herbarium data to biodiversity data aggregators and Dandjoo on a weekly basis.
- Through the AVH and ALA, 85.5 million herbarium data records were downloaded in 33,900 download events. The Western Australian Herbarium dataset is also available via the Global Biodiversity

Information Facility (GBIF - 1.2 billion records in 41,600 download events) and through Dandjoo.
- More than 3700 GenBank accessions have been linked to specimens and made available to the Australian Reference Genome Atlas.
- Data cleaning and migration activities, including improving geocoordinates, identifying and linking agents, continue towards planned migration to the new collections management system (Specify).
- More than 7800 high resolution images of Herbarium specimens were captured and shared with departmental staff and industry consultants and a further 301 high resolution images of type specimens were delivered to the online JSTOR Global Plants Initiative. Specimen imaging was focused on the more than 3800 threatened and priority taxa in collections, an initiative to digitally transform the Herbarium collections. A volunteer imaging program was initiated to systematically capture high resolution images of the entire research collection, and share specimen images online with all stakeholders (currently >25,000 images), with sensitive data redacted from relevant images.

Management Implications

- WAHerb is a comprehensive vouchered specimen database for Western Australian plants, providing a source of information that consultants, land managers, and policy makers can use for updates on species distribution, conservation status, plant identification, and identification of knowledge and collecting gaps. It ensures that research and management activities for the State are informed by up to date and valid botanical information.
- The curated herbarium collections data is a heavily utilised digital resource for systematic and taxonomic research, collections management, environmental assessment, ecological and other scientific research, conservation, restoration and remediation projects, biosecurity management and planning, educational uses and citizen science.

Future Directions

- Continue timely addition, editing and validation of specimens and specimen records to maintain currency and connectivity of the Herbarium collection, the Western Australian Plant Census and departmental and external biodiversity data providers, including Florabase, Dandjoo, AVH, ALA, and GBIF.
- Complete the migration of the collections management system to Specify.
- Accelerate the newly created specimen imaging volunteer program to digitally transform the collection and enable the efficient capture and delivery of specimen images for online access.
- Scan field notebooks to enhance digital biodiversity data associated with specimens.
- Develop protocols for management of culturally sensitive data and indigenous knowledge.

The Western Australian Plant Census and Australian Plant Census

CF-2011-111

S James, C Parker, J Percy-Bower, T Macfarlane

Context

The Western Australian Plant Census (a component of WACensus and Nomos) is the authoritative database of the flora (vascular and non vascular plants, algae, fungi and slime moulds) found in Western Australia, including synonyms created by taxonomic research and concept changes. It is continually updated to reflect changes in our knowledge of the flora. The census constitutes the fundamental master list for many departmental processes and data sets, including the threatened and priority flora database maintained by the Species and Communities Program, the Herbarium's specimen database (WAHerb), Max (the departmental software for information based on taxonomic names), Florabase and Dandjoo (Biodiversity Information Office).

The Australian Plant Census (APC) is a Council of Heads of Australasian Herbaria project, part of the National Species List infrastructure, designed to provide a consensus view of all Australian plant taxa. The APC delivers authoritative information on what species occur in Australia as a whole to obtain accurate national statistics and resolve differences in opinion and knowledge for taxa that cross State boundaries. In addition to working systematically through the vascular plant families, the APC process provides for updates as taxonomic changes or new findings are formally published. The consensus also extends from family and genus level to an overall classification of the plants that occur in Australia. The Western Australian Plant Census is updated to reflect the consensus view, produced annually. The APC provides the key name list for the Atlas of Living Australia and the Australasian Virtual Herbarium.

Aims

- Maintain an accurate and timely listing of all plants, algae, fungi and slime moulds in Western Australia, including current names and synonyms, and harmonize this with the national taxonomic consensus.
- Provide taxonomic advice and updates for Nomos.

Progress

- The Western Australian Census (WACensus) currently documents all of the known native and alien vascular plants for Western Australia, but cryptogams continue to be assessed and have not yet been comprehensively entered into the database.
- 719 plant names (696 formally published and 23 informal (phrase) names) were added to the WACensus during 2023-24. The inclusion of cryptogams (particularly fungi, lichens and freshwater algae) in the WACensus is currently a focus.
- A total of 1470 name updates were made to the WACensus.
- Plant groups for which several name changes were made include *Drosera* (8 taxa; 46 collection items), *Leptospermum* (18 taxa; 1454 collection items), Rutaceae (19 taxa; 1043 collection items), *Hibbertia* (7 taxa; 225 collection items), and the genus *Pigea* (10 taxa; 1011 collection items).
- WACensus updates were regularly distributed to 169 registered Max users.
- More than 1340 archived census forms, including descriptions of phrase name taxa, were scanned by volunteers and are now electronically available for departmental use.
- The Western Australian Plant Census is an integral part of the Biodiversity Information Office platform, Dandjoo, and taxonomic names system, Nomos. The Herbarium team has assisted with almost 600 queries relating to taxonomic updates in the past year.
- The State's contribution to maintenance of the Australian National Species List cooperative database continued with addition of 154 new vascular plant names and creation of 894 new instances (data on synonymy, authors and publications) and 1994 data updates. Herbarium staff contributed to discussions on Australian taxonomy and nomenclature resulting in the annual publication of the APC.

Management Implications

- WACensus provides a single, authoritative official list of the flora of Western Australia, with their currently accepted classification, scientific name, correct spelling and authority. Delivery of this information is through the Florabase website, Nomos, Max, and other linked databases and websites.
- Current information on names, taxonomic acceptance and occurrence in Western Australia provided by the WACensus is used for conservation status lists, publications, signage, and legal requirements.
- The Herbarium's contributions to the Australian National Species List and the Australian Plant Census support national and international names databases used in biodiversity aggregators such as the Atlas of Living Australia, Australasian Virtual Herbarium, Global Biodiversity Information Facility and Catalogue of Life.

Future Directions

- Continue to provide a comprehensive and up to date State and national census across all plant, algae and fungal groups.
- Continue to ensure the collections of the Western Australian Herbarium remain taxonomically correct for biodiversity and conservation research, and DBCA business needs.
- Development of a new, more efficient online database forum for APC.
- Assist with the decommissioning of WACensus and Max, and provision of replacement tools.
- Participate in the XX International Botanical Congress nomenclature session in Madrid, Spain, to contribute to the International Code of Nomenclature.

Systematics of the triggerplant genus *Stylidium*

SP-2010-1

J Wege

Context

With more than 300 known taxa, the triggerplant genus *Stylidium* is one of Australia's most abundant and diversified genera. While substantial progress has been made over the past 20 years in documenting Australia's *Stylidium* diversity, our knowledge of the genus remains insufficient for scientific and

conservation needs. There are new taxa awaiting formal description, species complexes that remain poorly understood and a number of nomenclature and typification issues that require resolution. The most significant issue at this point is the lack of an overarching flora treatment for the family Stylidiaceae, which hinders survey and accurate identification by conservation personnel, botanical consultants and other stakeholders.

Aims

- Improve the underlying taxonomic knowledge necessary for effective biodiversity management of the triggerplant family Stylidiaceae and make this information readily accessible to stakeholders.
- Investigate phylogenetic relationships within *Stylidium* and use these data to inform taxonomic research and conservation management.

Progress

- Research visits to herbaria in Darwin, Canberra, Adelaide, Brisbane and Sydney were conducted to prepare species profiles for the *Flora of Australia*, write manuscripts documenting undescribed species, and correct specimen misidentifications. This led to the discovery of novel species, new records of poorly known species (including range extensions), and previously unrecognised type specimens.
- Two collaborative papers on *Stylidium* from northern Australia were written and submitted for publication in *Nuytsia*. They include the description of 15 novel species (including 8 from Western Australia) and an identification guide to the 50 species that occur in the Northern Territory.
- 707 specimens at the WA Herbarium were annotated to correct or confirm their identity.
- c. 1800 photographic records were identified on iNaturalist, some of which represent new populations of poorly known species.
- Field work enabled the collection of voucher specimens and associated data to inform future research.

Management Implications

- Herbarium-based taxonomic research and targeted field work continues to improve our understanding of the *Stylidium* species that occur in WA and other jurisdictions, and their distribution, habitat requirements and conservation status.

Future Directions

- Continue preparing species profiles for the *Flora of Australia* and associated research papers, visiting select Australian herbaria as required.
- Progress phylogenetic research and identification guides.

Taxonomic resolution and description of new plant species, particularly priority flora from those areas subject to mining in Western Australia

SP-2009-6

K Shepherd, M Hislop, T Macfarlane, S Dillon, C Wilkins, J Wege, B Anderson

Context

Western Australia boasts a rich and diverse flora, however, it is far from fully documented as 1042 putatively new and undescribed taxa remain listed on Western Australia's vascular plant census. Of these, 530 (51%) are recognised as taxa of conservation concern and are poorly known, geographically restricted and/ or under threat. Furthermore, ongoing taxonomic assessments of herbarium collections, floristic surveys and botanical evaluations of mineral leases continue to reveal more potentially new species. A lack of detailed information about these 'unknown' plants hampers accurate identification, which in turn delays the department's ability to assess their conservation status effectively.

Aims

- Resolve the taxonomy and expedite the description of phrase-named plant taxa, particularly threatened and priority flora and those vulnerable to future mining activities.

Progress

- 25 new species were recognised for Western Australia, of which 14 are conservation-listed. These include three new species of *Geleznowia*, two of which are known from few extant plants and may therefore warrant recognition as Threatened, and novel species of *Thysanotus* and *Styphelia*.

- Taxonomic research on *Lasiopetalum* and allied genera, *Tecticornia*, *Thysanotus* and *Stylidium* has been progressed along with associated manuscripts.
- An informally named, conservation-listed species of *Alyogyne* was matched with an available, neglected name and found to be more widespread.
- Eight potentially new and poorly known taxa in *Chamelaucium*, *Commersonia*, *Hibiscus*, *Ipomoea*, *Olearia* and *Platysace* were added to the State's vascular plant census along with a putative new species of *Leucopogon*.

Management Implications

- The provision of names, scientific descriptions, illustrations and associated data will enhance the capacity of conservation and industry personnel to identify these new species, thereby improving conservation assessments and effective management.

Future Directions

- Identify and formally describe new taxa of conservation significance.

Taxonomic review and floristic studies of the benthic marine algae of north-western Australian and floristic surveys of Western Australian marine benthic algae

SP-2009-9

J Huisman, C Parker

Context

This project involves systematic research into a poorly known group of Western Australian plants and is directly relevant to the department's biodiversity conservation programs. It includes floristic studies of the marine plants of several existing and proposed marine parks and areas of commercial interest, to provide baseline information that will enable a more comprehensive assessment of the Western Australian marine biodiversity. These include Shoalwater, Marmion, Ningaloo, Dampier Archipelago, Barrow Island, Montebello Islands, Rowley Shoals, Scott Reef and the Maret Islands.

Aims

- Collect, curate and establish a collection of marine plants representative of the Western Australian marine flora, supplementing the existing Western Australian Herbarium collection.
- Assess the biodiversity of the marine flora of Western Australia, concentrating initially on the poorly-known flora of the tropics.
- Prepare a marine flora guide for north-western Australia, documenting this biodiversity.

Progress

- A paper describing the new species *Rhipilia psammophila* was published in *Australian Systematic Botany*, including the transfer of *Chlorodesmis baculifera* to *Rhipilia* and the first record of reproductive structures for the genus.
- 192 specimens of marine algae were added to the WA Herbarium collection.
- A red seaweed common in the Perth region that has in the past been identified as the potentially invasive *Hypnea musciformis* has been identified by DNA sequencing as a cryptic species that will be described as new.
- The yellow-green seaweed *Vaucheria estuarii* has been recorded for the first time in the Perth region and its molecular analysis led to clarification of the identities of invasive species of *Vaucheria* reported from the U.S.A. and Europe. A paper was published in *Phycologia*.

Management Implications

- Easier identification of marine plant species leads to a more comprehensive understanding of their conservation status, recognition of regions with high biodiversity and/or rare species, recognition of rare species, recognition of potentially introduced species and discrimination of closely-related native species.
- Enhanced knowledge of marine plant species allows a more accurate assessment of management needs and potential impacts of environmental change, including change conferred by resource developments, biosecurity breaches and climate change.

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Future Directions

- Publication of papers describing new and existing genera, species and other categories, including a new species of *Hypnea*.
- Undertake further taxonomic studies of Western Australian species of the red algal genus *Gracilaria*.
- Undertake taxonomic studies of marine algae occurring in the Swan-Canning Estuary.
- Undertake taxonomic assessments of turf algae, including descriptions of potentially new species of filamentous red algae.

The Western Australian marine benthic algae online and an interactive key to the genera of Australian marine benthic algae

SP-2009-8

J Huisman, C Parker, M Chalmers

Context

This project is a direct successor to the *Western Australian Marine Plants Online* and will provide descriptions of the entire currently known Western Australian marine flora through *Florabase*. Interactive keys enable positive identification of specimens and provide a user-friendly resource that enables the identification of marine plants by non-experts. It will be of great value in systematic research, teaching, environmental and ecological research, environmental monitoring and quarantine procedures.

Aims

- Prepare an interactive key to the approximately 600 genera of Australian marine macroalgae.
- Provide online descriptions of the Western Australian marine flora, including morphological and reproductive features, to enable easy comparison between species.
- Provide online descriptions of higher taxa (genus and above).
- Incorporate descriptions and images of newly described or recorded taxa of marine flora into *Florabase*.

Progress

- Data for 192 algal specimens, newly added to the Western Australia Herbarium collection, are now available via *Florabase*, improving taxonomic and distribution knowledge concerning the Western Australian marine flora.
- 24 new algal names have been added to the census of Western Australian flora.
- 573 existing WA Herbarium records of marine flora have been edited to update synonymy, cited specimens, and family changes.
- Scoring of character states for the interactive key is nearing completion.
- Additional fact sheets describing morphological and reproductive features have been prepared for inclusion in the interactive key, to assist in character recognition. Existing fact sheets have been edited for consistency.
- Numerous additional *in situ* (particularly from the Perth region, including the Swan-Canning Estuary, and Coral Bay) and microscopic images of marine algae have been taken.

Management Implications

- Easier identification of marine plant species will lead to a more accurate understanding of their conservation status and enhanced knowledge of marine biodiversity that will permit a more accurate assessment of management proposals and practices, and threats to biodiversity.
- Provision of a readily available web-based information system will facilitate easy access by managers, researchers, community and other stakeholders to marine plant species inventories and up-to-date names.

Future Directions

- Distribution of test versions of the interactive key to garner feedback.
- Continue collating existing species descriptions and write new descriptions for uploading to *Florabase*.
- Upload additional marine plant images to ImageBank/*Florabase*.

Mating system variation, genetic diversity and viability of small fragmented populations of threatened flora, and other key plants of conservation importance

SP-2001-1

R Binks, M Byrne, K Lazar, R Dillon, A Crawford, L Monks, J Filipe

Context

Understanding the interaction between mating systems, levels of inbreeding and patterns of genetic variation within populations of species is a key element in assessing the viability of plant populations, particularly rare and threatened taxa, and the development of management strategies that reduce the likelihood of local extinction and increase the probability of successful establishment of restored populations.

Aims

- Assess the relationship between effective population size and levels of genetic diversity and the minimum effective population size for maintaining genetic diversity in natural and restored populations.
- Assess the effects of population size and habitat degradation on mating system parameters that indicate inbreeding or the potential for inbreeding.
- Assess whether reduction in population size, increased inbreeding and reduced genetic variation are associated with any reduction in fitness.
- Assess whether there are differences in the levels of genetic diversity and mating system parameters between rare and common congeners, which will provide a more general understanding of rarity in this flora and how it can be managed.
- Assess patterns of genetic diversity and population differentiation in rare species to assess previous management actions and inform future actions.

Progress

- Assessment of fitness traits is ongoing in a common garden experiment involving 1100 seedlings of *Banksia brownii* from one translocated and four natural populations, to examine trait differences between populations, and implications for population mixing, and to benchmark the performance of the translocated population. Initial findings have shown that outcrossed seedlings have higher fitness than self-pollinated seedlings and management of the translocated populations should focus on ways to improve pollinator services to improve long-term translocation success. Two manuscripts have been published from this work, with one published in *Australian Journal of Botany* and the second in *Restoration Ecology*.
- Genetic diversity was assessed in translocated and natural populations of *Acacia cochlocarpa* subsp. *cochlocarpa,* and genetic structure was assessed across the range of *A. cochlocarpa* subsp. *cochlocarpa* and its sister taxa *A. cochlocarpa* subsp. *velutinosa*. Levels of genetic diversity in two translocated populations were found to be equivalent to the wild source population and two other wild populations, and across the two subspecies patterns of genetic structure generally indicate significant differentiation between them. A manuscript describing this study is in preparation.
- Genetic analysis of two species, *Banksia cuneata* and *Chorizema humile*, is underway to assess genetic diversity and population differentiation across natural and translocated extant populations, as well as to assess the genetic diversity of seed collections currently stored in the Western Australian Seed Centre, Kensington.
- Genetic analysis of *Grevillea acropogon* is underway, with preliminary findings indicating that genetic diversity has been successfully captured in the established translocation and that the disjunct northern population is a separate species, which has been named *G. kulikup* in a paper published in *Telopea*. Further genetic analysis that will include a newly discovered population of *G. acropogon* is now underway.
- Genetic analysis of *Tetratheca butcheriana* has been completed. The results showed moderate levels of genetic diversity but highly limited gene flow across the species' very narrow range that coincided with gaps in plant distribution greater than 350m, such that the species will be vulnerable to impacts that increase fragmentation. A manuscript detailing these results is in preparation.

Management Implications

- Assessment of genetic variation and mating system parameters will inform prescriptions for the prevention of inbreeding and maintenance of genetic variation in small fragmented populations of rare and threatened plants, and will facilitate strategies for managing inbreeding and loss of genetic diversity during translocation programs.
- For species in resource-rich areas, such as *T. butcheriana* in the Pilbara, information on genetic diversity and gene flow patterns will also inform impact assessments for future mining activities.

Future Directions

- Finalise mating system and genetic diversity studies on translocated and natural populations of *A. cochlocarpa* and publish findings.
- Complete genetic analyses for *B. cuneata*, *C. humile* and *G. acropogon* and publish findings.
- Finalise manuscript on *T. butcheriana* for publication.

Translocation of critically endangered plants

SP-2001-4

L Monks, R Dillon, M Byrne

Context

The contribution of translocations (augmentation, introductions, reintroductions) of threatened flora to the successful recovery of species requires the development of best-practice techniques and a clear understanding of how to assess and predict translocation success.

Aims

- Develop appropriate translocation techniques for a range of critically endangered and other threatened flora considered priorities for translocation.
- Develop detailed protocols for assessing and predicting translocation success.
- Establish a translocation database for all threatened plant translocations in Western Australia.

Progress

- Two multi-species seed orchard sites for threatened Stirling Range plant species were monitored for plant survival and seed production. This monitoring data was included in a paper on the recovery of threatened Stirling Range plant species following fire which was published in *Australian Journal of Botany*.
- Monitoring of one translocated population of *Banksia cuneata* was undertaken to assess medium-term (five-year) success. Vegetation quadrats installed at the *B. cuneata* translocation prior to planting were monitored, in order to assess the impact on the vegetation community from the translocation five years after planting commenced.
- Monitoring of one translocated and the wild populations of G*revillea maxwellii* was undertaken to assess the success of the translocation after nine years and to initiate data collection in order to develop a population viability model for the species to inform future management options.
- Infill planting was undertaken at the translocation site for G*revillea acropogon* to boost the number of plants.

Management Implications

- Successful translocations lead to the improved probability of persistence for threatened flora, particularly critically endangered plant species. Ongoing monitoring of translocations is providing information on the success of methods used and the probability of long-term success, and informs other flora translocation projects.
- Further development of success criteria and methods for analysing long-term success, such as the use of population viability analysis (PVA), mating system analysis and genetic variability analysis, will ensure completion criteria are adequately addressed and resources can confidently be allocated to new translocation projects.
- Improved awareness of best-practice translocation methods by departmental staff and others undertaking such work leads to greater translocation success.

Future Directions

- Develop a PVA model for translocated and natural populations of *Acacia cochlocarpa* subsp. *cochlocarpa* using demographic data already collected.
- Continue to monitor plant survival, growth and seed production at translocation sites for *Grevillea calliantha*, *G. acropogon* and threatened Stirling Range flora.
- Analyse monitoring of vegetation plots at one *Banksia cuneata* translocation site, to assess impacts of translocation activities on associated vegetation. Draft manuscript describing translocation and vegetation monitoring results.

- Continue to undertake annual monitoring of *Grevillea maxwellii* translocation and natural populations in order to develop a PVA model. Analyse monitoring data collected from nine-year-old translocated plants and compare to equivalent data collected from wild populations.
- Establish a new translocation site for *Grevillea calliantha* and for the recently described species *Grevillea kulikup.*

The population ecology of critically endangered flora

SP-2000-15

C Gosper, R Dillon, R Tangney, B Miller, J Overton, M Chick

Context

South-west Western Australia is a global hotspot of plant diversity. Understanding the patterns of occurrence and traits of threatened and Priority flora, and the relative importance of multiple threatening processes, including the interactions between fragmentation and small population processes, fire regimes, weed invasion, climate change, disease and grazing, is critical for the conservation and management of threatened flora and threatened ecological communities (TECs).

Aims

- Determine the critical biological factors and the relative importance of contemporary ecological interactions and processes in limiting population viability and persistence, particularly for critically endangered species and other key plant species occurring in TECs.
- Improve understanding of patterns of distribution of threatened and priority flora, their ecological, evolutionary and genetic traits, and how these traits mediate susceptibility to key threats.

Progress

- Long-term vegetation monitoring of Stirling Range threatened flora impacted by bushfires, disease and browsing continued in collaboration with staff from Albany District. A paper on the effectiveness of threat mitigation approaches has been published in the *Australian Journal of Botany.* Data were contributed to a national synthesis of responses of Australian biodiversity to the unprecedented 2019-20 bushfires with a manuscript currently under review, and research testing whether threatened montane Stirling Range flora have shifted in distribution towards more mesic climate refugia following the 2018 and 2019 bushfires, associated with ongoing climate warming and drying across the region, continued.
- Extensive seed collection of the critically endangered *Commersonia apella* was undertaken in collaboration with Warren Region, obtaining over 17,000 seeds from 15 populations. Most seeds have been allocated to the Western Australian Seed Centre for long-term storage, while a portion have been used in experiments to quantify germination response to temperature to inform fire management for population recruitment.
- Targeted survey was undertaken with Warren Region staff to gain population estimates of the critically endangered *Andersonia annelsii* and assess the vigour of *A. annelsii* in response to prolonged summer drought.
- The potential for management actions to assist with recovery of threatened flora populations through stimulation of persistent soil-stored seed banks was assessed through quantifying seed in soil core samples taken from within either translocated (*Darwinia carnea* and *Hemigenia ramosissima*) or natural (*Grevillea dryandroides* subsp. *dryandroides* and *Conostylis wonganensis*) populations. Considerable quantities of fruit were found in the translocated populations but fruit fill and viability was variable (45% fill and 70% viability for *H. ramosissima*; 3% and 87% respectively for *D. carnosa*). No seed was found in soil samples from populations of *G. dryandroides* subsp. *dryandroides* and *C. wonganensis*. This work was undertaken in partnership with Wheatbelt Region.
- To measure the effect of kangaroo density on vegetation within *Banksia* woodlands at Thomsons Lake and Harry Warring Nature Reserves, in collaboration with Swan Region staff, seven paired sites were established and surveyed for plant species composition and structure prior to the installation of a fenced exclosure at one of each pair.

Management Implications

- Studies of the effects of fire interval, *Phytophthora* dieback, browsing and threat mitigation actions on population trends for 26 threatened and priority flora in the Stirling Range National Park provided critical information on impacts of 2018 and 2019 fires and priorities for species recovery through *in situ* threat management and translocation. Recurrent phosphite spraying led to greater survival of

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Phytophthora-susceptible flora, fencing to exclude herbivores led to greater growth and sometimes increased survival, and translocated populations with supplemental water had greater growth and earlier flowering than wild populations, demonstrating the effectiveness of these threat mitigation and flora recovery approaches.

- Studies investigating the impact of disease, fire regimes, climate change, grazing and environmental weeds on threatened flora and threatened ecological communities is providing critical information for supporting species recovery and enhancing community condition.
- Seed ecology and seed bank studies of threatened flora are providing information to inform fire management of these populations to support population persistence.

Future Directions

- Continue demographic studies of key threatened flora species and quantify the condition of key threatened ecological communities in the context of prevailing threatening processes and threat mitigation programs.
- Complete the analysis of spatial patterns of threat intensity in the Southwest Australian Floristic Region to define hotspots and priority areas for flora recovery and management.
- Develop a model of vegetation condition in Fitzgerald River National Park so that temporal and spatial trends in *Banksia* decline can be assessed and monitored.
- Analyse data on flora persistence in fragmented landscapes to identify plant trait, landscape context and land management correlates of population persistence.

Seed biology, seedbank dynamics and collection and storage of seed of rare and threatened Western Australian taxa

SP-1999-10

A Crawford, S Dudley, A Monaghan

Context

Seed conservation is a specific and targeted action to conserve biodiversity and entails banking genetic material in the form of seed. Seed banking provides an important opportunity for assessing and utilising genetic material for *in situ* recovery actions and seed research. Understanding the seed biology and ecology of plant species is important for the conservation and management of conservation significant Western Australian taxa and for developing and implementing recovery plans for rare and threatened flora.

Aims

- Provide a cost effective and efficient interim solution to the loss of plant genetic diversity by collecting and storing seed of rare and threatened Western Australian plant species, and thereby provide a focus for flora recovery.
- Increase knowledge of seed biology, ecology and longevity.
- Incorporate all information into a corporate database and provide relevant information on seed availability, seed biology, storage requirements and viability of seed of rare and threatened taxa to assist the development of management prescriptions and preparation of recovery plans and translocation plans.

Progress

- A total of 66 seed collections (48 species) were banked at the Western Australia Seed Centre, Kensington; 48 of these collections (31 species) were for species listed as critically endangered, endangered, or vulnerable (threatened flora), three of these collections (two species) were Priority flora.
- Six collections of the vulnerable species *Consotylis micrantha* were collected for the Australian Seed Bank Partnership's Seeds of Hope project.
- The seed bank now contains 6250 collections (1932 taxa) representing 353 threatened flora, 753 Priority flora and 826 flora for ecological restoration.
- 115 germination tests were conducted.
- 20 accessions were used to produce seedlings of six threatened species for use in translocation.
- Seed of one species, *Schoenia filifolia* subsp. *subulifolia*, has been provided to continue a seed production area at the Central Regional TAFE in Geraldton.
- Soil seed bank studies were conducted on seven threatened species.

Management Implications

- Seed conservation supports the survival of species in the wild by providing the genetic material for reintroduction. Seed is provided for translocations of threatened flora and for departmental restoration projects.
- Provision of seed biology and ecology data increases the success of threatened flora recovery actions, particularly through knowledge of how pre-treatments may stimulate seed germination.
- Knowledge about soil seed banks will help inform *in situ* management of wild populations and will help assess success of translocated populations.

Future Directions

- Ongoing collection of seed of threatened and other conservation significant flora, focussing on species either not represented in the seed bank or with low quantities of banked seed, for long-term conservation and use in translocations.
- Complete a review of the long-term (>10 years) storage performance of seed collections held in the Western Australian Seed Centre.

Genetics and biosystematics for the conservation, circumscription and management of the Western Australian flora

SP-1998-3

M Byrne, R Binks, B Anderson, J Kestel, K Lazar, D Bradbury, C Gosper

Context

The flora of Western Australia is complex due to the antiquity of the landscape, and this can lead to obscurity in taxonomic identity, which impacts the conservation status of rare and threatened taxa. Genetic analysis can inform the biosystematics and conservation of these taxa.

Aims

The primary aim is to provide genetic information for the conservation and management of Western Australian flora, especially rare flora. Current projects aim to:

- Determine the genetic relationship between *Verticordia spicata* subsp. *spicata* and the critically endangered *V. spicata* subsp. *squamosa.*
- Determine the genetic relationships within four species complexes (*Geleznowia*, *Isopogon*, *Synaphea* and *Wurmbea*) as part of the Genomes of Australian Plants (GAP) initiative.
- Assess the taxonomic status of *Rhagodia* sp. Hamersley (M. Trudgen 17794) in relation to *R. eremaea* in the Pilbara.
- Determine the genetic relationships among several subspecies and species in the *Grevillea brachystylis* complex.
- Assess the hypothesised hybrid status of three threatened *Eucalyptus* species, *E. crispata*, *E. leprophloia* and *E. pruiniramis.*
- Determine the genetic relationships among 12 species of the mulga (*Acacia aneura*) species complex.

Progress

- Genetic analysis and morphological assessment of *Verticordia spicata* has shown that there is a lack of evidence to support the continued recognition of *V. spicata* subsp. *squamosa* as a subspecies distinct from *V. spicata* subsp. *spicata*. A paper is currently under review in *Conservation Genetics*.
- Genetic analysis is largely complete for the four species complexes in the Genomics for Australian Plants project. Two of the studies have now been published (*Geleznowia*: *Australian Systematic Botany* and *Isopogon*: *Taxon*). Genetic analysis for the *Wurmbea* study is now complete and morphological analysis is underway, with a draft manuscript in preparation. Further genetic analysis of the *Synaphea* study is being undertaken given additional complexities around hybridisation and clonality.
- Genetic analysis for the *Grevillea brachystylis* species complex is now complete. Results indicate that the current classifications in this group (*G. bronweniae*, *G. brachystylis* subsp. *brachystylis*, subsp. *grandis*, subsp. *australis* and subsp. Yelverton) are genetically distinct, as is an additional currently un-named entity in the Blackwood Plateau region. A draft manuscript is in preparation to report on the genetic findings, while morphological assessment to enable taxonomic revisions is underway.
- Genetic analysis of hybridsation in eucalypts of the Midwest (*Eucalyptus leprophloia*, *E. pruiniramis*, *E. crispata*) is now complete. Results determined that *E. pruiniramis* is not of hybrid origin but confirmed

that both *E. leprophloia* and *E. crispata* do represent hybrid entities. A draft manuscript is in preparation.
- Genetic analysis of *Rhagodia* sp. Hamersley is now complete. Results show that it is a distinct species from *R. eremaea* and warrants formal description as a species. A draft manuscript is in preparation.
- Genetic analysis for the pilot study of the *Acacia aneura* complex is now complete. Results showed high levels of clonality that was consistent with apomixis, as well as high levels of hybridisation. The data had sufficient resolution to delimit 10 of the 12 current mulga species. Morphological assessment of these samples is now underway.
- Genetic analysis for Western Australian *Minuria tridens* is largely complete. Results showed that the two Western Australian populations are not *M. tridens* and instead represent two separate species that are more closely related to *M. cunninghamii*. A report is in preparation.
- Genetic analysis for *Adenanthos eyrei* is underway. DNA extraction and sequencing for the type specimen was successful and the sequencing of additional specimens, including *A. forrestii*, *A. cuneatus* and *A. ileticos*, is in progress.

Management Implications
- Resolution of the taxonomic status of *V. spicata* subspecies will allow re-assessment of the need for conservation listing and resource allocation to the management of *V. spicata* subsp. *squamosa*.
- Genomic analysis of the four species complexes in the GAP project will resolve the species within each group and identify those with conservation concerns to enable conservation listing and appropriate management.
- Genomic analysis of *R.* sp. Hamersley will facilitate a formal species description if needed, and in conjunction with the survey data from sampling, will allow its conservation status to be assessed.
- Genomic analysis of the *G. brachystylis* complex will delimit taxa, allow re-assessment of conservation statuses and provide clarity to on ground conservation officers.
- Genomic assessment of putative hybrid origins for the three *Eucalyptus* species will provide clarity on the need for conservation listing and the resources allocated to their management.
- Genomic assessment of the *A. aneura* complex will provide support for delimiting species amongst the challenging morphological taxonomy of this complex group and allow appropriate management of these species in the arid zone.

Future Directions
- Finalise publication of the *V. spicata* manuscript.
- Complete genetic analyses of *Synaphea* and *A. eyrei*.
- Complete morphological assessments for *A. aneura, G. brachystylis* and *Wurmbea*.
- Finalise draft manuscripts for *G. brachystylis*, Midwest *Eucalyptus* hybridisation, *M. tridens* and *R.* sp. Hamersley for publication.

Remote Sensing and Spatial Analysis

Program Leader: Katherine Zdunic

The Remote Sensing and Spatial Analysis Program seeks to integrate the science and application of remote sensing and spatial analysis into departmental programs. For a department that manages large tracts of terrestrial and marine conservation parks and reserves, the efficient use and analysis of spatial data is crucial for understanding natural processes and informing management actions.

In recent times the availability of spatial data has increased dramatically. With this increase in data, the Program is continuing to develop sophisticated statistical analysis, interpretative and automation techniques to synthesise data into a form where they directly assist departmental staff.

The program undertakes fire mapping over extensive areas of the State. Utilising time series satellite imagery and ground information, monitoring programs have been established in the forest, wetland, marine, coastal, rangeland and tropical savanna environments. Species and habitat modelling and spatially explicit assessments, such as risk assessments, allow managers to identify areas of concern and efficiently utilise resources. Program scientists collaborate with other parts of the department, universities, CSIRO, natural resource management groups, resource companies and other research providers.

Species Distribution Modelling under Climate Change

SP-2024-11

L Van Der Weyde

Context

The Climate Adaptation Initiative (CAI) will undertake research that aims to address WA-specific climate adaptation knowledge gaps, including developing a better understanding of the vulnerability of terrestrial threatened species and ecological communities to climate change and their capacity to adapt to it. One component of the initiative involves spatial and ecological modelling which can provide a useful tool for increasing scientific knowledge, project planning and actions to protect ecosystems under future climate change scenarios. Incorporating knowledge of species-specific habitat requirements, as well as predicted changes in rainfall and temperature, can provide information on potential shifts in distribution and ranges of species in the near future. This knowledge can add to the existing ecological needs of threatened species and is necessary for informed decision making by conservation managers.

Aims

- Undertake research to address key knowledge gaps for WA threatened species, including climate vulnerability and adaptation linked with genetics and ecology, to inform the most impactful on-ground actions to support climate resilience and adaptation.

- Develop distribution maps for key species and assemblages providing information on projected changes in distribution under several Global Climate Models.
- Identify areas of low and high risk for species under future climate scenarios.

Progress

- A comprehensive review of the literature including but not limited to WA, was undertaken on species at risk to climate change. Previous studies have ranked threatened and non-threatened species using various techniques such as expert elicitation, trait identification and species distribution models. These studies were synthesised to identify key knowledge outputs and gaps. The review highlighted a list of potential species for further investigation, but more species knowledge, regional input and potential management plans are needed for further selection.
- Selection of global climate models that are applicable to the Australian landscape were identified and these showed that the south-west region of WA is expected to experience higher temperatures and lower rainfall over the coming decades in WA. This has therefore led to this area being identified as the focal study region for the CAI.
- A review of species distribution modelling techniques evaluated both statistical and machine learning approaches. The choice of models is largely driven by the available data e.g. presence-only or presence-absence, but can also be extended to use multiple sources of data where available. The primary approach will be to use statistical analysis using down-weighted Poisson regression for presence-only data while also additionally accounting for spatial autocorrelation and bias in data collection using modelled covariates.
- Consultation with regional staff has been undertaken to identify key species vulnerable to climate in the southwest of WA for species distribution modelling.

Management Implications

- Modelling can inform monitoring of species that have undergone significant distribution changes and range contractions by focusing specifically on the key habitat requirements, allowing research to be directed to fine-scale targeted areas, making effective use of time and resources.
- Species distribution models that inform where species are likely to be able to persist under future climate change scenarios are available for identifying potential translocation sites, key habitats where species are at risk or are secure and potential dispersal corridors.
- Spatial models can incorporate existing threats to identify areas requiring increased management actions to further secure habitat for threatened species, both now and under future climate change scenarios.

Future Directions

- Develop spatially explicit models of species and ecological community distributions under different climate scenarios and spatially represent threats for selected species identified as priority projects.
- Modelling of several species including: chuditch to identify distribution changes under climate change and in conjunction with genetic analyses, heath mouse to assist in identifying suitable areas for future monitoring and noisy scrub bird to aid in the identification of translocation sites.
- Prepare reports and manuscripts for publication.

Novel methods combining ground-based monitoring and remotely sensed observations to inform management and measurement of ecosystem condition in the rangelands

SP-2021-11

K Zdunic, J Ruscalleda Alvarez

Context

The mulga rangelands of the Midwest have experienced long-term degradation from the cumulative impact of 150 years of pastoral activity. Changing precipitation regimes and increasing temperatures threaten to further modify the trajectory of ecological condition in these ecosystems, with the impact of vegetation mortality and invasive species both likely to become more pronounced in future decades. However, while the extent of degradation is widely acknowledged, it is not known whether these ecosystems have the ecological capacity to naturally recover when agricultural grazing pressures are removed or how resilient they might be to future climatic extremes.

Aims

- Deliver new insights into the functioning of rangeland ecosystems in WA, and tools to undertake future monitoring and evaluation of these ecosystems.
- Develop a method to relate remote-sensing based measurement of ecosystem condition to on-ground monitoring datasets.
- Integrate new remote sensing technologies into assessments of rangeland condition and change detection.
- Determine the recovery potential of degraded rangeland ecosystems in Western Australia.

Progress

- Further tested the vegetation cover model developed in 2023, by adding further validation data from a field trip completed in April 2024. The vegetation model was compared to existing fractional cover data sets and to a simple vegetation index model approach. The vegetation model was applied to an area that will be used as a case study to show the use of the model in rangelands management monitoring.
- Processed aerial LiDAR dataset analysis into an output that can be effectively used to generate a vegetation structural map in the rangelands. Collected field data for validation of the structural map in a field trip in April 2024.
- Created several models to predict vegetation structure at different scales (20m and 100m) and at different complexity levels (3, 4 and 6 vegetation structural classes) through time series optical and radar satellite imagery.

Management Implications

- Identifying the recovery potential of particular areas of the landscape allows land managers to design targeted interventions in areas either most at risk of further degradation, or in places with the greatest potential to recover.
- Developing new remote-sensing based monitoring methods will allow more spatially comprehensive assessments of changes in vegetation condition than are currently practicable.

Future Directions

- Publish papers describing the vegetation cover model, the vegetation structural map generated through the LiDAR dataset and the model to predict vegetation structure using optical and satellite imagery.
- Generate a vegetation potential map that we can use to compare with the current status of vegetation, with the final goal of identifying areas that have the potential to host more vegetation than they currently do.
- Share the results of the project with stakeholders in the rangelands and test these products in different properties across the Midwest.

Dirk Hartog Island vegetation monitoring

SP-2018-9

R Van Dongen

Context

In 2009, Dirk Hartog Island (DHI) was gazetted as a National Park and the process to remove introduced animals and reintroduce native mammals began. A vegetation monitoring program was developed that integrates detailed floristic surveys, repeated site photography and Landsat satellite imagery to provide a comprehensive picture of vegetation condition and how the island's ecology has changed since destocking.

Aims

- Monitor changes in native vegetation cover following destocking of introduced herbivores.
- Monitor native vegetation cover changes with the recent reintroduction of native fauna.

Progress

- The 2022-23 vegetation cover monitoring report was completed, showing that 39% of DHI has experienced a significant increase in vegetation cover above pre-destocking levels.
- Fieldwork was carried out, where remotely piloted aircraft (RPA) data and records of the location and species of dominant shrubs were collected. Processing and analysis of imagery captured by RPA to date

is ongoing with cover measures and, where possible, species identification being recorded. Results from this work show, for example, that at site AGWA657 the median shrub diameter increased from 1.8 m in 2015 to 2.7 m in 2022.

Management Implications

- Results from the program demonstrate the ecological benefits of the eradication of introduced species and provide evidence that, with the improvement in vegetation condition, the mammal reintroduction program has a high likelihood of success.
- The data collected and further study of the fauna exclusion plots will aid in measuring the impacts of the reintroduced fauna.

Future Directions

- Update vegetation monitoring and sand dune area movement using Landsat imagery and carry out field validation of vegetation change.
- Continue assessment of changes to buffel grass extent over the period 2015 to 2023 and further investigate buffel grass detectability.
- Carry out field identification of plants that have significantly changed in extent over the 2015 to 2023 period and provide growth and cover statistics.
- Produce a draft paper looking into the combined effects of climate and destocking on vegetation cover on DHI.
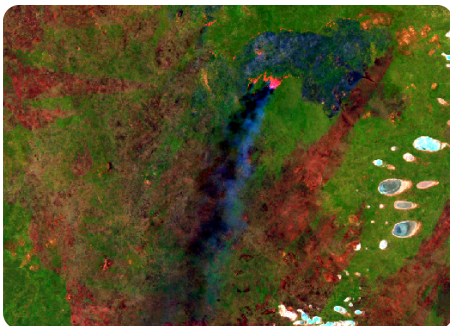
Remote sensing and spatial analysis for fire management

CF-2018-74

K Zdunic, B Huntley, J Chapman, P Rampant, R Van Dongen, J Ruscalleda Alvarez

Context

The department's fire management, monitoring and reporting functions require knowledge of fire events that are effectively derived through fire scar mapping. The imagery used for this analysis is predominantly satellite imagery and includes optical and thermal imagery from airborne platforms. Research areas include historical mapping that utilises the extensive archive record of satellite imagery and occasionally aerial imagery to build a fire history (or fuel age) for a location or to reconstruct the spread of major bushfires. These activities also include monthly mapping during the prescribed burn season. The project also plays a key role in fire research and development, through research into fuel growth, fire spread, fire risk and fire severity models. Internal and collaborative activities are carried out to further streamline and automate mapping techniques. General imagery support is also provided to Fire Management Services Branch and regional staff, including incident mapping and prediction and advice about imagery and systems development.

Aims

- Improve processes of fire scar identification to enable historical fire regimes to be understood for safety and ecological applications.
- Improve burn security through development of methodology to detect and communicate hotspot locations.
- Develop techniques to provide inputs for fire behaviour models to enable desktop assessments.
- Carry out operational processing of fire severity maps for prescribed burn and expand the historical archive.
- Provide remotely sensed spatial and temporal data to assist with bushfire investigations and reporting.
- Develop protocols for airborne thermal capture of going fire for measuring fire rate of spread from prescribed burns and mapping bushfires.

Progress

- Fire scar information for the Pilbara and Goldfields regions, Kanyirninpa Jukurrpa, Desert Support Services and Tarlka Matuwa Piarku was supplied to inform and report on prescribed burning activities in the Western Desert and Pilbara regions.
- Supported the operational use of airborne thermal cameras to detect hotspots for burn security.
- Supported the use of thermal sensors on remote piloted aircraft for monitoring fire behaviour during studies in prescribed burns.

- Continued investigation into remote piloted aircraft based LiDAR for fuel accumulation modelling and fire behaviour response.
- Supported regional and district fire managers in interpreting satellite derived burn severity products.
- Fire severity mapping continued with severity maps of all prescribed burns in the 2023-24 season created and delivered. Severity maps for several wildfires that occurred in the southwest were also created.
- Historical burn severity mapping was completed for the Perth Hills, Wellington districts and much of the South West and Swan Coastal districts. Automated reports of key fire metrics have been developed for the Swan region. Analysis is ongoing into the effect of the time and severity on previous prescribed burns and the spread of wildfires in the Perth Hills.
- Continued development of the R software package (FireHistory) for Fire Science and the public to enable fast querying and analysis of DBCA fire history data, especially focusing on working with big data queries (spatial and temporal).
- Provided data to Fire Management Services Branch to inform fire recovery, fire chronology and emerging satellite technology and availability.
- Continued integration of a satellite derived spinifex fuel cover model with the Pilbara region.
- Testing of automated fire scar mapping in the Great Victoria Desert was undertaken in collaboration with Landgate and the Great Victoria Desert Biodiversity Trust.
- Thermal mapping of hotspots has advanced with the training of staff to operate the sensor and analyse the resultant data from the aircraft.
- Trials have commenced for capturing thermography of going fire for better understanding rates of spread in prescribed burn situations and the potential to map bushfires when other sources of information are not available.

Management Implications

- The information provided for fire management is designed to significantly increase the accuracy of reporting and decrease the risks of fire management activities. Delivering fire scar mapping and information allows practitioners to make informed decisions that lead to more efficient fuel reduction activities and successful completion of burn prescriptions.
- Fire severity mapping is providing quantitative measures on prescribed burn and wildfire outcomes and the provision of detailed statistics at reserve scale describing historical fire patterns is informing the impact of time since fire and burn severity have on wildfire spread, helping management undertake nature conservation and wildfire suppression.
- Consistent production and attribution of seasonal fire scar mapping have resulted in the compilation of an annual fire scar mapping product with improved date, area and cause attribution. This product is suitable to analyse and provide spatial metrics that will aid in assessing the effectiveness of the fire management program over Millstream Chichester and Karijini National Parks.
- Delivery of aircraft-based thermal imagery hotspots to on-ground staff improves the security of burns.
- Development of a new cost-effective method for ground staff to assess burn security by detecting boundary hotspots from a remote piloted aircraft can be more efficient in more remote areas or when visibility is limited from an aircraft.
- Using remote piloted aircraft based LiDAR for fuel height and density measurement will lead to a more accurate model of fuel accumulation for better management of fuel levels in the forest and safer bushfire management.
- Satellite derived spinifex fuel cover maps enable regional fire activities to be more targeted, efficient and safe in their fuel reduction activities.
- The initial trial of mapping and monitoring prescribed burns from the incendiary aircraft is providing valuable information for understanding rates of fire spread in different fuels and locations across the landscape aiding fire ecology research into the fuel and fire behaviour relationship.

Future Directions

- Continue development and automation of fire scar detection methodology.
- Investigation and development of new data sources including emerging satellite sensors and aerial capture.
- Fire severity mapping across the southwest will continue with a focus on expanding analysis techniques and building more sophisticated automated, reserve and district scale reporting. Research will also target improving the severity model for heath type vegetation and examining the degree to which cool, understory burns can be detected in karri forest.
- Continue testing and operationalise fire severity models in southwest forests.
- Implementation and development of spatial analysis of fire patterns and fuel loads.
- Assist in in implementing safe use of remotely piloted aircraft with thermal sensors for studies in fire behaviour and for burn security.
- Further remote piloted aircraft trials to create protocols of flight parameters for effective data collection.
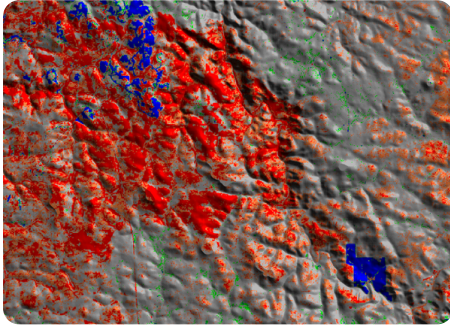
Remote sensing monitoring

CF-2018-72

K Zdunic, R Van Dongen, K Murray, B Huntley, J Chapman, G Loewenthal, G Pitt, P Rampant

Context

The measurement and analysis of change across terrestrial, wetland and marine environments using remote sensing provides essential historical and current information that can be used to understand the effects of management actions and natural events. The imagery used is predominantly satellite imagery, and also includes optical imagery from handheld and airborne platforms [manned aircraft and remotely piloted aircraft (RPA)] and LiDAR data. Field observations provide essential ground truth and calibration of remotely sensed data. Analysis techniques include an increasing number of sophisticated time series analysis tools and object orientated image classification. This work is underpinned by efficient and statistically rigorous analysis and batch processing techniques in the R programming environment. Remote sensing monitoring relies on repeatable and consistent source imagery and developing methods to produce reliable spatial and statistical products that the department can use for reporting on the State of the Environment, managing the conservation estate and assessing the threats to biodiversity.

Aims

- Undertake remote sensing monitoring and research at a range of temporal and spatial scales using technologies that include satellite imagery, digital cameras, remotely piloted aircraft and LiDAR data.

Progress

- Time series for mangrove vegetation cover and products with collection 3 analysis ready satellite data have been updated for Lalang-garram, Shark Bay, Ningaloo and Montebello Islands Marine Parks using automated processing from in house developed R package groveR for Marine Park reporting.
- Millstream Chichester National Park riparian vegetation monitoring was continued.
- Further development of field monitoring protocols supporting the Fortescue Marsh management strategy was undertaken and led to the initial development of a vegetation monitoring framework.
- Wetland inundation and hydroperiod analysis for various wetlands throughout the state was undertaken utilising satellite imagery.
- Real-time kinematic remote piloted aircraft multispectral sensor workflow for Ramsar and other wetland fringing vegetation is under development with multiple tests conducted over the Muir-Byenup system.
- Technical knowledge of and protocols were developed for site surveying and GNSS post-processing of geolocated data.
- Assistance was provided to setup the Forest Health Monitoring Program test sites whilst also capturing remotely piloted aircraft sensor data. Captured data was post-processed to produce analysis ready LiDAR and photogrammetry data products and protocols were written.
- Continued remote piloted aircraft capture testing using a variety of sensors at Benger swamps in order to develop appropriate measures to manage bittern habitat.
- Continued development of cover and structure measure from close range and satellite remote sensing of the Badimia reserves to support carbon projects.
- Completed Geospatial data reports summarising changes in rainfall, vegetation cover trends and fire history metrics across the Perup Management Plan Area, Parker Range and Lake Magenta Nature Reserve.
- Completed an assessment of senescence across Wheatbelt Reserves. A model to predict senescence was created using field observations and Landsat satellite data and applied to all Reserves in the Wheatbelt region.
- A project to map vegetation types relevant to fire management and reporting across the Great Western Woodland was initiated. An image processing and classification methodology has been developed and applied to several management areas.
- An assessment of vegetation cover across the Kwinana freeway foreshore for 2023 was carried out using image segmentation and classification applied to aerial photography. Cover levels from 2023 across 12 management zones were then compared to cover levels from 2005, 2010, 2014, 2018 and 2021.
- The development of a drought and die-off analysis of the south west for the 2023-24 summer has been initiated. The analysis uses field observation of drought impact across a range of vegetation types and regions to build a predictive drought impact model with satellite imagery.
- Developed a method for detecting Swan and Canning River seagrass extent at shallow depths using field data and high resolution satellite imagery

- Improving options for ground truthing and validation for Shark Bay seagrass mapping for 2020 and 2023 by looking at alternative sources to *in situ* field data and aerial photography both of which are scarce. This has involved creating a photo index of dugong survey photos and sourcing high resolution Geosat satellite data.
- Developed a method of estimating the genus composition of seagrass lost where only the first year of seagrass mapping was mapped to species level in a time series.

Management Implications

- Wetland inundation and hydroperiod analysis provides information to understand the status and conservation significance of wetlands especially those remotely located.
- Evaluation of wetland characteristics is informing locations of suitable habitat for threatened species.
- Real-time kinematic remote piloted aircraft multispectral sensor processing workflows will enable repeatable analysis and the development of a framework for vegetation and wetland monitoring.
- Protocols for site surveying and GNSS post-processing of geolocated data will ensure best practice for data capture from the real-time kinematic remote piloted aircraft.
- Development of consistent monitoring protocols and framework will assist the coordination of the collection of data by DBCA and joint management partner ranger groups and thereby the effectiveness of conservation actions on the Fortescue Marsh.
- Mangrove monitoring information provides quantitative locational changes of mangrove canopy informing management actions and is applied in Conservation and Parks Commission reporting.
- Improved landscape mapping resolution aids management at scales relevant to parks and reserves.
- Vegetation monitoring across various environments including mangroves, riparian zones, rangelands and forests, provides quantitative information for assessing vegetation changes and informs management actions.
- Management plan evaluations for several National Parks and Nature Reserves are supported by satellite imagery analysis and spatial data analytics.
- The Wheatbelt senescence analysis provided management with an indication of in which reserves senescence may be significantly impacting vegetation condition. This was used in conjunction with ground observations to plan prescribed burning.
- Vegetation mapping in the Great Western Woodland will be used by the Goldfields region to plan prescribed burns and in post burn reporting.
- The Kwinana Freeway vegetation cover assessment provides a statistical assessment of vegetation change in 12 management zones which can be used to assess the effectiveness of revegetation activities.
- Draft versions of the drought mapping are informing of potential fire risk, highlighting areas where potential vegetation hazards may occur and assisting the Department of Water and Environmental Regulation to investigate interactions with water drawdown.
- Through measurements and classification of imagery captured using remote piloted aircraft, the size and density of trees in drought impacted areas in the jarrah forest is informing forest management strategies to mitigate drought impacts.
- Seagrass extent mapping of the Swan and Canning River will assist in management, reporting and modelling of river dynamics.
- Multiple sources of ground truthing and validation improve seagrass mapping time series and provide Gascoyne District and World heritage staff with trusted data forinformed decision making. Mapping of the locational changes of seagrass will be used in reporting to the Conservation and Parks Commission.

Future Directions

- Undertake research and develop inputs to Forest Management Plan reporting including forest health monitoring and program development.
- Continue research into forest condition with a focus on resilience.
- Continue to explore and develop cloud processing options with Geoscience Australia.
- Develop and refine the use of remotely piloted aircraft imagery and LiDAR for vegetation monitoring and mapping. Including the development of capture specification and analysis pathways to determine vegetation structure and cover attributes.
- Update Roebuck Bay/Yawuru, 80 Mile Beach, Mayala and Maiyalam and Bardi Jawi GaarraMarine Parks mangrove monitoring timeseries and test the accuracy of the products developed for Lalang-garram Marine Park.
- Finalise methods for seagrass classification and complete the Swan and Canning River 2023 seagrass extent map.
- Continue seagrass mapping for 2020 and 2023 in Shark Bay with better sources of ground truthing and validation.
- Expand vegetation mapping in the Great Western Woodland.

Spatial analysis and modelling

CF-2018-73

K Zdunic, G Loewenthal, B Huntley, J Kinloch

Context

The spatial analysis and modelling project develops and utilises tools to assist in the evaluation, interpretation and prediction of conservation values, threatening processes and management actions. These tools generally integrate spatial data sets, expert knowledge and GIS modelling techniques to produce spatially explicit products that can be used to inform decision making. Projects can be focused on species occurrence (species distribution models or habitat suitability modelling), animal movement (for example, identification of home range or habitat linkages), landscape scale processes (including assessment of habitat fragmentation) or assessments such as quantifying risk (for example risk presented by feral cattle to biodiversity values). Identification of areas of high conservation value for protection is also undertaken by combining numerous conservation value data sets and using software to evaluate possible conservation scenarios.

Aims

- Develop spatial models to describe ecological processes, thereby increasing the understanding and protection of biodiversity.
- Develop and utilise spatial analysis tools to inform management and support decision making.
- Collate and summarise spatial information using statistical and documented methods to inform monitoring and management practices.

Progress

- A draft habitat suitability model for the yellow-spotted monitor (*Varanus panoptes*) was extended to include Kimberley and Pilbara bioregions. The new version incorporated observations collected by Traditional Owner Ranger Groups into the modelling.
- Climate suitability spatial modelling for the invasive plant pathogen myrtle rust was initiated.
- Spatial variables were developed for the North West Shelf flatback turtle rookeries and at-sea distribution models and a research manuscript commenced.
- Regional conservation planning processes were supported with spatial analysis, including the update of fauna into the base datasets and preparation of flora data for the South Coast region.
- Ongoing spatial analysis to support the investigation of climate impacts on threatened flora populations across the Stirling Range National Park.

Management Implications

- Spatial information on where significant habitat of the yellow-spotted monitor is likely to occur will be used to optimise the location of cane toad taste aversion training.
- Spatial information on areas of higher climatic suitability of the establishment of myrtle rust will enable the prioritisation of conservation efforts to the highest risk areas.
- Species distribution models provide information on the likelihood of habitat for a species being present and thus are critical for determining species conservation and management priorities and actions.
- Information on the conservation values and threats present in each conservation management unit, contributes to the identification of management priorities during DBCA's regional conservation planning process.
- The identification of refugia for threatened flora populations can be used to inform management to mitigate the impact of climate change.

Future Directions

- Further develop landscape scale spatial metrics that assess conservation values and threats that can be used for monitoring management interventions.
- Finalise models for the yellow spotted monitor along the cane toad front.
- Develop models to identify areas at high risk of myrtle rust establishment for the current climate and under future climate scenarios.
- Develop spatial resources and tools to support the South Coast strategic planning and Perth and Peel regional planning.
- Develop further functionality for the DBCA fire history analysis software to include additional metrics.

- Continue to provide spatial support for hydrological modelling and management of the Swan and Canning rivers.
- Provide spatial support to the development of 1:50,000 mapping of the swan coastal plain.
- Produce protected area statistics reports.
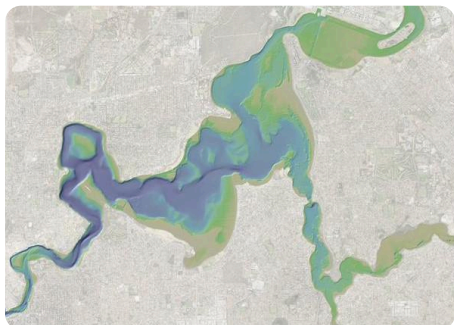
Spatial data management

CF-2018-75

K Zdunic, K Murray, B Huntley, J Kinloch, G Loewenthal, R Van Dongen, P Rampant, J Chapman

Context

This core function manages spatial data sets by creating metadata, cleaning data to a corporate standard and saving or migrating data in a secure and accessible corporate data repository - the Spatial Data Library. Many of the data sets in the Spatial Data Library are identified through departmental project requirements. Large data sets include imagery and digital elevation models captured for general use across the department or for specific projects and have multiple uses such as time series analysis, spatial analysis, modelling, and decision making for management, monitoring, planning and policy. Departmental collaborations also produce key data sets that are important but may not be ready to use or need a license arrangement to be utilised by the department. Making fundamental data sets accessible to all staff through corporate GIS software is an effective way of communicating what science is being undertaken and also assists with determining management priorities and actions.

Aims

- Identify and manage fundamental data sets created internally and externally that have value to the department and multiple uses.
- Collate, clean and create metadata for final spatial data sets developed by departmental activities and science collaborations, and migrate this data into Corporate GIS applications and the Spatial Data Library.

Progress

- Applied processes to make spatial data discoverable and accessible as the department moves data storage to a cloud environment.
- LiDAR data sets purchased by other state agencies were obtained and included for corporate use.
- Applied processes to make current and historical bathymetry data for the Swan and Canning Rivers more accessible and discoverable.
- Coordinated departmental bathymetry data needs and lodged the areas requested to AusSeabed (Geoscience Australia) and the Western Australia Marine and Coastal Data Group.
- A review of data management protocols was undertaken and new protocols implemented.
- Undertook development and training in access and application of scripts to enable access and processing of satellite imagery maintained on the national computing infrastructure.

Management Implications

- Terrestrial and marine spatial data of corporate value can be accessed internally using cloud-based platforms, and data that is of value to external stakeholders can be identified, documented and made available on portals such as DataWA.
- Making available updated state-owned LiDAR and other data reduces duplication and increases the capacity of spatial modelling of soils, vegetation and habitats for management.
- New bathymetry at better resolutions can assist department staff in navigation, management, research and monitoring operations in state Marine Parks waters.
- Continued development and migration of user-friendly spatial data sets will support the department's need to improve the discoverability and accessibility of science data for all staff.

Future Directions

- Identify terrestrial and marine spatial data sets to be migrated to the corporate data menu.
- Continue to update satellite imagery, LiDAR and digital elevation model catalogues.
- Continue to develop scripts and functions to utilise satellite imagery on national computing infrastructure.

Rivers and Estuaries Science

Program Leader: Kerry Trayler

The Rivers and Estuaries Science Program undertakes and supports research across a wide range of disciplines to address knowledge gaps and inform management of the Swan Canning Riverpark. Research is aligned with the Swan Canning Research Strategy and WAMSI estuarine research priorities. Strong collaborative linkages exist with universities, research centres and other government departments. Scientific advice and support is provided to the Rivers and Estuaries Branch in relation to waterway condition, management, and incident response including algal blooms, fish-kills, sewage overflows and dolphin deaths.
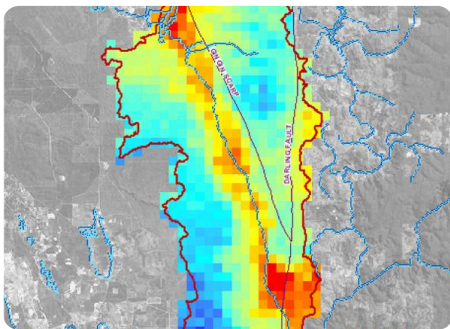
Ellen Brook catchment nutrient export: sources and pathways

SP-2022-33

S Adiyanti, K Trayler, A Basnett

Context

Ellen Brook is a tributary to the Swan Canning Estuary and is identified as the major contributor of nutrient loads to the system. Water quality in Ellen Brook catchment and its sub-catchments is influenced by a mixture of land uses and activities affecting both surface and groundwater inputs. Previous attempts have been made to model nutrient exports from the catchment, but there remain uncertainties in the groundwater and land use type contributions to the overall nutrient export to the estuary. Refinement of nutrient modelling with inclusion of groundwater-surface water interactions is essential to reduce these uncertainties. To better inform land management policy and support decision making for nutrient interventions, a distributed 2D processed-based hydrological and nutrient model for Ellen Brook is being developed. The model will be used to quantify nutrient export from specific land use types, differentiate active and legacy sources and illustrate spatial and temporal variability. Climate change influence will also be investigated.

Aims

- Generate a hydrological and nutrient export model for the Ellen Brook catchment that will estimate the surface flux (discharge), baseflow, and regional groundwater contribution to nutrient export.
- Identify active and legacy sources contributing to stream nutrient load.
- Estimate the relationship between nutrient export and change in land use and land cover.
- Estimate the land use-specific nutrient export rate.
- Predict climate change impact and catchment management scenarios for Ellen Brook nutrient export.

Progress

- The calibration and validation of Ellen Brook mHM hydrological model 2010-2023 has been completed. The inclusion of estimated daily flows of Lennard Brook, Yalyal Brook and Breera Brook into the 2D

model has significantly improved the comparison between simulated and observed flows at upstream and downstream gauges within the catchment, with the coefficient of determination being >0.9 for both daily and monthly flow. Flows from the three brooks were estimated using a baseflow separation technique, combined with sporadic, available flow data on a few summer days in 2011, 2017, 2019, 2020, 2021, 2023, provided by the Department of Water and Environmental Regulation's Healthy Rivers program.

- Comparison between Ellen Brook simulated recharge at 1km grids and the Perth Regional Aquifer Modelling System (PRAMS) recharge 2010-2019, indicates the Ellen Brook hydrological model is performing well.
- Identification of active and legacy sources of nutrients and development of the relationship between nutrient export and changes in land use/land cover has progressed.

Management Implications

- Understanding the seasonal variations of nutrient concentrations at each monitoring station and their relationship with flow will give an indication of whether nutrients are from active or legacy sources, which is critical to assess the influence of water quality improvement measures within the catchment on water quality targets.
- Development of the nutrient export model provides an opportunity to evaluate how land use change affects water quality and whether intervention options are effective in achieving water quality targets.

Future Directions

- Develop a Bayesian nutrient model utilising 1km gridded simulated flow and nutrient monitoring data collected at 34 monitoring sites between 2010 and 2023.

Habitat enhancement approaches within the Swan-Canning Estuary.

SP-2022-29

L Arrowsmith, K Trayler, J Baker

Context

The Swan Canning Estuary (SCE) is a microtidal system that has become subject to increasing urbanisation and development along its shorelines. As a result, river walls and rock revetments have been used to modify the shoreline and provide protection against erosion, often resulting in reduced natural habitats and species abundance. Eco-engineered habitats are an alternative method to aid in protecting shorelines and reducing erosion, whilst promoting biodiversity and alleviating declines in habitats. As existing modifications in the SCE reach the end of their intended lifespans and new structures are built to reduce erosion, there is potential to integrate eco-engineered technological and nature-based solutions in the SCE.

Aims

- Evaluate and incorporate the use of Living Seawalls (LSW) habitat panels along three sections of river wall within the lower SCE to assess their effectiveness in enhancing habitats.
- Provide baseline information on the effectiveness of two commonly used erosion control techniques for enhancing habitat.
- Determine the effectiveness of LSW panels for enhancing habitat percentage cover and richness along river walls compared to unmodified walls.
- Investigate the influence each habitat panel design has on colonisation rates and species diversity on all panels.

Progress

- Sampling frequency has been increased from biannually to quarterly, to facilitate an assessment of seasonal changes in species richness and diversity on LSW habitat panels.
- LSW habitat panels were assessed a further three times in this reporting period to evaluate the micro- and macrospecies present on the panels.
- Atypically high water temperatures and extremely low tides resulted in extensive desiccation of the settled macroalgae and invertebrate species.
- The panels have been repositioned so that they are closer to the seawalls, providing more stability against wave energy.

- Wave attenuation data has been downloaded from wave loggers located at each site every two months, providing data on wave and boat wake energy impacting seawalls in the area.

Management Implications

- The project is continuing to provide guidance to local governments on how to improve conservation of estuarine biodiversity by incorporating eco-engineering solutions to modified seawalls.
- Information on how panel application, type and positioning along a seawall influences species richness, abundance, cover and growth will inform planning decisions on the value of these approaches to improve habitat under Western Australian conditions.
- The methodologies, such as panel installation and suitability, as well as biodiversity assessment protocols will be used to inform other projects aimed at improving habitats along the SCE shorelines.

Future Directions

- Continue seasonal sampling to assess changes in species richness, abundance and diversity on LSW habitat panels.
- Continue to collect and analyse fish community data to assess fish interactions with the panels.
- Finalise results of the project for upcoming conference presentations and publications.
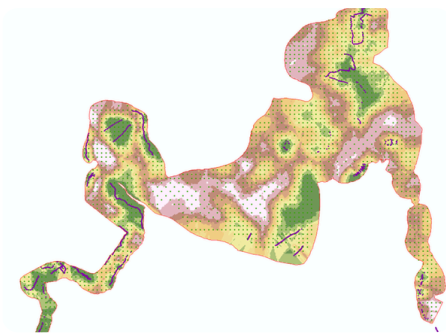
Mapping habitat in the Swan-Canning Estuary.

SP-2022-30

L Arrowsmith, K Trayler, J Cosgrove, S Adiyanti, P Howie, J Baker

Context

Ocean sprawl is an increasing disturbance that is occurring along the Lower Swan Canning Estuary (LSCE), replacing complex marine habitats with simplistic artificial structures, that can result in the decline of species richness and abundance. Using remote image collection methods (ROVs, drop-cameras, and tow-cameras) in conjunction with habitat classification systems, benthic surveys can be conducted across areas of importance to assist is assessing species abundance and extent of species reduction over time. As the LSCE is an important ecosystem for a range of species and habitats, as well as recreational users, collecting data to establish distribution maps of key habitats is essential to understand the influences of this system.

Aims

- Produce broad scale habitat maps of the benthic habitat in the LSCE to inform assessments of benthic habitat diversity.
- Develop and consolidate maps of key species and communities and identify areas of ecological significance in the LSCE.

Progress

- Habitat images from the 2019-20, 2023 and 2024 habitat mapping surveys have been uploaded to the ReefCloud database.
- Habitat types, including macroalgae and seagrass, and associated invertebrate and fish species, have been classified in the images using a combination of human identification and AI learning.
- Baseline maps of the 2019 habitat data have been completed for the LSCE.
- Satellite imagery of the LSCE has been acquired for 2023 and 2024.

Management Implications

- Benthic habitat maps identifying areas of ecological importance and coverage through the LSCE will help to inform management decisions.
- The methodologies and analyses used to develop these maps provides a framework for future mapping to assist in informing river managers of trends in benthic habitats over time.

Future Directions

- Continue to classify benthic habitat images.
- Continue to develop maps to illustrate high density areas of ecologically important habitat within the LSCE.

- Consolidate satellite imagery data across years to show changes in the distribution of habitats and associated species in the LSCE.
- Integrate seagrass monitoring data with other benthic data to help gain a broader understanding of overall benthic habitat within the system.
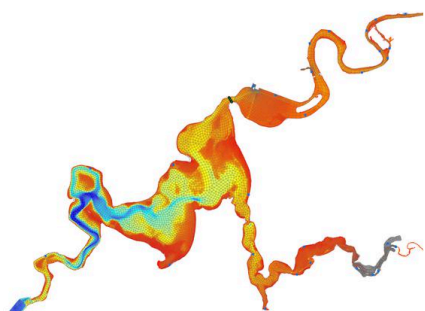
Using Swan Canning Estuarine Response Model to optimise oxygenation plant efficiency

SP-2022-34

S Adiyanti, K Trayler

Context

Understanding spatiotemporal variability in hydrodynamic and biogeochemical conditions of the Swan Canning Estuary is essential to improve the distribution of oxygen-saturated water injected via side-stream supersaturation oxygenation plants at Guildford and Caversham. Information on dissolved oxygen distribution and likelihood of benthic water experiencing hypoxia in each season are needed to ensure the plants are operating optimally under current and future climate conditions. This project will contribute to improved oxygenation approaches in the estuary by developing better understanding of variability and drivers of oxygen conditions and enabling predictive support for decisions in relation to oxygenation effectiveness.

Aims

- Refine the application of a 3D hydrodynamic oxygen predictive model, the Swan Canning Estuarine Response Model (SCERM44).
- Understand the impact of seasonal variations in estuary conditions on the extent of the oxygenation plant generated plumes.
- Understand how salt wedge dynamics influence oxygen distribution.
- Understand the influence of the catchment inflow water quantity and quality.
- Assess approaches to improve oxygenation plant efficiency.
- Assess the potential impact of 2030 climate change scenario and oxygenation adaptation required.

Progress

- The new meshgrids for the whole domain (SCERM44) have been refined using the latest available bathymetry survey data, including the 2023 survey from Bayswater to Yagan Bridge in Belhus. The refinement improved the performance of the 3D hydrodynamic biogeochemical model, enabling correct representation of the spatiotemporal variability from the marine waters at the estuary mouth to the brackish waters of the upper reaches.
- All necessary boundary conditions 2007-2023 have been prepared, which include 44 catchment inflows and nutrients simulated using Swan Canning Catchment Model (eWater SOURCE) and 2D meteorological forcing (BARRA-R, BARRA-PH, ERA-5). Initial conditions were prepared using routine estuarine monitoring data.
- Model validations were performed for both SCERM44 and SCERM29 using simulated, time series data compared against actual field data up to 2023.
- Automated processing scripts (in MATLAB and Python) have been prepared to compare simulated vs field data efficiently.

Management Implications

- The refined model will provide key understanding of hydrodynamics and oxygen dynamics of the Swan Canning Estuary, in particular, the upper reaches of the Swan Estuary which are influenced by the oxygenation plants. This will assist the oxygenation plant managers to optimise operations under present day conditions and adapt to projections under future climate conditions.

Future Directions

- Conduct flow measurements in transects across the estuary, with a focus on the Middle and Upper Swan Estuary, to help further refine the model.
- Apply CMIP6 reanalysis climate model result when available (DWER and Murdoch Uni), particularly for future climate scenario.

Apply acoustic technologies to investigate fish communities and movement

SP-2020-29

S Hoeksema, K Trayler, J Watsham, P Novak

Context

How fish utilise the Swan Canning Estuary, including distances moved on a daily or seasonal basis and movements in response to changes in environmental condition, remains a key knowledge gap despite a number of detailed studies on fish biology and ecology over the past three decades. This information is particularly important in relation to recreationally targeted fish species that have high value to the Perth community.

Acoustic technology can be utilised to provide valuable information on fish movements relative to water quality parameters, such as salinity and dissolved oxygen, and to major interventions within the river system, such as the Swan Canning Oxygenation Program and the Kent Street Weir fishway. Acoustic technology can also be employed to understand how fish utilise habitats of differing complexity, particularly those that are not suited to traditional sampling methods. An acoustic array was established in the Swan Canning river system in 2016.

Aims

- Utilise acoustic technology to assess fish communities and movement relative to water quality, habitat complexity and inriver interventions.

Progress

- Analyses of movement data of 120 tagged black bream (*Acanthopagrus butcheri*) relative to physico-chemical estimates produced by the Swan Canning Estuarine Response Model are being finalised and a journal article drafted.
- Acoustic receivers were redistributed and a further five receivers deployed to increase the spatial coverage in the Lower Swan Canning Estuary.
- Preliminary analyses were undertaken on movement data of the three juvenile bull sharks (*Carcharhinus leucas*) tagged between 2021-2023, which helped to inform targeted sampling in 2023-24.
- A further two juvenile bull sharks were successfully tagged and released within the Middle and Upper Swan Estuary in 2023-24.
- A collaborative agreement was established with Department of Primary Industries and Regional Development (DPIRD) to acoustically tag and track juvenile (DBCA) and adult (DPIRD) bull sharks in the Swan Canning Estuary. Three real-time acoustic receivers were deployed by DPIRD in the lower reaches of the estuary at East Fremantle, Blackwall Reach and Canning Bridge.
- Six genetic samples have been obtained from bull sharks within the Swan Canning river system, which contributed to DPIRD's state-wide genetic library for this species.

Management Implications

- The application of acoustic receiver technology combined with water quality estimates derived from model outputs will help improve understandings of how fish populations respond to changes in environmental conditions and help to inform operation of the Swan oxygenation plants and Kent St Weir/fishway.
- Tagging juvenile bull sharks within the Swan Canning Riverpark will elucidate their movements within the river system and improve our understanding of residency time, distribution and habitat use to identify whether important nursery areas exist that require protection or enhancement.
- Collaboration with DPIRD and data from the three real-time receivers deployed at priority areas in the estuary will help inform shark hazard risk mitigation strategies in the estuary and nearshore coastal environment.

Future Directions

- Finalise analysis of bream movement data relative to water quality in the Swan Canning Estuary and produce journal article.
- Undertake further tagging of juvenile bull sharks during the pupping season in 2024-25 and analyse movement data.
- Continue to collaborate with DPIRD in 2024-25 to help inform shark hazard risk mitigation strategies in the estuary and nearshore coastal environment.

Investigations of contaminants in the Swan Canning

SP-2020-26

P Novak, K Trayler, S Hoeksema

Context

The Swan Canning Estuary is home to diverse faunal assemblages, productive seagrass and macroalgal communities and is a focus for many water-based activities, including recreational fishing. The estuary is situated wholly in the Perth metropolitan region and drains a large agricultural catchment. It faces many anthropogenic stressors, including flow reduction, excessive nutrient input, and contaminant loading associated with a range of contemporary and historical land uses. Ensuring environmental and social values are maintained requires an understanding of threats. In particular, it is vital to understand the extent, distribution and potential impact of both novel and legacy contaminants, evaluate risks to the ecosystem and human health and improve approaches to management.

Aims

- Determine the distribution, extent and types of contaminants in the surface waters and sediments of the Swan Canning Estuary and its catchment.
- Determine the uptake of contaminants in key estuarine biota.
- Understand potential risks to human health through consumption of estuarine species.
- Explore potential control mechanisms for contaminants.

Progress

- A project investigating plastic infrastructure, such as jetties and boardwalks, as a potential source of plastic pollution to the Swan Canning Estuary has been completed. A report has been published and a paper submitted to *Marine Pollution Bulletin*, which is currently under review.
- An assessment of the efficacy of the Ellen Brook constructed wetland to remove PFAS from surface waters and a preliminary assessment of the data has been completed.

Management Implications

- Information on the distribution and concentration of contaminants in the Swan Canning river system is used to identify potential environmental risks.
- Published reports and produced data are used in the assessment of development applications and other planning advice requests within the Swan Canning Riverpark to inform the suitability of works or commercial activities and to inform the potential requirements of baseline assessments.
- Results and recommendations from the plastic infrastructure report are being used to help guide the installation of future inriver infrastructure within the Swan Canning Riverpark.
- Data on the effectiveness of the Ellen Brook constructed wetland has been used to inform the future treatment of the wetland filter media.

Future Directions

- Finalise report on the effectiveness of the Ellen Brook constructed wetland to remove PFAS from surface water.
- Prepare a manuscript on PFAS in biota of the Swan Canning Estuary is ongoing.
- Develop a monitoring plan for contaminants within the Swan Canning river system.

Swan Canning water quality monitoring

SP-2020-27

J Cosgrove, K Trayler, J Gregory, P Howie, A Gillies, S Hoeksema, J Watsham, P Novak, S Thompson, S Muller, J Chapman

Context

Water quality in the Swan Canning Estuary and its catchment has been routinely monitored over the past 25 years, producing one of the largest continuous data sets for any estuarine system in Australia. Data produced through the monitoring program provides essential information to assess system response to management actions, changes in estuary condition over time and is used to report against estuary water quality targets, catchment nutrient reduction targets and phytoplankton trigger levels. Data has also been used to progress the development of estuarine and catchment models that contribute to decision support.

Aims

- Undertake routine monitoring of water quality and biological parameters in the Swan Canning Estuary and its catchment to provide weekly updates and annual reports on the condition of the river system that inform management actions.
- Undertake weekly monitoring of physical water quality parameters and fortnightly collection of phytoplankton and nutrient samples at routine estuarine monitoring sites, and fortnightly monitoring of physical water quality parameters and collection of nutrient samples at routine monitoring sites.

Progress

- Routine weekly water quality profiles were taken at 36 sites and fortnightly phytoplankton and nutrient samples were collected at 21 sites throughout the Swan Canning river system. Fortnightly water quality and nutrient samples were also collected at up to 33 sites in the Swan Canning catchment.
- Water quality reports and phytoplankton information were updated weekly on the 'Monitoring and reporting in the Swan Canning Riverpark' page of the DBCA website.
- A beta-version of an online data dashboard to provide monitoring data to stakeholders and the public in a more timely and effective manner was developed and is anticipated to be made publicly available in early 2024-25.
- Historical monitoring data was used to develop local baseline water quality triggers and provide further monitoring data for major works around the river.
- A technical report on the condition of the Swan Canning river system (2015-2020) is nearing completion.

Management Implications

- The online data dashboard will replace public facing weekly updates and annual data reports and present monitoring data to the public in a more interactive manner.
- Routine water quality monitoring helps to protect the Swan Canning Riverpark by allowing development of locally relevant water quality triggers for inclusion into environmental management plans.
- Information on potential public health risks, such as algal blooms, black-water events and fish-kills, are provided to Department of Health, Department of Primary Industries and Regional Development and DBCA incident management teams, as required.

Future Directions

- Continue routine water quality monitoring in the Swan Canning river system and catchment and utilise data to inform management and research.
- Finalise and deploy the beta-version of the online data dashboard to publicly present water quality data and work towards the development of further functionality and updates.
- Finalise the production of the technical report on the condition of the Swan Canning river system (2015-2020) in early 2024-25.
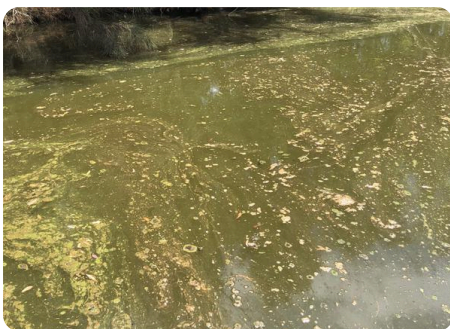
Algal blooms: investigations and control

SP-2018-35

J Cosgrove, K Trayler, S Thompson, S Hoeksema

Context

Parts of the Swan and Canning Rivers are affected by temporally and spatially variable algal blooms. While most algal blooms are harmless, on occasion, toxic blooms occur that can be harmful to the rivers, wildlife and humans. The impact of these blooms on environmental and social values will depend on the type and severity of the bloom. Understanding the dynamics of algal blooms is important in determining their impact and approaches to their control. Regular monitoring of the Swan and Canning Rivers enables retrospective

analyses of bloom events and adaptive approaches to in-river bloom management. Many approaches are promoted for managing algal blooms. Finding useful and applicable methods for managing blooms in the Swan and Canning Rivers requires a combination of desktop analyses, laboratory and field based trials. It is also important to consider the potential impact of control products on waterway values.

Aims

- Investigate harmful algal blooms and understand factors influencing their presence and toxicity.
- Test the products suitable for controlling algae in laboratory and field settings.
- Understand the risks associated with blooms and bloom control products.
- Refine tools that contribute to understanding algal blooms.

Progress

- Where harmful algal species were detected in the waterway, investigation of blooms across spatial and temporal scales was undertaken to build understanding of the conditions that influence these events.
- Liaison with Murdoch University's Institute for Immunology and Infectious Diseases has led to opportunities to genetically characterise key harmful algal bloom species.
- Investigation of the efficacy of activated clays in floccing *Karlodinium* out of the water column mirrored work being done on the control of *Alexandrium*. Results of small-scale trials were highly promising, with almost 100% removal with a low dose clay application of 0.1 g/L.
- A brief literature review of human health risk associated with the toxin β-N-methylamino-L-alanine (BMAA) has commenced, including liaison with the Department of Health.

Management Implications

- Routine water quality monitoring continues to provide early detection of algal blooms, with additional targeted response sampling providing enhanced spatial and temporal data for improved incident management.

Future Directions

- Investigate the long-term algal bloom dataset and historical management actions in the Kent St weir pool to understand key drivers influencing bloom intensity and frequency.
- Review existing data on the environmental safety of poly-alum chloride as an additive to clay slurries for algal bloom control and consider opportunities for mesocosm or confined medium scale inriver trials of activated clays to mitigate algal blooms.
- Look for opportunities to gain further knowledge of *Karlodinium* cf. *armiger* in the Swan Canning Estuary.

Incident investigations, response and advice

CF-2018-95

K Trayler, J Cosgrove, S Thompson, P Novak

Context

Rivers and Estuaries Science plays an essential role in investigating issues as they arise in the Swan Canning Riverpark. This involves investigating events (such as harmful algal blooms, fish kills and pollution discharge), examining causes, implications and response actions.

Aims

- Monitor toxic algal blooms as they arise and report to an incident response team.
- Investigate fish kills as they arise and inform the incident response team.
- Investigate dolphin deaths as they arise, collate information and advise management and operations when required.
- Investigate and provide advice to management on contaminant spills.
- Provide information and advice to support river management and planning.

Progress

- The REB/RES Incident Management Team (IMT) was activated in response to bloom conditions in early November 2023. Weekly reporting on blooms and implications for estuarine health and management

occurred through to the end of bloom conditions in April 2024. Despite very high concentrations of *Karlodinium*, particularly in the Upper Swan Estuary, no significant fish kills were recorded.

- Pre- and post-season interagency IMT meetings and end of season communications were undertaken to ensure a coordinated and consistent approach regarding toxic *Alexandrium* blooms and response; however densities of *Alexandrium* remained low this season.
- Regular monitoring of the pathogenic bacterium *Vibrio* occurred throughout the year to build a data set that will inform development of a risk assessment model.
- Science advice was provided in response to 31 formal requests from the Rivers and Estuaries Branch in 2023-24 to inform appropriate monitoring and mitigation measures for development approvals and commercial activities within the Swan Canning Development Control Area.

Management Implications

- Monitoring results and scientific advice effectively supported response management actions.

Future Directions

- Respond to river incidents and involve key stakeholders and other management agencies where necessary.
- Provide advice to Rivers and Estuaries Branch incident management teams and statutory assessments unit.

Investigating fish communities as an indicator of estuarine condition

SP-2018-33

K Trayler, J Watsham

Context

Fish communities exhibit predictable responses to ecosystem degradation and stress, and thus may be used as sensitive indicators of the ecological condition of these systems. Biotic indices, based on fish and other biological communities, are now used worldwide to quantify the ecological health of rivers, lakes, estuaries and many other environments. This project applies a Fish Community Index (FCI) developed by Murdoch University in collaboration with government agencies (2007-12) as a measure of the condition of the Swan Canning Estuary. This has been part of regular monitoring and reporting on the waterway since 2012 and a report on fish communities in the Swan Canning Riverpark is released to the public annually.

Aims

- Undertake evaluation of the fish communities in the Swan Canning Riverpark for the purposes of applying the Fish Community Index of estuarine condition and reporting.

Progress

- A report documenting the 2023 fish community index (FCI) showed the combined scores for nearshore and offshore waters was the third best recorded in the last decade of monitoring.
- Scores in offshore waters of the Canning Estuary in 2023 were poor in comparison to other zones, continuing an historic trend.
- The low FCI scores in the Canning Estuary were largely driven by low species diversity and the dominance of the detritivorous Perth Herring.
- Summer and autumn sampling for 2024 has been completed and an annual report is being prepared.
- Juvenile bull sharks caught in association with this project were acoustically tagged and released to provide further information on the movement of this species.

Management Implications

- The good overall condition grade in 2023, and particularly those in the Swan, were a function of strong winter flows and good water quality, including low densities of harmful algae and oxic conditions through summer and autumn.
- Poor scores in the offshore waters of the Canning are most likely underpinned by the influence of water quality (e.g. salinity dynamics and night-time hypoxia), the lack of complex habitat and reduced food resources, with each of these working in isolation or combination.

Future Directions

- The recently completed 2024 monitoring will inform a new annual report on estuarine condition.
- Monitoring of the fish community will continue in summer and autumn 2024-25.
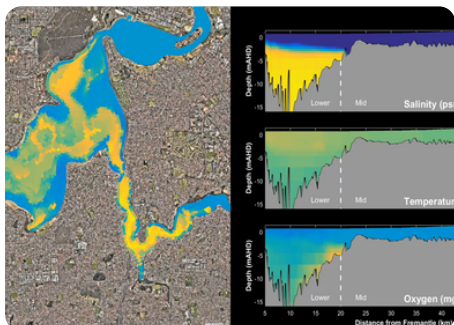
Model frameworks for estuarine reporting

SP-2018-27

S Adiyanti, K Trayler, S Hoeksema

Context

In the period spanning 2011-2016, the department and project partners at The University of Western Australia and Department of Water and Environmental Regulation resourced the development of a spatially resolved coupled hydrodynamic-biogeochemical model, the Swan Canning Estuarine response model (SCERM). The model is a useful tool that can be used for predictive purposes as well as display. The SCERM model has the capacity to complement but not replace, regular water quality monitoring and to simulate and display information on a wider spatial scale and over finer temporal resolution than the existing weekly water quality reporting. This project explores the capacity of a predictive model framework to rationalise water quality monitoring data, display information in a near real-time format and enhance understanding of the waterway.

Aims

- Evaluate optimal water quality data requirements for predictive modelling of estuarine conditions.
- Develop a display showing near real-time data.
- Validate model forecasts and hindcasts.
- Enhance understanding of estuarine dynamics.

Progress

- The Swan Canning Estuarine Response Model (SCERM44) formed the basis for input criteria into a new focused model domain in the mid to upper reaches of the Swan Canning (SCERM29).
- The model was updated to include new bathymetry and additional inputs to the upper domain and a broader timeframe (2007-2023).
- Data frameworks established for the model were used to inform a beta-version of an online data dashboard that is designed to provide water quality monitoring data to stakeholders and the public.

Management Implications

- The Swan Canning Estuarine Response Model (SCERM44) is an important tool that can be adapted to inform new management questions.

Future Directions

- Refine the model for application to habitat suitability assessments and assessments of the potential impacts of various climate scenarios.
- The beta-version of the data dashboard is anticipated to be made publicly available in early 2024-25.

Seagrass monitoring and evaluation

SP-2018-39

J Cosgrove, K Trayler, P Howie, J Watsham, A Gillies, C Phelps, J Chapman

Context

Seagrasses are a highly valued component of estuary ecosystems as they improve water quality by reducing sediment resuspension, removing nutrients, providing habitat and as a food source for waterbirds. Seagrasses respond to changes in their physical and chemical environment and are recognised as being a bioindicator of ecosystem health, with loss of seagrass representing degraded conditions. Ensuring that seagrass communities remain viable and resilient is an essential component of effective estuary management. DBCA continues to monitor seagrass throughout the Swan Canning Estuary to inform management decisions on new development proposals and to track the condition of estuarine health.

Aims

- Describe the variability of seagrass characteristics, including seagrass cover, species composition and seagrass reproduction, in response to possible changes in key environmental and climatic conditions.
- Understand the sensitivity of seagrass metrics in response to anthropogenic stressors, such as water quality, sediment stress, drift macroalgae load and invasive species.
- Integrate benthic assessment data with habitat mapping data to produce a benthic habitat map of the estuary which includes seagrass population distribution.

Progress

- Annual seagrass monitoring was conducted within the Swan Canning Estuary. Additionally, a large-scale intensive quadrat survey and nutrient analysis was conducted.
- All seagrass morphometric analyses have been completed and data analysis is underway. Nutrient analyses are nearly complete.
- Seagrass beds were impacted by environmental conditions in 2023-24, including the hottest November on record, summer temperatures 1-3 °C above average, and atypically low tides (average decrease of 13.4 cm) resulting in large areas of seagrass being exposed.
- Seagrass flowering and fruiting were maintained at similar levels to last year, although seed numbers dropped by approximately 66% from the previous 2-year average, suggesting a possible stress response.
- Average seagrass biomass reduced in 2023-24 by approximately 8% from the previous 3-year average.
- Processing of 2023 benthic imaging data was completed and an updated map of seagrass distribution in the Swan Canning Riverpark will be produced.

Management Implications

- Seagrass as a bioindicator can be used to help inform overall estuary condition. This is done through the analysis of key performance metrics and key pressure metrics which describe abiotic and biotic factors that influence seagrass communities. These metrics are incorporated into the annual reports (2022-23 and 2023-24) and have been used to support reporting on the River Protection Strategy.
- Data and observations across the 2023-24 season show significant impact of exposure and heat stress on seagrass meadows in the Swan Canning Estuary. Similar environmental conditions are expected in 2024-25. Reduced above ground biomass may impact Black Swans, which feed on seagrass, and increases the importance of deeper meadows as a source of propagules.
- An updated map of seagrass distribution will be available to internal and external stakeholders to guide environmental management plans, public education and research. Comparison with previous mapping efforts will allow identification of areas of seagrass loss or gain.

Future Directions

- Analyse the high-resolution seagrass metrics by depth quadrats and nutrient content in seagrass and sediment to gauge changes in environmental biochemistry and subsequent seagrass health.
- Finalise annual seagrass reporting and look for opportunities for public engagement and education.
- Finalise a map of seagrass distribution from 2023 data and make available to internal and external stakeholders. Review 2019 benthic imagery data and reprocess following updated methodology applied to 2023 data to ensure mapping outputs are comparable.
- Continue implementing, reviewing and validating seagrass monitoring as stipulated in the 5-year reporting cycle.
- Explore diversity of macroalgal species in the Swan Canning Estuary.

Species and Communities

Program Leader: Ruth Harvey

Species and Communities Program supports the delivery of the Conserving Habitats, Species and Ecological Communities Service through the provision of biodiversity knowledge with consistent and reliable products, and information and advice regarding: legislation and policy development and interpretation, planning and priority setting, implementing biodiversity conservation programs, maintenance of data and other information, and community engagement. The program supports the department's operations in the areas of conservation of threatened fauna, flora and ecological communities ; fauna and flora management; wetlands and off-reserve conservation. It administers the departmental Animal Ethics Committee and provides support to the Threatened Species Scientific Committee and the Threatened Ecological Communities Scientific Committee.

Assessment and advice for conservation significant species and ecological communities

CF-2023-14

C Bourke, T Sonneman, A Connell, R Rees, K Griffiths, T Johnston, R Harvey

Context

The *Biodiversity Conservation Act 2016* (BC Act), the *Environmental Protection Act 1986* (EP Act) and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* provide legislative mechanisms for the protection of threatened species and ecological communities. Decisions for Ministerial authorisation to take or disturb threatened species or modify an occurrence of an ecological community require detailed understanding of the risks posed to the conservation of threatened biodiversity by these actions and cumulatively across all sources of impact. Assessing these risks, requires the application of specialist technical knowledge and consideration of up-to-date scientific information.

Aims

- Effectively translate and communicate scientific knowledge and information to decision makers and managers through appropriate processes.
- Develop and maintain digital processes for administering authorisations under sections 40 and 45 of the BC Act.
- Evaluate applications to take threatened species and modify threatened ecological communities under sections 40 and 45 of the BC Act.
- Provide advice to the Department of Water and Environmental Regulation (DWER) and the Department of Energy, Mines, Industry Regulation and Safety (DEMIRS) for decisions under the EP Act. This includes ensuring conditions and offsets are appropriate, aligned and based on best available scientific knowledge.
- Provide advice internally within DBCA to inform decisions under the EP Act, *Mining Act 1978* and *Planning and Development Act 2005*.

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- Publish and maintain public-facing guidelines, procedures and compliance documents to inform proponents regarding application processes

Progress

- Issued 425 authorisations under section 40 of the BC Act, 264 for threatened fauna and 161 for threatened flora.
- Three authorisations to modify occurrences of threatened ecological communities were issued under section 45 of the BC Act.
- Advice was provided on risks to the conservation of threatened species, and ecological communities to inform regulatory processes for key State Government initiatives and developments of economic importance to WA including green energy development, the Ord Irrigation Area, lithium and rare earth mineral proposals, bauxite mining expansion, oil and gas projects and major infrastructure projects.
- Responded to 97 internal formal requests for advice.
- Provided advice on 66 clearing permits to DWER and DEMIRS.
- Continued collaboration with other departments on Streamline WA and key policy documents.
- Improved and published new guidance on the department's website, including "Activities not likely to meet the definition of take or disturb for fauna", providing clarity to proponents and reducing time spent assessing activities with negligible risk.

Management Implications

- Improvements in the advice provided by the assessment team gives greater transparency, consistency and clarity for proponents and regulators with the continued use of standardised methods to assess risks to the conservation of threatened species and threatened ecological communities. By better identifying key risks to biodiversity, more effective avoidance, mitigation, authorisation conditions and offset requirements can be implemented.
- The program contributes to the delivery of Streamline WA initiatives and ongoing approvals reform by providing advice to decision making authorities that is targeted, effective, and timely.
- Material published on the website has lead to increased awareness and understanding of the legal requirements for the taking and disturbing of threatened species and modifying a TEC, has resulted in a decrease in enquiries and an increase in applications.

Future Directions

- Further guidance for proponents and other decision makers will continue to be developed and published on the website. This improves decision making for key species and ecological communities that are frequently impacted by proposals such as black cockatoos.
- Continue to engage with other government agencies and stakeholders to assist in communicating standard risk assessment methods and changes to regulatory requirements since BC Act implementation.
- Improvements to internal processes and systems will be supported by digital technologies to assist in a streamlined proponent experience.

Biodiversity knowledge management

CF-2023-41

J Donaldson, C Sands, Y Skinner, J Chick, S Williamson, A Cooke, E Skey, B Meagher, R Wright, M Greenwell, R Harvey

Context

The *Biodiversity Conservation Act 2016* (BC Act) provides the statutory basis for listing species that are at risk of extinction and ecological communities that are at risk of collapse as threatened. Processes for listing species and ecological communities as threatened depend on accurate and comprehensive biodiversity knowledge. Threatened species and ecological communities knowledge is also required by environment-related sectors including government, industry and research organisations to inform conservation and management planning and decision making.

Aims

- Ensure the lists of threatened species and communities ecological communities under the *Biodiversity and Conservation Act 2016* remain up-to-date as threats change and scientific understanding improves.

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- Ensure that listing processes are robust and involve scientific, operational, community, stakeholder and government consultation in a manner consistent with contemporary expectations, and administer the Threatened Species and Threatened Ecological Communities Scientific Committees and the Common Assessment Method framework.
- Maintain relevant departmental policies for the administration of the legislative process for maintaining conservation lists.
- Maintain contemporary, integrated and accessible databases, data catalogues, and data management systems, with appropriate data standards.
- Collect and curate data for conservation listed species and ecological communities, and make available as appropriate.

Progress

- Two updates of the threatened species lists under the BC Act were gazetted.
- As at 30 June 2024, there were 444 threatened flora species (174 critically endangered, 151 endangered and 119 vulnerable), including ten additions, two de-listings, 18 up-listings (assignment to a higher threat category), two down listings (assignment to a lower threat category), six criteria only changes and seven name changes.
- As at 30 June 2024, there were 250 threatened fauna species (59 critically endangered, 59 endangered and 132 vulnerable) including two additions, one criterion only change and six name changes.
- As at 30 June 2024, there were 65 threatened ecological communities (45 critically endangered, nine endangered and 11 vulnerable).
- Priority lists were maintained. As at 30 June 2024 there were 3478 species of priority flora, 220 species of priority fauna, and 390 priority ecological communities.
- Work on development of the the new threatened species and ecological communities database, Boranga, continued to ensure integration and functionality with other Corporate systems.
- Data for conservation listed species and ecological communities continued to be entered and curated in existing data bases, with 65,712 occurrence records for threatened and priority species (63,048 fauna and 2664 flora) and 166 ecological communities added or modified.
- The data provision service managed 2028 data search requests for threatened and priority flora (792), fauna (627) and ecological communities (609).

Management Implications

- High quality curated and effectively maintained data supports decision making for management of conservation significant species, ecological communities and wetlands. Improvements in sharing this data led to improved efficiency of service delivery in conservation and streamlining of approvals.
- Maintaining updated lists of threatened and priority species ensures that conservation and protection measures are appropriately targeted.

Future Directions

- The Boranga database will be launched and ongoing work to increase functionality and integration with Dandjoo, the State's biodiversity data repository, will ensure that this continues to deliver benefits for conservation decision making.
- Ongoing updates to the threatened species and ecological communities lists will be made to ensure that the list continues to be based on best available knowledge and is reflective of current biodiversity risk.

Conservation and recovery of threatened ecological communities

CF-2023-16

K Schell, R Luu, A Wisolith, R Harvey

Context

Ecological communities are listed as threatened under the *Biodiversity Conservation Act 2016* (BC Act) when they are at risk of collapse and the BC Act provides a number of statutory mechanisms to conserve and recover threatened ecological communities. Provision of expert scientific advice to guide the application of statutory conservation and management planning, regulation and on-ground implementation, improves conservation outcomes for ecological communities around the State.

Aims

- Develop, test and review threatened ecological community (TEC) identification and monitoring techniques to ensure methods are kept up to date with current scientific knowledge and environmental impact assessments (EIAs) are based on correct identification of TECs.
- Document and describe ecological communities eligible for listing as priority ecological communities (PECs) and TECs.
- Coordinate the preparation and implementation of recovery plans for TECs.
- Contribute to combined listing and preparation of conservation advice led by the Commonwealth government.
- Provide scientific knowledge to guide development of effective mitigation strategies for management of threats acting on terrestrial, aquatic, estuarine and marine ecosystems, and contribute to regional conservation planning with scientific knowledge.
- Leverage opportunities for stakeholder involvement in TEC recovery planning and recovery teams.
- Provide advice to land managers on appropriate fire management strategies.

Progress

- Specialist advice and support was provided to internal and external stakeholders on recovery actions and land management activities to support conservation of ecological communities.
- The document *Methods for survey and identification of Western Australian threatened ecological communities* was updated on the department's website, and provides further detailed information about floristic community types on the southern Swan Coastal Plain.
- Expert technical advice was provided to the Commonwealth government to inform listing decisions for one TEC under the *Environment Protection and Biodiversity Conservation Act 1999*.
- Technical and scientific advice was provided on environmental impact assessments, including Section 45 authorisations to modify TECs under the BC Act.
- To ensure correct and more consistent identification of TECs associated with floristic community types, instruction and training was provided to DBCA staff on assigning floristic community types from survey results using the statistical package PATN.
- A number of anomalies within corporate records concerning TECs and PECs are progressively being investigated and resolved.
- Historic datasets were identified and interpreted to contribute to a reanalysis of floristic commmunity data for the Swan Coastal Plain.
- Fact sheets for 65 TECs were updated and published on the department's website.
- Support was providedto Recovery Teams for the Albany District, Swan Region and Warren Region.
- Fire risk assessment reports for TECs and PECs were distributed to regional and district departmental staff to improve biodiversity outcomes associated with prescribed burning practices.

Management Implications

- Provision of accurate and up to date scientific information helps to guide TEC recovery plans and recovery teams, improves the effectiveness of conservation actions and maximises recovery outcomes.
- Listing of TECs and PECs means they are given priority consideration when planning and carrying out activities including the management of weeds, pests, diseases, fire, hydrology and visitor access, with the aim of protecting them, restoring their values and decreasing their vulnerability to threatening processes.

Future Directions

- Pursue improvements in ecological community knowledge and ensure this is adequately captured into corporate systems.
- Continue to provide scientific knowledge and advice for the protection, conservation and management of TECs and PECs.
- Continue to provide advice for legislative requirements related to ecological communities, and continually improve and processes and guidelines based on feedback from users.
- Updated analysis of the Swan Coastal Plain floristic data will be refined and assessed for implications for ecological community descriptions and protections and used as a basis for ongoing conservation planning.

Fauna conservation and recovery

CF-2023-18

J Richards, K Schell, L Povh, A Robey, F Carpenter, N Palmer, A Raycraft, R Harvey

Context

Fauna is listed as threatened under the *Biodiversity Conservation Act 2016* (BC Act) when it is at risk of extinction in the wild and the BC Act provides a number of statutory mechanisms to conserve and recover threatened, specially protected and other native animal species. The department has obligations under the *Animal Welfare Act* 2002 (AW Act) to ensure requirements for ethical consideration of animals in departmental research and management activities, which are achieved through the administration of an Animal Ethics Committee (AEC) and associated reporting. Provision of expert scientific advice to guide the application of statutory conservation and management planning, regulation and on-ground implementation, improves conservation outcomes for the State's fauna.

Aims

- Provide up to date scientific advice for the management, protection and recovery of threatened and priority fauna.
- Ensure that recovery programs for threatened fauna species, including translocations, are evidence-based and effective.
- Inform policy and strategic direction relating to fauna using up-to-date science.
- Ensure that management requirements for harvest quotas and reporting of the commercial harvest of kangaroos in WA are met.
- Ensure that animals used for scientific purposes are cared for and used in an ethical and humane manner and that the department meets its commitments under the AW Act and the Australian Code for the Care and Use of Animals for Scientific Purposes.

Progress

- Advice and support were provided to internal and external stakeholders on recovery actions for threatened fauna species, land management activities to support conservation, and national recovery plans.
- Advice and support were provided to 17 State fauna recovery teams to ensure continued conservation and recovery of threatened species, and to the national recovery teams for mala, malleefowl, albatross and petrel, and bilby.
- Provided expert technical advice on applications for fauna licences under the *Biodiversity Conservation Regulations 2018*.
- Reviewed and provided recommendations on eight proposals for intra- and interstate translocations involving six threatened and one priority fauna species, and including one species into and two releases from, captive-breeding programs.
- Provided the annual report on the commercial harvest of kangaroos in WA in 2023 to the Australian Government and published the Management Plan for the Commercial Harvest of Kangaroos in Western Australia 2024-2028.
- The AEC met six times, conducted a total of 294 assessments, approved 18 new projects and approved the renewal of 13 projects. There are 128 active AEC approved projects for fauna monitoring, general fauna research, translocations, fauna surveys, education, feral animal control research and marine research.

Management Implications

- Provision of accurate and up to date scientific information helps to guide threatened fauna recovery plans and recovery teams, improves the effectiveness of conservation actions, and maximises recovery outcomes.
- Expert assessment of fauna translocation plans, and provision of technical and management advice on translocations, minimises animal welfare risks and optimises translocation success.
- Assessment of kangaroo population dynamics ensures that commercial harvesting continues at a sustainable level.
- Ensuring that fauna management activities are formally assessed by the departmental AEC and conducted in accordance with Standard Operating Procedures, fulfills legislative requirements of the AW Act.

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Future Directions

- Continue to deliver strategic direction and coordination of the conservation, management, protection and recovery of fauna in an efficient and effective manner.
- Continue to ensure that the correct processes and advice are in place for the department to meet its requirements under the AW Act.
- Continue to implement BC Act requirements related to native fauna, and ensure processes and guidelines are in place as required.

Flora conservation and recovery

CF-2023-19

K Schell, A Hutchinson, T Llorens, R Harvey

Context

Flora is listed as threatened under the *Biodiversity Conservation Act 2016* (BC Act) when it is at risk of extinction in the wild and the BC Act provides a number of statutory mechanisms to conserve and recover threatened and other native plant taxa. Provision of expert scientific advice to guide the application of statutory conservation and management planning, regulation and on-ground implementation, improves conservation outcomes for the State's flora.

Aims

- Provide up to date scientific advice for management, protection and recovery of threatened and priority flora.
- Ensure that recovery programs for threatened species, including translocations, are evidence-based and effective.
- Inform policy and strategic direction relating to flora using up-to-date science.
- Leverage stakeholder involvement in recovery teams.
- Provide advice to land managers on appropriate fire management strategies.
- Provide scientific advice to prioritise and develop IUCN assessments for priority and threatened species.
- Use best-available scientific information to ensure licensing and harvesting decisions are evidence based.

Progress

- Provided expert technical advice towards combined assessments and conservation advices led by the Commonwealth government for four flora species.
- Provided expert technical advice on nominations to alter the list of threatened flora species in Western Australia for 21 flora species.
- Reviewed the listing status of 12 threatened flora species.
- Conservation status assessments resulted in 42 additions to the priority flora list, change in category of 10 taxa, and delisting of seven taxa after survey and taxonomic review clarified their conservation status.
- Provided advice and support to internal and external stakeholders on recovery actions and land management activities to support conservation of threatened flora.
- Approved one translocation proposal. Assessed five translocation proposals and provided advice to potential proponents.
- Provided support to threatened flora recovery teams for Albany District, Swan Region, Warren Region and for two meetings of the Goldfields Region.
- Provided technical and scientific advice on environmental impact assessments including Section 40 authorisations to take threatened flora under the BC Act, on applications for flora licences under the *Biodiversity Conservation Regulations 2018*, and on issues relating to the management of the Western Australian flora industry.
- Provided support to volunteers to survey 36 poorly-known priority flora species to contribute towards conservation status assessment.

Management Implications

- Accurate, contemporary and comprehensive lists of threatened and priority flora facilitate improved environmental impact assessments, and development of more effective conservation and recovery

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actions.

- Provision of accurate and up to date scientific information helps to guide threatened flora recovery plans and recovery teams, improves the effectiveness of conservation activities and maximises recovery outcomes.
- Provision of expert technical and management advice on applications to take threatened or priority flora, and for environmental impact assessment, assists the department and other land managers to conserve threatened and priority flora and maximises the potential for positive conservation outcomes.

Future Directions

- Continue to deliver strategic direction and coordination for conservation, management, protection and recovery of flora in an efficient and effective manner.
- Continue to assess the conservation status of native flora species and prepare nominations for listing and recovery plans where necessary.
- Continue to prepare high quality technical flora advice to stakeholders as required.
- Continue to implement BC Act requirements related to native flora, and ensure processes and guidelines are in place as required.

Wetland mapping

CF-2023-13

F Felton, J Donaldson, R Harvey

Context

Western Australia is home to many different varieties of wetlands, from tidal mangroves and billabongs, to salt lakes and fresh water springs. Access to accurate geospatial and ecological information about wetlands improves the basis for informed decisions on the management and conservation of wetlands. The department coordinates mapping of Western Australia's wetlands and maintains digital datasets containing spatial data and associated attribution. The mapping identifies the presence of wetlands, delineates boundaries, classification and assigns the wetland to a management category on the basis of its values. This mapping ensures accurate information about wetlands is available to land managers and decision makers, improving the basis for informed decision making about wetland management and conservation.

Aims

- Maintain current datasets and, where opportunities arise, expand the extent of wetland mapping for Western Australia.
- Maintain and improve documentation to standardise wetland mapping procedures.
- Use contemporary ecological and hydrological scientific information to continuously improve policies and methodology supporting the wetlands datasets.
- Provide input to, and assist with, the development of national wetland mapping guidelines and the Australian Wetland Inventory.
- Assist in the development of strategic policy for the conservation of high ecological value wetlands.
- Provide advice on wetland mapping and values to stakeholders in a timely manner.

Progress

- Assessed eight requests to modify wetland evaluation, and one request to modify wetland delineation in the *Geomorphic Wetland Swan Coastal Plain* dataset.
- Provided technical advice for 74 requests relating to wetland mapping, land use planning and general wetlands matters to departmental staff, other State and Commonwealth agencies, landowners, and consultants.
- Finalised and acquitted the final 13 projects for the Healthy Wetland Habitats program.
- Engaged with external stakeholders for three major projects aimed at improving wetland management and addressing climate change

Management Implications

- Accurate wetland mapping facilitates better conservation, protection and management outcomes for wetlands and wetland ecosystems by improving the evidence base for environmental impact assessment, prioritising management actions and land acquisition, and assisting with identifying

suitable habitat for conservation significant species.

Future Directions

- Continue to review and maintain wetland mapping datasets and provide technical advice on wetlands values to internal and external stakeholders.
- Continue to review wetland mapping methodologies to incorporate new technologies and support the development of contemporary wetlands policy.
- Undertake wetland mapping for the Badimia conservation reserves.

Wetlands conservation

CF-2023-20

H Bucktin, K Schell, A Pinder, R Harvey

Context

Wetlands provide essential habitats for many native fauna and flora species and migratory birds, as well as providing essential ecological services, such as reducing the severity of floods, providing refuges for wildlife during drought, carbon sequestration and filtration of sediments, nutrients and pathogens. The Ramsar Convention on Wetlands is an intergovernmental treaty that provides the framework for the conservation and wise use of representative, rare and unique wetlands, and wetlands that are important for biodiversity conservation. Being a signatory to the Ramsar Convention, Australia has undertaken to ensure our internationally important wetlands are conserved. There are 12 Ramsar wetland sites in Western Australia.

Aims

- Provide input to policy development for wetlands of high conservation value in accordance with the Ramsar principles and promote the wise use of wetlands.
- Provide scientific and technical guidance to site managers for conservation of wetland values.
- Contribute expertise to adaptive management and consider climate change adaptation measures.
- Collaborate with the Commonwealth government and with key stakeholders to deliver responsibilities under the Ramsar Convention.

Progress

- A desktop assessment was undertaken and communicated to site managers, science staff, Conservation Commission, stakeholders, other states and the Commonwealth to inform management, monitoring and reporting of ecological condition of Ramsar listed wetlands in WA.
- Six-monthly reports were provided to the Commonwealth via the Wetland and Aquatic Ecosystem Sub-Committee. A strategic approach to managing and reporting on Ramsar wetlands in Australia is being developed.
- Two Ramsar Information Sheets (RIS) were updated and submitted for approval by the Ramsar Secretariat. A further two RIS revisions are underway.
- Ramsar wetland projects were co-designed with NRM groups for Commonwealth funding under National Heritage Trust and Urban Rivers and Catchments Grants to improve knowledge, management and restoration of wetlands with community involvement.
- In celebration of the World Wetlands Day on 2nd February the Department works with the Cockburn Wetlands Centre. This year the Centre hosted the 20th annual WA Wetlands Conference 2024.

Management Implications

- Implementing a collaborative and strategic approach to managing and reporting on Ramsar wetlands will improve delivery of wetland conservation and clarify roles and responsibilities for monitoring, managing and reporting on Ramsar wetlands in WA.
- Updating Ramsar Information Sheets and condition reporting, assists in meeting national obligations under the Ramsar Convention and provides guidance to on-ground managers.
- Working with on-ground managers and Natural Resource Management groups builds capacity to deliver collaborative management and restoration projects for Ramsar wetlands.

Future Directions

- Continue to implement a strategic framework for monitoring, managing and reporting on Ramsar wetlands in WA.
- Develop collaborative projects and continue to work with Natural Resource Management groups, the Commonwealth and stakeholders to provide leadership in adaptive management and climate change mitigation for high conservation value wetlands and Ramsar sites.
- Continue to work with scientists and on-ground managers to collate information on the status of Ramsar wetlands and report to the Commonwealth.

External Partnerships

Project Title	Partners	External Funding	Departmental Involvement
A morphological and molecular investigation to resolve the taxonomic status of *Rhagodia* sp. Hamersley from the Pilbara bioregion	Rio Tinto, GHD	$59,000	K Lazar, B Anderson, R Binks
A partnership approach to filling key knowledge gaps on dugongs in northern Australia using novel technologies	National Environmental Science Program - Marine and Coastal Hub, Reef and Rainforest Research Centre	$379,366	K Waples, K Crook, H Raudino
A Population Management Plan for the Wheatbelt Black-flanked Rock Wallaby	WWF-Australia and Western Australian Government's State NRM Program	$10,450	L Povh, K Ottewell, A Raycraft, B Beecham, M Dziminski
Advancing observations and predictions of WA marine heatwaves	Department of Jobs, Tourism, Science and Innovation Marine Heatwaves Group	$500,000	C Ross
Aluta quadrata plant water use and niche characteristics	Rio Tinto Iron Ore	$306.382	W Lewandrowski, J Stevens
Aquatic microinvertebrate identification and systematics	R.J. Shiel and Associates	$5000	D Cale, K Quinlan, A Pinder
ARC Training Centre for Mining Restoration	Curtin University, The University of Western Australia, Society for Ecological Restoration Australasia, Sinosteel Midwest Corporation, Mineral Resources, Hanson Construction Materials, Karara Mining Limited, BHP Iron Ore Pty Ltd	$4,961,622	D Merritt, S Krauss, J Stevens
Assessing the ecosystem-wide risks of threatened species translocation	Australian Research Council, University of Queensland, The University of Western Australia	$311,377	M Byrne
AusTraits: a national database on the traits of Australia's complete flora	University of New South Wales, Western Sydney University, Royal Botanic Gardens and Domain Trust etc	$500,000	C Gosper
Australian sea lions in the Perth metropolitan area: abundance, movement and	Edith Cowan University, University of Western Australia, Australian National University,	$264,803	H Raudino, K Waples

Project Title	Partners	External Funding	Departmental Involvement
habitat use.	Department of Primary Industries and Regional Development		
Australian wide synthesis of baited video data to answer broad-scale ecological questions	Curtin University, Australian Institute of Marine Science, The University of Western Australia, Department of Primary Industry and Regional Development, Flinders University, Department of Environment and Water (SA), Deakin University, Department of Primary Industries (NSW), University of Tasmania, CSIRO, FinPrint	Nil	T Holmes, S Wilson, J Goetze
Automated Groundwater Dependent Vegetation Detection and Monitoring Tool	Automated Groundwater Dependent Vegetation Detection and Monitoring Tool, Atlas Iron, Fortescue, BHP Iron Ore Pty Ltd, DWER, Rio Tinto, Roy Hill, Minres, Digital Earth Australia, Geoscience Australia, Frontier SI	Nil	B Huntley
Baseline microbial surveys in Swan Canning	Murdoch University	Nil	S Hoeksema, K Trayler
Beyond fire frequency: understanding seasonal timing of fire for ecosystem management	Australian Research Council	$453,000	B Miller, K Ruthrof
Building resilience to change for mammals in a multi-use landscape	Australian Research Council, Murdoch University, Western Australian Museum, Roy Hill	$536,000	L Gibson, M Byrne, K Ottewell
Characterising organic carbon sources supporting cave pool communities in the Leeuwin Naturaliste Ridge	Margaret River Busselton Tourist Association Inc, Curtin University	$10,000	G McGrath, M Venarsky
Collation of historic data for Shark Bay, Marmion and Shoalwater Islands Marine Parks.	Murdoch University	$20,000	J Goetze
Conceptual population model and knowledge gaps for little penguin colonies in Western Australia	Conceptual population model and knowledge gaps for little penguin colonies in Western Australia	$18,000	I Leal, S Wilson, T Holmes
Conservation and management of the bilby (*Macrotis lagotis*) on the Dampier Peninsula, Kimberley	Main Roads Western Australia, Kimberley Land Council, Rangelands NRM Western Australia, Nyamba Buru Yawuru Ltd, Walalakoo Aboriginal Corporation, Bardi Jawi Aboriginal Corporation	$600,000	F Carpenter, B Greatwich, M Dziminski
Contemporary ecological factors and historical evolutionary factors influencing the distribution and abundance of arid-zone reptile species in space and time	University of Michigan - Department of Ecology and Evolutionary Biology	Nil	M Cowan
Detection and identification of dugong through seawater eDNA	Curtin University	$40,000	W Robbins

Project Title	Partners	External Funding	Departmental Involvement
Developing a non-invasive monitoring approach for Barrow Island boodies (*Bettongia lesueur*)	Astron Environmental Services	$27,204	K Ottewell
Development of tissue culture protocols	Alcoa Mining	$13,350	B Funnekotter, K Elder
Diversity of infaunal polychaete assemblages in Walpole and Nornalup Inlets Marine Park	Edith Cowan University, Australian Museum Research Institute	Nil	I Leal, S Wilson
Dugong population and habitat survey - Shark Bay and Ningaloo	CSIRO, National Environmental Science Program - Marine Biodiversity Hub	$123,622	H Raudino, K Murray, K Waples
Ecology and management of the bilby in the Pilbara	Fortescue Metals Group, Millennium Minerals, Roy Hill	$2,005,000	F Carpenter, M Dziminski
Ecology and management of the northern quoll in the Pilbara	Atlas Iron, Fortescue Metals Group, Iron Ore Holdings, Roy Hill, Main Roads Western Australia	$195,000	L Gibson
Ecology and management of the Pilbara leaf-nosed bat	Atlas Iron, Rio Tinto, BHP, Kanyirninpa Jukurrpa, BatCall WA	$320,000	K Ottewell, L Gibson, L Umbrello
Ecology and management of the Pilbara olive python	Atlas Iron, Main Roads Western Australia	$125,000	D Pearson, L Gibson, M Cowan
eDNA detection of cane toads in the West Kimberley and Koolan Island	Mount Gibson Iron Limited	16500	L Dugal, K Fernandes, A Pinder
Enhancing the resilience of urban rivers: informing the regional restoration of the Djarlgaroo Beeliar Canning River, Perth)	National Environmental Science Program - Resilient Landscapes Hub; University of Western Australia; Perth NRM; Armadale Gosnells Landcare Group	Nil	K Trayler
Facilitating collaborations between AusSeabed and Kimberley Region marine operations by crowd sourcing bathymetry to improve national bathymetry data	AusSeaBed Geoscience Australia	Nil	K Murray, W Robbins, K Zdunic
Fire severity and dense forest stands	Department of Fire and Emergency Services	$50,000	R Van Dongen, V Densmore, K Ruthrof
Fremantle Marine Quality Monitoring Program	Fremantle Ports	$30,659	S Hoeksema, K Trayler
Genetic diversity and population structuring of *Tetratheca butcheriana* in the Pilbara bioregion of Western Australia	Rio Tinto	$97,000	R Binks, M Byrne, J Filipe
Genetic studies of Pilbara EPBC Act listed threatened vertebrate fauna	Murdoch University	$235,000	M Cowan, D Pearson
Genomics for Australian plants	BioPlatforms Australia, Ian Potter Foundation, Royal Botanic Gardens Victoria, Centre for Australian Plant Diversity Research, Australian Tropical Herbarium, Royal Botanic	$1,800,000	S Krauss, M Byrne

Project Title	Partners	External Funding	Departmental Involvement
	Gardens and Domain Trust, Southern Cross University		
Geographe Bay seagrass satellite mapping	Department of Water and Environment Regulation	$60,000	B Huntley, K Zdunic, K Murray, S Bell
Global FinPrint	Florida International University, Australian Institute of Marine Science, James Cook University	$120,000	J Goetze
Great Western Woodlands carbon methodology	CSIRO, Woodside	$315,000	C Gosper, K Zdunic
Great Western Woodlands fire history update and data quality improvement.	Great Western Woodlands fire history update and data quality improvement.	29,813	J Ruscalleda Alvarez, K Zdunic
Great Western Woodlands SuperSite	CSIRO, Australian SuperSite Network, Terrestrial Ecosystem Research Network, National Research Infrastructure for Australia	Nil	C Gosper
Hydrogeochemistry of Walyarta Springs	BHP, CyMod Systems, Australian Nuclear Science and Technology Organisation	$120,000	J Rutherford
Identification botanist position at the Western Australian Herbarium	Rio Tinto	$120,000	S Dillon, J Huisman
Impact of prescribed fire on desert fire regimes	Hannah Cliff and Gareth Catt, Indigenous Desert Alliance	Nil	J Chapman, V Densmore
Integrated conservation and translocation of the threatened banded ironstone species *Tetratheca erubescens* (Elaeocarpaceae)	Mineral Resources Ltd, The University of Western Australia	$997,000	C Elliott, W Lewandrowski, B Miller, S Krauss, D Merritt, J Stevens
Integrating ecological, social and cultural values of the coastal waters of Roebuck Bay	Murdoch University, University of Western Australia, Rio Tinto, Nyamba Buru Yawuru, Edith Cowan University, University of Notre Dame, James Cook University	$980,000	S Fossette-Halot, K Crook, K Waples, H Raudino, S Whiting
Island genomes: enhancing management of Australia's threatened mammals	Australian Research Council, Australian National University, University of Adelaide, Australian Museum, Western Australian Museum	$460,000	K Ottewell, M Byrne
Karri forest fuel dynamics	Department of Fire and Emergency Services, Bushfire Front	Nil	J Hollis, A Wills, S Samson, V Densmore, N Burrows
Lifeplan: A Planetary Inventory of Life	Duke University, Swedish University of Agricultural Sciences, University of Helsinki	$30,000	K Quinlan, A Pinder
Lifespan estimation in marine turtles using genomic promoter CpG density	CSIRO	$310,000	T Tucker, S Whiting
Long-term monitoring of intertidal communities at limestone and granite reefs in Ngari Capes Marine Park	The University of Western Australia	$5,000	I Leal, S Bell

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Annual Report 2023-2024

Project Title	Partners	External Funding	Departmental Involvement
Mapping flatback turtle foraging areas in the Kimberley	Australian Institute of Marine Science, CSIRO	$1,000,000	S Fossette-Halot, S Whiting, T Tucker
Mapping of mature woodlands in Ngadju lands for fire management	CSIRO, Ngadju Conservation Aboriginal Corporation, University of Bristol	$265,000	C Gosper, K Zdunic, G Page
Marine turtle stable isotopes	CSIRO, The University of Western Australia	Nil	T Tucker, S Whiting
Millstream riparian vegetation monitoring	Department of Water and Environmental Regulation, Water Corporation	$2000	B Huntley
Mirnong Maat (whale journeys) – Southern Right Whale research project	University of Aukland, Macquarie University, University of Western Australia	Nil	H Raudino, K Waples, S Bell
Molecular characterisation of stinking passionflower (*Passiflora foetida*)	Net Conservation Benefits, CSIRO	$913,000	M Byrne
Morphological and molecular assessment of *Minuria tridens*	Curtin University, Leichhardt	$94,700	R Binks, B Anderson
Optimising fire regimes for fire risk and conservation outcomes in *Banksia* woodlands in the Perth area	Australian Research Council, Murdoch University	$455,000	K Ruthrof, R Miller, B Miller
Optimising seed sourcing for effective ecological restoration	Australian Research Council, Flinders University, CSIRO, The University of Western Australia	$460,000	D Merritt, S Krauss
Oz Mammals Genomics	BioPlatforms Australia, Centre for Biodiversity Analysis, Western Australian Museum, Australian Museum, South Australia Museum, Museum of Victoria, University of Adelaide	$1,112,000	K Ottewell, M Byrne
Peatland resilience - Global Peat Microbiome Project	Global Peat Microbiome Project (GPMP)	Nil	J Rutherford
Phylogenetics and floral symmetry development of the core Goodeniaceae	Department of Organismal Biology and Ecology, Colorado College (USA), St John University (USA)	Nil	K Shepherd
Phylogenomics of the Western Australian flora	Genomics for Australian Plants	Nil	B Anderson
Population genomics of the Critically Endangered Gilbert's Potoroo	Gilbert's Potoroo Action Group and State NRM	$35,000	M Millar, R Sun, T Friend, K Ottewell
Predicting the ecological impact of cane toads on native fauna of north western Australia	Australian Research Council, University of Sydney, Department of the Environment and Energy, Australian Reptile Park	$503,000	D Pearson
Prioritising onground actions for the endangered Australian sea lion	Landscape SA and South Australian Research and Development Institute	$32,600	K Waples, H Raudino
Quantifying responses of forest thinning and developing social license to	Alcoa	$166,600	G McGrath, R Van Dongen, K Ruthrof

Project Title	Partners	External Funding	Departmental Involvement
build adaptive capacity in forest management			
Radio Frequency Identification devices as a new method to estimate Little Penguins population size: Penguin Island as case-study	Murdoch University	Nil	T Holmes, I Leal
Redclaw crayfish impact assessment and eDNA detection tool	BHP, Department of Primary Industries and Regional Development, Department of Water and Environmental Regulation, Fortescue Metals Group, Precision Biomonitoring, Rio Tinto, Stantec	$475,000	A Pinder
Restoring *Banksia* Woodland communities after mining	Hanson Construction Materials	$25,000 pa	W Lewandrowski, J Stevens
Seagrass adaptation and acclimation responses to extreme climatic events	Australian Research Council, The University of Western Australia, University of Adelaide, Australian Genome Research Facility	$525,000	S Krauss
Securing the future for bilby in the Fitzroy Catchment / West Kimberley	National Environmental Science Program - Northern Australia Environmental Resources Hub, Environs Kimberley, Kimberley Land Council	$540,000	F Carpenter, B Greatwich, M Dziminski
Seed collection zones for the Pilbara	Rio Tinto, BHP	$450,000	R Binks, M Byrne
Seed collection, storage and biology	Millennium Seed Bank, Australian Seed Bank Partnership, Department of the Environment and Energy	$12,000	A Crawford
Skeletochronology and stable isotope analyses of flatback turtles	The University of Western Australia, National Marine Fisheries Service (USA), Northern Territory Museum, Western Australian Museum, Queensland Department of Environment and Science, Pendoley Environmental, Australia Government Department of Agriculture, Water and Environment	$400,000	T Tucker, S Whiting
Spatial and temporal analysis of ghost bat populations in the Pilbara using non-invasive sampling methodologies: Towards a robust genetic monitoring protocol	BHP Iron Ore Pty Ltd	$190,000	S McArthur, R Sun, K Ottewell
Spatio-temporal variability of coral reefs at the global scale: causalities, idiosyncrasies and implications for ecological indicators	SCORE-REEF	Nil	J Goetze, S Wilson, T Holmes, C Ross
Strategic weed assessment of the Pilbara Bioregion	Roy Hill, Atlas Iron, CSIRO, Pilbara Corridors, Rangelands	$350,000	R Binks, M Byrne

External Partnerships 119

Project Title	Partners	External Funding	Departmental Involvement
	NRM Western Australia, Pilbara Mesquite Management Committee		
Surveying wetland biodiversity on Ngadju lands	Ngadju Aboriginal Corporation	$27,000	M Lyons, M Venarsky, K Quinlan, A Pinder
Swan Canning Estuary microplastics and plastics survey	Department of Water and Environmental Regulation	$75,000	P Novak, K Trayler
Systematics and biogeography of the Inocybaceae	National Science Foundation (USA)	$19,000	N Bougher
Targeted taxonomy of poorly known Pilbara flora	Fortescue	$692,000	C Gosper, J Huisman, R Binks
Testing the efficiency and efficacy of Felixer feral cat grooming traps	Ecological Horizons, Fortescue Metals Group, Roy Hill	$85,000	L Gibson
The long-term monitoring of seagrass communities in Geographe Bay	Geocatch, Edith Cowan University, Department of Primary Industries and Regional Development	$10,000	B French
The *Stylidium* phylogeny and pollination project	Royal Botanic Gardens - Kew, University of Portsmouth (UK)	Nil	J Wege
Threatened Species Initiative	BioPlatforms Australia: Threatened Species Initiative	Nil	K Ottewell
Threatened Species Initiative (plants)	Threatened Species Initiative (plants)	Nil	M Byrne, R Binks, A Crawford, L Monks
Towards an eFlora treatment of *Tephrosia* (Pers.) in Australia: taxonomic revision of the genus in Western Australia and the Northern Territory	Australian Biological Resources Study, Queensland Herbarium, Northern Territory Herbarium, University of the Western Cape (South Africa)	$515,000	R Butcher, T Macfarlane
Translocations of mammals from Barrow Island: offset program	Chevron	$9,500,000	J Angus, S Garretson, C Sims, L Gibson
Understanding 3D landscapes to manage ecosystem water, carbon and water quality.	CSIRO	Nil	J Rutherford
Understanding sources of feral cats in Dryandra Woodland through DNA analysis	Peel Harvey Catchment Council	$20,000	K Ottewell
Using ecophysiology and remote sensing approaches to monitor *Tetratheca butcheriana* population dynamics in the Brockman Range	Rio Tinto	$434,000	W Lewandrowski, J Stevens
WAMSI-Westport seagrass project	Edith Cowan University	$1,200,000	S Strydom

Student Projects

Project Title	Student	Duration	Academic/s	DBCA Officer/s	Page
Assessing pressure on coral communities from snorkelers at high visitation sites in Ningaloo Marine Park	Chloe Deakin (PhD)	2024 - 2025	Dr M O'Leary (The University of Western Australia)	T Holmes, C Ross	125
Assessing the structure of boodie warrens using geophysics	Eloise Oakley (MSc)	2024 - 2024	A/Prof M Leopold	G McGrath, C Lohr	125
Chemical indicators of groundwater disconnection from forested streams	Kunzang Rinchen (MSc)	2024 - 2025	A/Prof A Rate (The University of Western Australia)	G McGrath	126
Geophysical characterisation of peat	Jarrad Mckercher (MSc)	2023 - 2024	Dr D Blake	G McGrath	126
How has the invertebrate fauna of the Swan-Canning Estuary Changed over the last 40 years	Ruth Lim (MSc)	2023 - 2024	Dr J Tweedley	K Trayler	126
How marine parks affect benthic communities in the Swan River estuary.	Emily Stout (PhD)	2023 - 2024	Dr J Tweedley	K Trayler	127
Radar remote sensing of lake hydrology	Wangchuk Namgay (MSc)	2024 - 2025	Prof J Awange (Curtin University)	G McGrath	127
Assessing genetic diversity, translocation success and future management options for the Critically Endangered *Grevillea acropogon*	Darcy St Jack (BSc Honours)	2022 - 2024	Dr R Standish (Murdoch University)	L Monks, R Binks	128
Investigating the mechanics of native seedling emergence	Stephanie Lye (PhD)	2023 - 2027	Dr A Guzzomi, Dr M Masarei (The University of Western Australia)	D Merritt	128
Investigating wind and wave impacts on the Swan Estuary Marine Reserve foreshore – Nedlands	Shuhao Lim (MSc)	2022 - 2023	Dr C Pattiaratchi (The University of Western Australia)	S Adiyanti	128
Understanding drivers of fish communities - eagle rays	Emily Taljaard	2022 - 2023	Dr J Tweedley	K Trayler	129

Project Title	Student	Duration	Academic/s	DBCA Officer/s	Page
	(PhD)				
Alexandrium spp. in Western Australia: characterisation, toxin mobility and control options	Sheilah Kwambai (PhD)	2021 - 2024	Prof A Lymbery, Prof N Moheimani, Dr D Laird (Murdoch University)	J Cosgrove	129
Canning River water quality and macrophyte investigation	Aimie Gillies (PhD)	2022 - 2022	A/Prof N Callow	P Novak	129
Chasing Flamingos - Tracking synthetic eDNA in a river network using passive sampling methods	Suzanne Thompson (MSc)	2022 - 2025	Dr A Hopkins, Dr A Koenders (Edith Cowan University)	J Hyde, G McGrath	130
Ecophysiology of seed dormancy of *Hibbertia*	Savuti Henningsen (PhD)	2022 - 2025	Dr T Erickson (The University of Western Australia)	D Merritt	130
Extending aerial surveys beyond target marine mammal species: an application of strip transect methodology to humpback whale abundance estimation in Exmouth Gulf, WA	Jennah Tucker (BSc Honours)	2022 - 2023	Dr C Salgado Kent (Edith Cowan University)	K Waples, H Raudino	131
Microplastic distribution, sources, ingestion and health impacts in urban estuarine environments	Thomas Crutchett (PhD)	2021 - 2024	Dr R Hovey (The University of Western Australia)	P Novak	131
Phylogeographic analysis for Kalloora conservation management in the South-Western Australian Floristic Region	Geneveive Carey (MSc)	2022 - 2023	Dr A Lullfitz, Prof S Hopper, Dr W Webb (The University of Western Australia)	R Binks	132
Plastic pollution in urban drains	Mitchell Williams (PhD)	2022 - 2022	A/Prof J Mcllwain	P Novak	132
The influence of mining on the movement ecology and behaviour of the endangered northern quoll (*Dasyurus hallucatus*)	Mitchell Cowan (PhD)	2022 - 2025	Prof D Nimmo, Prof S Setterfield	L Gibson	132
Comparative analysis of diet in island populations of banded and rufous hare-wallabies in Shark Bay	Rachyl Stover (MSc)	2021 - 2022	Dr R Davis, Dr A Hopkins (Edith Cowan University)	H Mills, S Cowen	133
Dirk Hartog Island fauna reintroductions disease risk analysis	Fiona Knox (PhD)	2019 - 2022	Prof K Warren, Dr R Vaughan-Higgins (Murdoch University)	S Cowen, C Sims	133
Environmental DNA as a tool to monitor fish movement in the Canning River	Emma Stevens (MSc)	2021 - 2021	Dr L Beesley, Dr D Gleeson (The University of Western Australia)	S Thompson, J Hyde	133
Quantifying the loss of antipredator traits in	Natasha Harrison	2021 - 2024	A/Prof B Philllips (The University of	A Wayne	134

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havened mammal populations and their relationship with population density and resource competition.	(PhD)		Melbourne), A/ Prof J Hemmi, A/ Prof N Mitchell, Dr L Valentine (The University of Western Australia)		
Understanding patterns of phenotypic and genetic divergence in island mammals to improve conservation outcomes	Kate Rick (PhD)	2020 - 2023	A/Prof N Mitchell (The University of Western Australia)	K Ottewell	134
Assisted colonisation of the western swamp tortoise (*Pseudemydura umbrina*): the role of energy requirements in translocation decisions	Bethany Nordstrom (PhD)	2020 - 2024	Prof S Jarman, A/ Prof N Mitchell (The University of Western Australia)	M Byrne	135
Characterisation of mitochondrial function in the cryopreservation of threatened flora	Lily Whelehan (PhD)	2019 - 2024	Prof R Mancera (Curtin University)	B Funnekotter	135
Conservation of Australian rainforest plant species utilising cryopreservation	Lyndle Hardstaff (PhD)	2018 - 2023	Prof R Mancera (Curtin University)	B Funnekotter	135
Development of cryopreservation for the recalcitrant seeded Australian plants *Syzygium australe* and *S. paniculatum*	Lei Hou (MSc)	2020 - 2020	Prof R Mancera (Curtin University)	B Funnekotter, E Bunn	136
Ecology of flatback turtles (*Natator depressus*) at a coastal foraging ground, Western Australia	Jenna Hounslow (PhD)	2019 - 2025	Dr A Gleiss (Murdoch University)	S Whiting, T Tucker, S Fossette-Halot	136
Role of redox homeostasis in recovery from cryopreservation in *Arabidopsis thaliana*	Milana Lukic (PhD)	2020 - 2023	Prof R Mancera (Curtin University)	B Funnekotter, E Bunn	136
Survey methods and population estimates of the chuditch across its range	Melissa Taylor (PhD)	2020 - 2023	Dr N Armstrong, Dr K Bryant, Dr M Calver (Murdoch University)	A Wayne	137
Taxonomy and evolutionary history of *Australocypris* giant ostracods from Australian salt lakes	Mahabubur Rahman (PhD)	2019 - 2022	Dr J Chaplin (Murdoch University)	A Pinder	137
Taxonomy and evolutionary history of *Parartemia* brine shrimp from Australian salt lakes	Aminul Islam (PhD)	2020 - 2023	Dr J Chaplin (Murdoch University)	A Pinder	138
Understanding predator-prey interactions between ghost crabs and marine turtles for better management of an endangered species	Casper Avenant (PhD)	2019 - 2023	Prof G Hyndes	S Whiting, S Fossette-Halot	138
Assessing ecological resilience of post-mining restoration: testing fire	Ebony Cowan (PhD)	2019 - 2022	Dr J Fontaine, Dr R Standish (Murdoch	B Miller	138

Student Projects

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recovery across a restoration chronosequence			University)		
Influence of fire history and seed distribution on the movements of granivorous finches in the East Kimberley	Sydney Collett (PhD)	2018 - 2021	Dr H Campbell (Charles Darwin University)	I Radford	139
Shifting soil fungal communities in response to fire and weed management in urban banksia woodlands	Aaron Brace (PhD)	2019 - 2023	Dr A Hopkins (Edith Cowan University), Dr J Fontaine (Murdoch University)	K Ruthrof, B Miller	139
Ecologically tolerable fire regimes for key banksia woodland plant species	Russell Miller (PhD)	2015 - 2019	Prof N Enright, Dr J Fontaine (Murdoch University)	D Merritt, B Miller	140
Near-surface remote sensing of plant condition in mine site restoration environments	Jaume Ruscalleda Alvarez (PhD)	2017 - 2021	Dr E Veneklaas, Dr J Yong (The University of Western Australia)	J Stevens	140
Predicting effects of climate change and thinning on growth, health and water yield of jarrah and karri stands using individual-based modelling	Shes Bhandari (PhD)	2018 - 2020	Dr M Renton, Dr E Veneklaas (The University of Western Australia)	R Mazanec	141
Soil-microbial-plant signals and effects on plant eco-physiological performance for mine site restoration	Wei San Wong (PhD)	2017 - 2021	Dr R Trengove, Dr E Veneklaas, Dr J Yong (The University of Western Australia)	J Stevens	141
The effect of diet on the growth and reproduction of western swamp tortoise at Perth Zoo	Grace Wilkinson (MSc)	2018 - 2019	Prof P Horwitz (Edith Cowan University)	H Mills	141
Factors affecting the success of threatened flora translocations	Leonie Monks (PhD)	2016 - 2020	Dr R Standish (Murdoch University)	M Byrne	142
Ecology of the feral cat in coastal heaths of the south coast of Western Australia	Sarah Comer (PhD)	2014 - 2021	Dr D Roberts, Dr P Speldewinde (The University of Western Australia)	D Algar	142
The health status of marine turtles in northern and western Australia	Erina Young (PhD)	2016 - 2024	Prof K Warren, Dr N Stephens, Dr R Vaughan-Higgins, Dr L Yeap (Murdoch University)	S Whiting	143

Student Project Reports
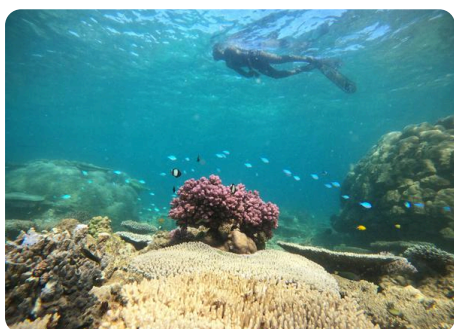
Assessing pressure on coral communities from snorkelers at high visitation sites in Ningaloo Marine Park

Student: Chloe Deakin

Academic(s): Dr M O'Leary

Scientist(s): T Holmes, C Ross

Progress Report

Oyster Stacks is listed in the current Ningaloo Marine Park management plan as an area of concern due to coral damage resulting from snorkelling activities, particularly at low tide when corals are shallow and more vulnerable. This project aims to 1) quantify spatial and temporal patterns in snorkeller activities at Oyster Stacks during peak-season, 2) explore relationships between snorkeller use with site visitation, environmental variables, and existing management, and 3) assess the impacts of visitor pressure and snorkeller damage on the coral communities.

Fieldwork has been undertaken where data collection methods included GPS tracking of snorkellers, snorkeller counts, deployment of a tilt drift meter to obtain real-time environmental information, deployment of a MetroCounter to record carpark traffic, and in-water surveys of coral colony damage and benthic photo-transects. Data analysis for the project is underway.

Assessing the structure of boodie warrens using geophysics

Student: Eloise Oakley

Academic(s): A/Prof M Leopold

Scientist(s): G McGrath, C Lohr

Progress Report

Boodies (*Bettongia lesueur*) are unique among macropods for their construction of complex warren systems which have been observed to extend in diameter up to 70m and having as many as 90 unique entrances. This project seeks to improve understanding of the below ground life of boodies by quantifying warren structure using two geophysics techniques, ground penetrating radar and electrical resistivity tomography,

Trial measurements have been completed with the geophysics equipment to be used in the study. Analysis of the trial data, and modelling different measurement methods is underway.

Chemical indicators of groundwater disconnection from forested streams

Student: Kunzang Rinchen

Academic(s): A/Prof A Rate

Scientist(s): G McGrath

Progress Report

Forested streams are known to be sensitive to silvicultural practices in their catchments as well as climate change. Historical thinning has raised stream flows and salinity temporarily, due to a rise and then fall in a salty groundwater contribution to streamflow. With a regional drying trend and evidence of streams disconnecting from groundwater it is hypothesised forested streams are generally becoming fresher. This project seeks to quantify the spatial and temporal changes in the relationship between streamflow and salinity in forested streams across a range of flow relevant timescales from hysteretic salinity versus flow relationships with a storm event, and seasonal cycles to annual flow versus annualised salinity relationships.

A database of streamflow, groundwater level and water quality is being compiled. Training on data analysis methods has commenced.

Geophysical characterisation of peat

Student: Jarrad Mckercher

Academic(s): Dr D Blake

Scientist(s): G McGrath

Progress Report

The peatlands of the Walpole-Nornalup National Park are at threat from a drying climate and altered fire regimes. To better protect these biodiverse systems they need to be mapped and the hydrological conditions which support them characterised. Part of that characterisation requires measuring their lateral and vertical extent at sites where groundwater levels and water quality are monitored. This project looks to assess the potential of a geophysics technique, induced polarisation, to map the subsurface distribution of peat. This will involve collection of peat samples, measurement of their electrical properties in the laboratory and measuring peat depths at a field site.

Laboratory measurements were made of the chargeability and phase shift of peat samples collected from Walpole. In addition, two 150m long transects were measured at a peat site near Walpole. Resistivity and chargeability measurements corresponded with measured peat thickness along parts of these transects. Unlike the properties of peats from Europe and North America the peat samples from Walpole had only weak chargeability and phase shift properties within the range of frequencies tested. A report detailing the data collected and the results of analyses was completed.
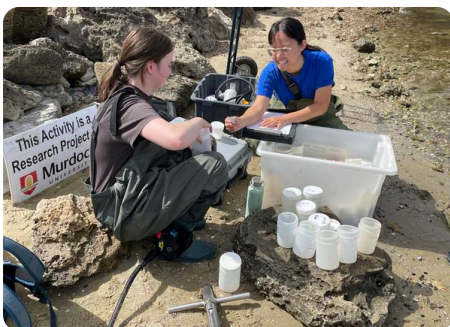
How has the invertebrate fauna of the Swan-Canning Estuary Changed over the last 40 years

Student: Ruth Lim

Academic(s): Dr J Tweedley

Scientist(s): K Trayler

Progress Report

This investigation aims to compare contemporary invertebrate fauna in the Swan Canning Estuary to historic datasets in order to evaluate whether changes have occurred over the last 40 years and whether these can be attributed to factors associated climate change and urbanisation.

Sampling has occurred at four sites in the estuary, across three seasons and analysis is underway. The project will provide contemporary information on waterway health using invertebrates as indicators, and provide insights on the influence of changes in salinity and eutrophication over time.

How marine parks affect benthic communities in the Swan River estuary.

Student: Emily Stout

Academic(s): Dr J Tweedley

Scientist(s): K Trayler

Progress Report

This project is focused on invertebrate communities of the Swan Estuary Marine Park and will compare the species richness, diversity, abundance and composition of the benthic macroinvertebrate fauna in different habitats within the three zones of the marine park, and evaluate these relative to areas outside the park. The investigation will evaluate invertebrate habitat preferences relative to underlying factors and provide baseline information towards future monitoring approaches.

Sampling has been completed over two seasons. Preliminary evaluation of data collected in the summer season indicated significant differences in invertebrate communities in the three marine park zones.

Radar remote sensing of lake hydrology

Student: Wangchuk Namgay

Academic(s): Prof J Awange

Scientist(s): G McGrath

Progress Report

Remote sensing offers great hope in monitoring basic hydrological aspects of the thousands of wetlands, lakes and estuaries across Western Australia. Active radar, through interferometric methods, has the potential to measure water level fluctuations in these systems to accuracies of a few centimeters, providing some information on their hydrological functioning. To date, these approaches have not been trialed on WA wetlands. This project seeks to modify existing interferometric methods to quantify water level fluctuations and surface water extent in several lakes and a salt marsh across southwest Australia where data has been collected by DBCA.

Historical water level data collected from several lakes and a salt marsh have been shared and initial water level change estimates from Lake Clifton have been produced from one algorithm. Remote sensed imagery for other locations and time periods has been obtained.

Assessing genetic diversity, translocation success and future management options for the Critically Endangered *Grevillea acropogon*

Student: Darcy St Jack

Academic(s): Dr R Standish

Scientist(s): L Monks, R Binks

Progress Report

This project aims to undertake genomic and demographic studies of translocated and wild populations of the critically endangered *Grevillea acropogon* to support its conservation. This includes clarifying the taxonomic status of both natural populations, assessing the genetic diversity and ecological health of the translocated and wild populations, and assessing the most suitable source of seed (soil, plant, *ex situ* collections) for future conservation actions. The project will provide understanding of the conservation status of the species and recommendations on conservation activities required for species recovery.

Analyses showed that the established translocated population of *G. acropogon* met key success criteria regarding plant survival, reproductive output and genetic diversity. The northern population was found to be a separate species, as suspected by morphological evidence and confirmed with genetic data. It was also found that there was little difference in genetic diversity between the current generation of wild plants and the soil seed bank.

Investigating the mechanics of native seedling emergence

Student: Stephanie Lye

Academic(s): Dr M Masarei, Dr A Guzzomi

Scientist(s): D Merritt

Progress Report

A challenge to successful seed-based rehabilitation is the high mortality rate of emergent seedlings. The pre-emergence phase, where seeds have germinated but seedlings are yet to emerge from the soil, is a primary bottleneck for seedling survival.

Laboratory experiments to determine the relationship between maximum pre-emergent shoot length and incubation temperature for seedlings of *Acacia inaequilatera* and *Corymbia calophylla* have been completed. Experiments to determine how soil properties influence maximum shoot length have commenced. Design and construction of a test rig to measure the emergence forces of seedlings using a range of electronic force sensors has been completed for future experiments to study the mechanics of seedling emergence in soils of differing properties.
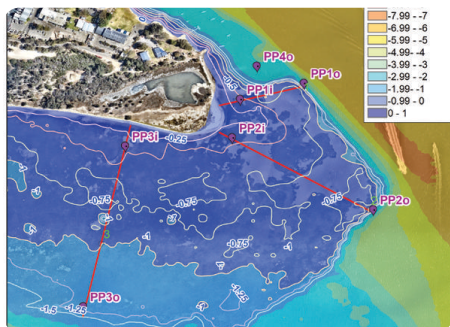
Investigating wind and wave impacts on the Swan Estuary Marine Reserve foreshore – Nedlands

Student: Shuhao Lim

Academic(s): Dr C Pattiaratchi

Scientist(s): S Adiyanti

Progress Report

This project is investigating how the wave height, energy and erosive power at the eastern shoreline of Pelican Point is being influenced by bathymetry, storm surges, wind waves and boat wakes, using an extensive dataset of water levels recorded at the northeast, southeast and southwest of Pelican Point over

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a six month period between December 2022 and July 2023.

Comparisons made of the cumulative energy of wind-wave events against boat wakes indicated that wind waves contribute far more energy to the shoreline of Pelican point. Similar magnitudes of erosion rate at the northeast shore and accretion rate at the southeast shore, along with foreshore shape changes, suggest that sediment has been washed from the northern shore to the southeast shore.

Understanding drivers of fish communities - eagle rays

Student: Emily Taljaard

Academic(s): Dr J Tweedley

Scientist(s): K Trayler

Progress Report

This project examined historic fish community datasets and new survey data to understand spatial and temporal patterns in the abundance of the Southern Eagle Ray (*Myliobatis tenuicaudatus*) and the factors that influence abundance and distribution.

Monthly sampling was conducted in the Lower Swan Canning Estuary between November 2022 and October 2023. Quantitative assessments of the species' biology, including diet, reproduction and age and growth relationships, were also undertaken. Results provided important information on the biology, seasonality and distribution of a species that is increasingly common in the Swan Canning Estuary and will contribute to ecosystem-based fisheries management.

Alexandrium spp. in Western Australia: characterisation, toxin mobility and control options

Student: Sheilah Kwambai

Academic(s): Dr D Laird, Prof N Moheimani, Prof A Lymbery

Scientist(s): J Cosgrove

Progress Report

Globally, harmful algal blooms represent a major and growing threat due to their undesirable ecological, economic and health impacts. Since 2019 the Swan Canning Estuary has suffered repeated blooms of *Alexandrium, a* species that produces toxins that can cause potentially fatal paralytic shellfish poisoning in humans via consumption of impacted seafood. This project is aimed at investigating the toxicity and genetics of local *Alexandrium*, while also investigating a potential control method. Risk of exposure to toxins when eating crabs is also being investigated by measuring toxin mobilisation when crabs are cooked.

All major experimental components of this project are complete. Final analyses and preparation of results are underway, and progress was presented to the project technical advisory group, including representatives from the Department of Primary Industries and Regional Development and Department of Health. A journal article on the results of the clay trial is currently in prep.

Canning River water quality and macrophyte investigation

Student: Aimie Gillies

Academic(s): A/Prof N Callow

Scientist(s): P Novak

Progress Report

Submerged macrophytes play a fundamental role in the functioning of freshwater lakes and rivers providing food, refugia, shade and influencing physico-chemical conditions. A submerged macrophyte community has been an important part of the Kent Street Weir Pool in the Canning River for decades. Recent observations however suggest this community no longer occurs within the weir pool. This project aimed to determine long term changes in water quality and the macrophyte community and investigate potential reasons for changes in macrophyte abundance.

This research has confirmed that there has been no submerged macrophyte community in the KSW since 2017. Changes in light levels, influenced by management of the upgraded weir, were suggested as the likely cause of macrophyte loss. The outcomes of this investigation have been critical in scoping future work in this system. A manuscript is in preparation.

Chasing Flamingos - Tracking synthetic eDNA in a river network using passive sampling methods

Student: Suzanne Thompson

Academic(s): Dr A Hopkins, Dr A Koenders

Scientist(s): J Hyde, G McGrath

Progress Report

While eDNA is developing as a powerful tool to quantify biodiversity of aquatic systems, there remains uncertainties regarding the movement and fate of eDNA, particularly in streams and rivers. This study seeks to quantify the movement of artificial eDNA in an urban stream from a tracer experiment. This experiment will provide an improved understanding of the advection, adsorption and degradation processes eDNA experiences during its movement from the source to the sampler. These results will help provide a spatial context as to the distribution of sources relative to a sampling location for future eDNA measurements.

In-stream river discharge measurements have been undertaken to establish flow rating curves. A synthetic DNA has been designed, manufactured and tested for use in a field experiment, which involved the release of synthetic DNA and salt into Southern River, with the salt signal traced as an indicator of water movement. Water samples were collected at four sites downstream of the release location and filtered to collect samples of the DNA. Additionally, passive eDNA samplers were manufactured and deployed along the 4km experiment zone of Southern River. Samples are being processed to extract DNA and quantify the synthetic DNA using real-time PCR. Results are being compiled and a one-dimensional advection model is being built to analyse the results. The outcomes will improve understandings of eDNA movement in flowing systems. A poster was presented at the WA Biodiversity Conference 2023.

Ecophysiology of seed dormancy of *Hibbertia*

Student: Savuti Henningsen

Academic(s): Dr T Erickson

Scientist(s): D Merritt

Progress Report

Restoration of Jarrah forest species can be challenging due to complex seed dormancy mechanisms limiting seedling establishment. Seeds of *Hibbertia* possess complex dormancy and germination requirements. Reliable methods of propagation are yet to be established for most species. Within the jarrah forest of south-west WA, *Hibbertia* are common, and the inability to propagate their seeds precludes their use in mine site rehabilitation. This project will focus on the germination ecology of *Hibbertia* seeds through field trials studying the intra- and inter-specific variation in seed dormancy and germination timing of a range of *Hibbertia* species differing in collection year and location. Through linked laboratory studies, seed pre-treatments applicable to nursery settings will be developed to allow for the large-scale production of *Hibbertia* seedlings for planting in mine site rehabilitation.

Laboratory experiments have been established for Hibbertia species focussed on understanding how seasonal changes in temperature and moisture influence dormancy break and germination requirements. These experiments have been established for seeds collected in 2022 and 2023 to examine within-species variation in dormancy and germination traits. A multi-year field experiment was established in the summer of 2024 to study how seed embryo growth rates influence the timing of germination and seedling emergence amongst co-occurring species.
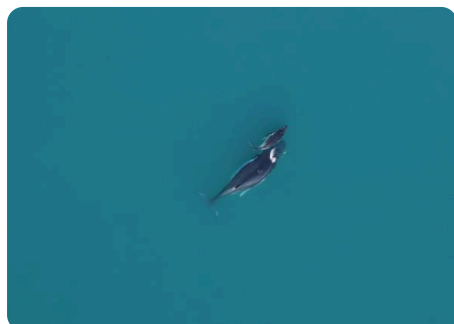
Extending aerial surveys beyond target marine mammal species: an application of strip transect methodology to humpback whale abundance estimation in Exmouth Gulf, WA

Student: Jennah Tucker

Academic(s): Dr C Salgado Kent

Scientist(s): K Waples, H Raudino

Progress Report

Aerial survey is a standard technique used in wildlife management to estimate population abundance and detect trends. It is particularly useful for species with large ranges and broad distribution patterns, such as marine mammals, as the technique allows relatively large areas to be covered over short periods of time. While aerial surveys are typically designed for specific target species, additional species are often recorded as surveys are generally infrequent due to expense and logistical constraints. Analyses to estimate abundance of non-target species recorded during surveys can have limitations as information recorded for these species may be constrained or incomplete. In this study, analysis of aerial survey data collected in Exmouth Gulf, Western Australia, will be extended beyond the target species (dolphins) and applied to humpback whale (*Megaptera novaeangliae*) and dugong abundance estimation. The results of this study will update current knowledge on the abundance and distribution of key marine mammals in Exmouth Gulf, to inform ongoing monitoring and management of this 'conservation dependant' population.

This study used existing data from aerial surveys conducted in Exmouth Gulf, Western Australia to produce abundance estimates of non-target humpback whales and dugong. For humpback whales, estimates were 2691 (CV= 44%) and 3915 (CV= 51%) respectively using two different best half strip widths and availabilty corection factors. For dugongs, absolute abundance was estimated using various techniques and availability correction factors with abundance varying between 838 (CV=115%) and 1013 (CV = 40%). Despite limitations in using these non-target data, the estimates produced are the first absolute abundance estimates of humpback whales in Exmouth Gulf and contriubte to informing ongoing monitoirng and management of humpback whale and dugong populations using Exmouth Gulf as critical habitat. This work highlights the potential for extending aerial survey effort beyond target species.

Microplastic distribution, sources, ingestion and health impacts in urban estuarine environments

Student: Thomas Crutchett

Academic(s): Dr R Hovey

Scientist(s): P Novak

Progress Report

This project extends on the recently published report on plastic contamination in the Swan Canning Estuary by determining the presence of microplastics (plastics <1mm) in surface waters and beaches of the estuary. The project will develop a method to identify the polymers of these microplastics and investigate the presence of microplastics in the digestive tracts of fish in the Swan Canning Estuary and the harm caused by these substances.

Spectroscopic analysis is continuing. A paper proposing the overflow density separation method as an accessible and reliable protocol to extract medium and high-density microplastics from environmental samples has been published in MethodsX and contributed to a National Environmental Science Program methods manual on environmental microplastic determination. An extensive systematic literature review has been undertaken, which it is intended to publish.

Phylogeographic analysis for Kalloora conservation management in the South-Western Australian Floristic Region

Student: Geneveive Carey

Academic(s): Prof S Hopper, Dr W Webb, Dr A Lullfitz

Scientist(s): R Binks

Progress Report

This project worked with the Wadandi people of the Busselton/Margaret River region to understand the cultural significance, traditional use and genetic health of the Kalloora (*Podocarpus drouynianus*).

The project has been completed, with molecular results showing high levels of gene flow through the species' main distribution, with some genetic differentiation of the disjunct northern populations. The high levels of chloroplast haplotype diversity within and among populations and lack of phylogeographic structure indicated historically large population sizes and high gene flow, with no evidence of contraction to refugia through historical climate fluctuations. These patterns are consistent with emus being a primary means of long distance seed dispersal, such that the connectivity of emu habitat is considered a significant factor in maintaining the demographic and evolutionary processes of Kalloora. This project also demonstrated that utilising a community-based framework informed by indigenous communities can provide mutual benefits for knowledge sharing and conservation practice.

Plastic pollution in urban drains

Student: Mitchell Williams

Academic(s): A/Prof J McIlwain

Scientist(s): P Novak

Progress Report

The recent report on plastic contamination in the Swan Canning Estuary highlighted some major differences in the accumulation of plastics on beaches within different regions of the estuary. The project aimed to determine whether there are differences in the amount of plastic washing down major drainage lines.

This work determined the types of plastic commonly washed down drains into the estuary, providing vital knowledge for the Plastic Free Riverpark Program and identifying priority catchments for remediation work.

The influence of mining on the movement ecology and behaviour of the endangered northern quoll (*Dasyurus hallucatus*)

Student: Mitchell Cowan

Academic(s): Prof D Nimmo, Prof S Setterfield

Scientist(s): L Gibson

Progress Report

The northern quoll (*Dasyurus hallucatus*) is threatened by habitat loss due to mining in the Pilbara region of Western Australia. This project seeks to identify the movement patterns of northern quolls living in mining landscapes.

Quolls prefer rocky habitats and creeklines, which likely serve as high-resource areas providing dens, food and safer travel than simpler habitats like spinifex sandplain. When quolls have larger amounts of spinifex sandplain in their home ranges, this leads to longer movements and larger areas required to survive. In

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mining landscapes, quolls avoided mining habitats during breeding season, likely due to a lack of mates and resources in these habitats. While quolls did den in these habitats, they don't provide the food and breeding opportunities that natural habitats do. Quolls used more energy in mining habitats compared to natural ones, supporting the suggestion that these areas contain less resources and likely a higher predation risk.

Comparative analysis of diet in island populations of banded and rufous hare-wallabies in Shark Bay

Student: Rachyl Stover

Academic(s): Dr R Davis, Dr A Hopkins

Scientist(s): H Mills, S Cowen

Progress Report

Banded and rufous hare-wallabies are threatened species that have been the subject of conservation translocations to Dirk Hartog Island as part of the Dirk Hartog Island National Park Ecological Restoration Project. These species co-exist on Bernier and Dorre Islands, but little is known of their inter-specific interactions. This project aims to understand how the diet of banded and rufous hare-wallabies may influence the outcomes of the ecological restoration of Dirk Hartog Island.

The assumption that banded and rufous hare-wallabies are exclusively browsers and grazers, respectively, is not supported by this study. Rather, both species appear to have relatively broad diets that overlap considerably (including some weed species) but vary according to seasonal availability. It appears that habitat preferences are more important than diet in niche partitioning where these species co-exist. There was also a significant difference in diet between where animals were sourced on Bernier and Dorre Islands and Dirk Hartog Island, where they were translocated.

Dirk Hartog Island fauna reintroductions disease risk analysis

Student: Fiona Knox

Academic(s): Dr R Vaughan-Higgins, Prof K Warren

Scientist(s): S Cowen, C Sims

Progress Report

This project aims to develop disease risk analyses (DRAs) for several species in the fauna translocations to Dirk Hartog Island. By identifying key disease risks related to these translocations, mitigation measures such as screening for specific pathogens can be put in place.

Two of the three disease risk analyses have been completed for native rodents and boodies, with the third for chuditch underway. Results of the completed DRAs identified 14 and 13 potential disease hazards, respectively, and mitigation strategies were identified for those with the highest level of risk. The project has identified novel pathogens and range extensions of known but potentially significant pathogens in Australian native rodents. A paper was published in *Wildlife Research* on the detection of *Chlamydiaceae* in several wildlife species in the Shark Bay region, including the first detection in Australian native rodents, although the risks for the translocation of species in the region are low. Two more manuscripts are in preparation.

Environmental DNA as a tool to monitor fish movement in the Canning River

Student: Emma Stevens

Academic(s): Dr D Gleeson, Dr L Beesley

Scientist(s): S Thompson, J Hyde

Progress Report

This project investigated the capacity of eDNA survey techniques to characterise the freshwater fish assemblage in the Canning River and the role that barriers play in limiting distribution of invasive fish. Sites in the Canning River were surveyed using three methods, 1) fyke netting, 2) active filtration of water for eDNA, and 3) passive collection of eDNA.

The study demonstrated that active eDNA sampling more consistently describes fish assemblage at any given site in this river, and required less replicates than the other methods. A subset of the data was used to compare methods for monitoring the invasion front of pearl cichlid, and to determine if an existing weir was limiting their spread upstream. Active filtration for eDNA was better at detecting pearl cichlids than fyke netting or passive eDNA sampling. Pearl cichlids were found to be already present upstream of the weir. A journal article on the pearl cichlid has been accepted for publication in *Environmental DNA*, and a manuscript on the broader project has been submitted to the same journal.

Quantifying the loss of antipredator traits in havened mammal populations and their relationship with population density and resource competition.

Student: Natasha Harrison

Academic(s): A/Prof N Mitchell, Dr L Valentine, A/Prof B Philllips, A/Prof J Hemmi

Scientist(s): A Wayne

Progress Report

The aim of this project is to develop robust behavioural assays for quantifying anti-predator responses in woylies, and then use these methods to assess the potential extent of the loss of anti-predator responses, populations at risk, possible drivers, and consequences for survival and reproduction. This information will assist in informing future management and translocation practices for woylies, and potentially other critical weight range species.

Findings from a comparison of anti-predator traits and survival probabilities among woylie populations in WA suggest that the presence of native predators, such as chuditch, inside havens may prevent the loss of anti-predator traits. This work identified potential management options to benefit anti-predator traits in havened populations: reduce resource competition, supplement genetic diversity with suitable 'wild' individuals, and consider imposing low predation pressure inside havens, ideally by native predators.

Understanding patterns of phenotypic and genetic divergence in island mammals to improve conservation outcomes

Student: Kate Rick

Academic(s): A/Prof N Mitchell

Scientist(s): K Ottewell

Progress Report

This project focuses on quantifying phenotypic and genetic divergence amongst island and mainland populations of several threatened mammals including the burrowing bettong (*Bettongia lesueur*), golden bandicoot (*Isoodon auratus*) and the dibbler (*Parantechinus apicalis*) to determine whether genetic and morphological differentiation between remnant populations reflects divergent adaptation or are artefacts of genetic drift, and the consequences for mixing populations of each species.

Population genomic assessment for island and mainland golden bandicoots has been completed and published in *Heredity*. Morphological measurements of museum specimens of dibbler and the burrowing bettong have been completed to investigate broad patterns of adaptation in each species, including an assessment of whether morphological differentiation in dibbler is associated with drift or divergent selection. Genomic analyses of island and mainland dibblers has been completed and a draft manuscript is nearing submission.

Assisted colonisation of the western swamp tortoise (*Pseudemydura umbrina*): the role of energy requirements in translocation decisions

Student: Bethany Nordstrom

Academic(s): Prof S Jarman, A/Prof N Mitchell

Scientist(s): M Byrne

Progress Report

The western swamp tortoise (*Pseudemydura umbrina*) is endemic to south-west Australia and occupies seasonal wetlands where hydroperiods are shortening due to declining rainfall. Trial assisted colonisation translocations south of their current habitat will test whether tortoises can grow in cooler climates where hydroperiods are likely to be more suitable in the future. The aims are to 1) develop novel environmental DNA methods to understand diet in new habitats; 2) document foraging behaviour in relation to water temperatures and prey availability; 3) link metabolic processes and food intake to predict long-term growth rates and reproduction in new environments.

This work has provided evidence that southern wetlands can provide viable habitat for this critically endangered species as juvenile tortoises released in an assisted colonisation trial showed increase in body mass over two years. An environmental DNA test specific to the western swamp tortoise has been developed.
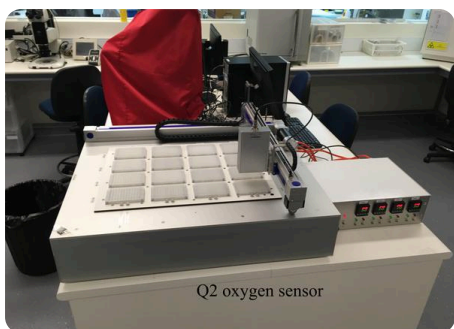
Q2 oxygen sensor

Characterisation of mitochondrial function in the cryopreservation of threatened flora

Student: Lily Whelehan

Academic(s): Prof R Mancera

Scientist(s): B Funnekotter

Progress Report

This project aims to examine the effects of cryopreservation on metabolism of plant tissues, with emphasis on mitochondrial function as these organelles are the primary sources of energy molecules that drive all cellular processes including the ability to recover from injury sustained to cells and tissues during the various steps of cryopreservation. A better understanding of the effects of cryogenic injury will enable better optimisation of cryopreservation for sensitive species, including many threatened taxa where *ex situ* storage remains a problem.

Measuring oxygen consumption of *Daucus carota* cells on the Seahorse XF analyser identified that certain cryoprotective agents show a significant negative effect on mitochondrial function. Optimisation of the Seahorse method using respiratory inhibitors to determine the specific parameters of mitochondrial function affected has been completed. Minor experimental work and data analysis is being completed.

Araucaria bidwillii seeds (arrow) being extracted from seed cones

Conservation of Australian rainforest plant species utilising cryopreservation

Student: Lyndle Hardstaff

Academic(s): Prof R Mancera

Scientist(s): B Funnekotter

Progress Report

This project has developed novel tissue culture and cryopreservation protocols for a range of recalcitrant-seeded (unable to be desiccated or stored at low temperatures) Eastern Australian rainforest taxa where

conventional *ex situ* seed storage is not possible.

The successful development of *in vitro* cultures of threatened recalcitrant seeded species in several genera (*Gossia*, *Macadamia*, *Rhodamnia*, *Rhodomyrtus* and *Syzygium*) has been achieved and cryopreservation protocols are being developed with shoot tips of these species (including incl. *S. paniculatum*) and embryonic axes of *Araucaria bidwillii*.

Syzygium australe

Development of cryopreservation for the recalcitrant seeded Australian plants *Syzygium australe* and *S. paniculatum*

Student: Lei Hou

Academic(s): Prof R Mancera

Scientist(s): B Funnekotter, E Bunn

Progress Report

Syzygium paniculatum and *Syzygium australe* are two rainforest species with recalcitrant seeds that are not storable by seed banking, with *S. paniculatum* currently threatened in its native habitat. The objective of this project is to develop a viable cryopreservation protocol for these species.

This project identified that *Syzygium* species have a strong tolerance to long incubation times in cryoprotective agents (CPA) but exhibit a complete lack of survival following liquid nitrogen exposure, which could indicate that post-cryogenic failure is primarily due to either insufficient vitrification promotion and/or insufficient suppression of ice formation. Thermo-analytical assessments (differential scanning calorimetry) measured the extent of ice formation in shoot tissues, permitting differentiation between cell death by actual ice damage and other stress factors such as CPA toxicity and reactive oxygen species damage.

Ecology of flatback turtles (*Natator depressus*) at a coastal foraging ground, Western Australia

Student: Jenna Hounslow

Academic(s): Dr A Gleiss

Scientist(s): S Whiting, T Tucker, S Fossette-Halot

Progress Report

This project aimed at improving our understanding of the foraging behaviour of flatback turtles using bio-logging tools such as daily diaries and animal-borne video cameras that collect accelerometry, orientation and swimming performance data.

Data were used to analyse the turtles' fine-scale vertical and horizontal movements at a major foraging ground in Yawuru Nagulagun Roebuck Bay Marine Park. Data and outputs from this project, including detailed maps of habitat use in relation to local environmental conditions, are being used to inform the dynamic spatial management of this species in Yawuru Nagulagun Roebuck Bay Marine Park.
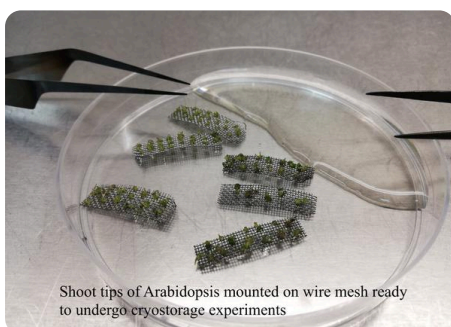
Shoot tips of Arabidopsis mounted on wire mesh ready to undergo cryostorage experiments

Role of redox homeostasis in recovery from cryopreservation in *Arabidopsis thaliana*

Student: Milana Lukic

Academic(s): Prof R Mancera

Scientist(s): B Funnekotter, E Bunn

Progress Report

This project examines the effects of oxidative stress on cryopreserved plant material, using the model species *Arabidopsis thaliana*, including mutant variants with reduced antioxidant contents. Oxidative stress is a primary impediment to successful cryopreservation of plant material, and a better understanding of this will be a crucial step forward in designing more efficient cryopreservation protocols for *ex situ* conservation of threatened plant species.

An optimised cryopreservation method for wild type *A. thaliana* has been developed using vitamin C- and GSH-deficient mutant plants (vtc2-1, vtc2-4, pad2-1 and cad2), to assess changes in transcriptome using RNA-seq. Assessments of the transcriptome, gene expression by RT-qPRC, oxidized DNA damage and antioxidant contents have been completed to understand the stresses imposed by cryopreservation.

Survey methods and population estimates of the chuditch across its range

Student: Melissa Taylor

Academic(s): Dr N Armstrong, Dr K Bryant, Dr M Calver

Scientist(s): A Wayne

Progress Report

Robust population estimates are fundamental to species conservation and management. This project aims to use lured remote sensor cameras and spatially-explicit capture-recapture (SECR) modelling to improve the reliability of density estimates for chuditch populations.

The results from the multi-location test of the camera trap method developed in this project (paired cameras 30cm off the ground in a 1km grid) were used to determine location-specific adjustments to improve SECR density estimate reliability. It was found that increasing survey duration is more beneficial than increasing the number of camera sites when detection rates are low. When detection rate is higher, increasing survey effort had marginal effect on density reliability. Fieldwork has been concluded. One paper is published in *Australian Mammalogy*. Two papers (spacing/layout trials and multi-location trial) are drafted for publication.

Taxonomy and evolutionary history of *Australocypris* giant ostracods from Australian salt lakes

Student: Mahabubur Rahman

Academic(s): Dr J Chaplin

Scientist(s): A Pinder

Progress Report

Salt lakes are a distinctive feature of WA's arid zones, supporting several invertebrate groups that are more diverse in WA than elsewhere. Their biota are threatened by lake bed disturbance, and by altered hydrology and water quality. This project aimed to use molecular data to assess the morpho-taxonomy of *Australocypris* ostracods and mytilocypridine systematics generally, and to test hypotheses about species radiations in *Australocypris*. Another goal was to develop a protocol for hatching and raising ostracods from eggs in sediment of dry lake beds.

A review article on giant ostracods published in *Marine and Freshwater Research* shows they are far more diverse in Australia than elsewhere and that the monophyletic subfamily Mytilocypridinae is endemic to Australia and of greatest diversity in Western Australia, especially in salt lakes. Salinity is shown to be a major driver of species distributions. The results of this study can be used to inform conservation planning for Western Australian wetlands, and direct further study of these unique invertebrates. A manuscript on mytilocypridine systematics is under review, with evidence for nine new species and for paraphyly amongst mytilocypridine genera. A manuscript on the phylogeography and evolutionary history of *Australocypris* have been drafted and a paper on egg hatching is under review. The latter suggests that egg hatching from dry wetland sediments may be an effective tool for survey and monitoring.

Taxonomy and evolutionary history of *Parartemia* brine shrimp from Australian salt lakes

Student: Aminul Islam

Academic(s): Dr J Chaplin

Scientist(s): A Pinder

Progress Report

Australia is home to numerous salt lakes that support a diverse range of endemic invertebrates largely restricted to these environments. The brine shrimp genus *Parartemia* is a good example, being one of the most diverse groups of invertebrates that only occurs in Australian salt lakes. This project focused on brine shrimp in Australia, with three aims: 1) to use molecular data to evaluate the taxonomy of *Parartemia*, which is currently based primarily on morphology, 2) to understand the evolutionary history and phylogeography of *Parartemia*, and 3) to investigate the distribution of the exotic brine shrimp *Artemia* in Australian natural salt lakes and investigate the genetic composition of *Artemia* using molecular data.

The findings of this study improve knowledge of *Parartemia* taxonomy and therefore conservation of salt lake biodiversity. A manuscript addressing the taxonomy of *Parartemia* has been submitted to the journal *Invertebrate Systematics,* suggesting that the species morphotaxonomy is largely valid, although many morphospecies contained significant molecular divergence. Two putative new morphospecies, three morphologically cryptic species and one case of over-splitting of a species were identified. A paper under going revision investigates the distribution, identity, origins and spread of the exotic brine shrimp *Artemia* in Australian natural salt lakes.
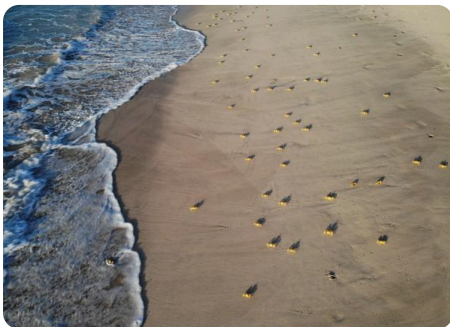
Understanding predator-prey interactions between ghost crabs and marine turtles for better management of an endangered species

Student: Casper Avenant

Academic(s): Prof G Hyndes

Scientist(s): S Whiting, S Fossette-Halot

Progress Report

This project examines predator-prey interactions between ghost crabs and hatchling sea turtles on the Pilbara coast to better conserve threatened turtle species and manage a native predator. It provides critical information regarding the potential impact of ghost crabs on turtle eggs and hatchling survival. Results are helping to assess the vulnerability of different nesting sites and determine if there is a need for management intervention.

Analysis of predation rates of flatback turtle eggs and hatchlings at one of the index rookeries for the North West Shelf flatback stock showed no egg predation was recorded whereas about 30% of hatchlings were predated, mainly by ghost crabs and silver gulls, resulting in a 51% egg-to-surf survival rate which was more than twice the egg-to-surf survival rate estimated for loggerhead turtles nesting at Ningaloo. These results are important for the management of this stock.

Assessing ecological resilience of post-mining restoration: testing fire recovery across a restoration chronosequence

Student: Ebony Cowan

Academic(s): Dr R Standish, Dr J Fontaine

Scientist(s): B Miller

Progress Report

This project investigates the resilience of banksia woodlands restored after sand mining to fire, specifically seeking to determine an age when restoration is resilient to fire. Investigations assessed resprouting capacity, soil seedbank dynamics and floristic compositon across a chronosequence of ages between three and 27 years since restoration.

Experimental fire has been introduced to sites across the chronosquence and post-fire regeneration monitored for 1.5 years. Regeneration from soil seedbanks and resprouting was observed, with factors including size, restoration age and soil compaction influencing resprouting success. There is evidence of sites returning to a similar pre-fire state following fire, with some differences in perennial vegetation composition remaining between restored and intact sites. Three papers have been published. One paper developed a framework for measuring the effects of disturbance in restoration projects and was published in Restoration ecology; another identifying drivers of post-fire resprouting success in restored Banksia woodlands was published in *Austral Ecology*; and the third on soil seedbank development of smoke responsive plant species in a 23-year restoration chronosequence was published in *Applied Vegetation Science*.

Influence of fire history and seed distribution on the movements of granivorous finches in the East Kimberley

Student: Sydney Collett

Academic(s): Dr H Campbell

Scientist(s): I Radford

Progress Report

According to ecological niche theory, sympatric species cannot occupy the same niche space. The coexistence of sympatric species is therefore thought to be facilitated by the partitioning of resources, habitat utilisation or both. Yet in the tropical savannas of northern Australia 3 sympatric grass finches co-exist. It is thought that threatened Gouldian finches have a more specialised diet of grass seeds and morphological adaptations for greater dispersal while the more common Long-tailed and Masked Finches have a generalist diet including a greater range of herbaceous seeds and invertebrates and are more sedentary in their movements. Fire regimes leading to increased movement to locate specialist food resources may increase risks to Gouldian finches of starvation or lost body condition. This study uses stable isotope analysis and novel radio telemetry methods to test hypotheses on diet specialisation and foraging behaviour through the Kimberley savanna dry season as resource shortages increase for grass finches through the year following grass seed drop.

Research from this project reinforces the importance of fine-grain prescribed burn mosaics for the benefit of Gouldian finches. Finches prefer to forage where prescribed burning has been conducted due to elevated seed density, greater diversity and availability of annual and perennial grass seeds throughout the year, and reduced foraging distances in the late dry season. Finer grain mosaics particularly benefit finches in the late dry season when seed scarcity is greatest. The third paper from this project examining how the threatened Gouldian finch preferentially forages in prescribed burnt savannas was published in the *International Journal of Wildland Fire*. Two other manuscripts from the project are currently in review.

Shifting soil fungal communities in response to fire and weed management in urban banksia woodlands

Student: Aaron Brace

Academic(s): Dr A Hopkins, Dr J Fontaine

Scientist(s): K Ruthrof, B Miller

Progress Report

The project aims to answer four key questions regarding the responses of soil fungal communities to 1) time since fire over a 50-year chronosequence, 2) time since fire within the first year, 3) fire and herbicide under field conditions, and 4) a range of herbicides under glasshouse conditions.

A breadth of fungal sequences (~20,000) have been identified, with various taxonomic and functional information being assigned. Results suggest that in the post fire environment, the soil fungal community is very dynamic in the early months of recovery, but throughout time it increases in diversity but decreases in relative abundance before plateauing approximately 30 years post-fire. Herbicide application has complex effects on the fungal community under field conditions and *ex situ* application of herbicide increased abundance and richness, especially of pathogenic species.

Ecologically tolerable fire regimes for key banksia woodland plant species

Student: Russell Miller

Academic(s): Dr J Fontaine, Prof N Enright

Scientist(s): D Merritt, B Miller

Progress Report

Fire is a dominant disturbance that shapes species and ecosystems. Many plant species have developed strategies and adaptations to cope with certain fire regimes. If fire occurs too frequently, too intensely, or otherwise outside of the limits of a species' tolerance, then populations are likely to decline or disappear. This project aims to determine the impact of varying fire regimes on the demographics of key banksia woodland plant species.

The project collected and analysed plant demographic data and fire-related plant trait data for six co-occurring species of banksia woodlands and demonstrates these woodlands have evolved with highly variable fire intervals, in a mixed-severity fire regime. This work has been accepted for publication in *Australian Journal of Botany.* A second paper examined the use of patterns of post-fire plant reproduction to inform minimum fire intervals for conservation management of banksia woodlands, identifying that woody species are generally tolerant of a wide range of fire intervals.

Near-surface remote sensing of plant condition in mine site restoration environments

Student: Jaume Ruscalleda Alvarez

Academic(s): Dr J Yong, Dr E Veneklaas

Scientist(s): J Stevens

Progress Report

Large scale assessments of plant condition are needed in restored plant communities to evaluate if ecosystems are functioning similarly to natural reference systems. Remote sensing can yield information on plant condition in a more efficient way than current physiological methods, which often require destructive sampling and are difficult to perform at large scales. This approach requires testing in biodiverse plant communities.

Relationships between physiological variables and their remotely-sensed proxy indicator for leaf water content and total chlorophylls concentration were accurately predicted for all studied species at the leaf level. This was not the case for other physiological traits. Identifying deviations in plant function and condition could enable early detection of potential issues in restoration and may be used to inform adaptive management to improve long-term restoration outcomes.

Predicting effects of climate change and thinning on growth, health and water yield of jarrah and karri stands using individual-based modelling

Student: Shes Bhandari

Academic(s): Dr E Veneklaas, Dr M Renton

Scientist(s): R Mazanec

Progress Report

Individual-based modelling (IBM) is an ecological modelling approach that represents individuals within populations or communities, and the interactions between them, with a relatively high level of detail and complexity. This study aims to develop an IBM of tree growth in water limited environments, to parameterise the model for jarrah and karri and to predict the impact of tree thinning on timber production, tree health, mortality and water yield using time series data collected between 1965 and 1992.

The final paper in this project examined the effect of stand density on growth and allometry of marri and was published in the Journal of the Royal Society of Western Australia. Thinning was concluded to have potential benefits for timber production, water management, and provision of a high-quality habitat and food resource for arboreal and avifauna.

Soil-microbial-plant signals and effects on plant eco-physiological performance for mine site restoration

Student: Wei San Wong

Academic(s): Dr J Yong, Dr E Veneklaas, Dr R Trengove

Scientist(s): J Stevens

Progress Report

The importance of soil biological properties such as microbial composition and the benefits conferred to soils and plants are often undervalued in mine site restoration. Microorganisms have been widely reported to be beneficial for agricultural crops for example through growth stimulation, increased nutrient uptake and plant tolerance against abiotic stress such as drought induced by microbial phytohormone and enzyme signals. Some of these beneficial microorganisms are also present in natural soil systems, although their role in facilitating seedling establishment is yet to be identified. This project aims to investigate if microorganisms known to benefit agricultural species can be applied to Western Australian natural systems via inoculations. The project also aims to elucidate the mechanisms involved in the positive effects of microorganisms on plants and explore how these findings can be integrated to improve mine site restoration strategies.

Evidence obtained from plant physiological measurements, phytohormone analysis and soil microbiomes highlight that further research is required before advocating the use of commercial microbial inoculants in post-mining ecological restoration. This project presents methods and insight that will benefit future research and industry applications.

The effect of diet on the growth and reproduction of western swamp tortoise at Perth Zoo

Student: Grace Wilkinson

Academic(s): Prof P Horwitz

Scientist(s): H Mills

Progress Report

The captive breeding for release program at Perth Zoo for the Western Swamp Tortoise (*Pseudemydura umbrina*) makes an essential contribution to the species' long-term conservation prospects. In doing so, the program has generated a considerable database on the biology of the captive population. This project investigated retrospective data collected across a total of nine breeding seasons (years) to determine the factors that influence the species' growth and reproduction in captivity. Diet was the main focus of the study, as nutrition provision is a key husbandry area and because of the difficulties in replicating western swamp tortoises' highly specialised wild diets in captivity.

Minor nutritional differences were found between the predominantly red-meat and white meat only captive diets; the white meat diet had slightly higher protein and protein to energy ratio, while the red meat diet had a higher fat content. Captive diets fed to offspring did not produce consistent differences for all juvenile growth or aestivation periods. Where differences did occur (however inconsistent), the red-meat diet yielded a significantly higher specific growth rate than the white meat diet. Captive diet fed to breeding females was a more prevalent factor across the reproductive variables with an overall, but again not entirely congruent trend, of the white meat diet having significantly higher reproductive fitness than the red meat diet. Given the species' abilities to reproduce and grow in captivity regardless of minimal nutritional differences, the white meat captive diet is recommended as more appropriate to the breeding program overall. Of all the factors examined, the variation between breeding seasons was the most consistently significant difference for growth and reproductive variables. The findings of the multi-factorial relationship between nutrition, growth and reproduction, highlight the areas requiring further research, such as the environmental factors in captive breeding settings themselves.

Factors affecting the success of threatened flora translocations

Student: Leonie Monks

Academic(s): Dr R Standish

Scientist(s): M Byrne

Progress Report

The aim of this study is to investigate factors affecting success of plant translocations, to inform future translocations and help prevent the extinction of plant species.

Analysis of ecological and genetic factors in translocations of *Lambertia orbifolia, Acacia cochlocarpa ssp. cochlocarpa* and *Schoenia filifolia* has provided information for management of these threatened species. An assessment of the soil seedbank and response to prescribed fire in *Acacia cochlocarpa* subsp. *cochlocarpa* indicates this is an effective approach to stimulate regeneration of translocated populations in this species. A meta-analysis investigating factors influencing plant translocations success showed fencing to prevent predation, and irrigation over the first two years, were key factors in translocation success. Three papers have been published and a fourth is in preparation.

Ecology of the feral cat in coastal heaths of the south coast of Western Australia

Student: Sarah Comer

Academic(s): Dr D Roberts, Dr P Speldewinde

Scientist(s): D Algar

Progress Report

This research is focussed on understanding feral cat spatial ecology, diet and their impacts on native species in four study sites on the south coast of Western Australia. This research will also test the effectiveness of stable isotope analysis for increasing understanding of feral cat dietary niche and impact on native species. The relationship between prey availability and climate and productivity indices will be studied in Two Peoples Bay Nature Reserve.

The project found strong evidence of an ongoing impact of feral cats on native mammals and passerines in conservation areas and fragmented landscapes on the south coast. Dietary and isotopic studies elucidated feral cat diet over extended time periods and provided evidence of feral cat predation on the critically endangered western ground parrot (*Pezoporus flaviventris*). Habitat preferences were similar to those in other areas of Australia, indicating that moisture gaining and high productivity areas are important to target in management programs. Areas of native vegetation provided significant refuge value in fragmented landscapes. Investigations into prey availability found that climatic variables and dynamic habitat indices, derived from remote sensed data, could be used to predict small mammal trap success and available biomass. These findings provide insights that can be used to improve timing of control efforts, such as cat baiting, in an adaptive management framework.Three manuscripts are currently in preparation.

The health status of marine turtles in northern and western Australia

Student: Erina Young

Academic(s): Prof K Warren, Dr L Yeap, Dr R Vaughan-Higgins, Dr N Stephens

Scientist(s): S Whiting

Progress Report

This project aimed to assess the health and disease status of sea turtles in Western Australia, with a focus on flatback turtles. For stranded dead and injured turtles, pathology can be used to diagnose the causes of death and injury, with parasite infections and fibropapilloma virus being specifically investigated. Ablood chemistry reference baseline can be developed for use nationally by turtle care facilities.

The outcomes of this project included the first comprehensive health assessment of sea turtles in Western Australia, including blood chemistry and reference baselines for nesting and in-water flatback turtles. Processes for pathology and pathology descriptions for flatback turtles were developed and personnel across the state were trained. Knowledge transfer to stakeholders included support for the banning of mass balloon releases in WA. A bacterium, *Streptococcus iniae*, was discovered to be associated with a novel disease related to a multiple species mortality event in Broome (fish kill), which was published in *Diseases of Aquatic Organisms*. Another paper on flatback turtle plasma and haematological reference values was published in *Endangered Species Research*. The project also contributed to three other papers, including a review of disease risk in sea turtles, mercury concentrations in flatbacks and plastic pollution prevalence in neonate sea turtles.

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Summary of Research Projects

Animal Science

Project Title	DBCA Region	IBRA/IMCRA	NRM Region	Page
Building resilience to change for mammals in a multi-use landscape: identifying refugia and landscape connectivity for small mammals in the Pilbara	Pilbara	Pilbara	Rangelands	2
Distribution and conservation status of the heath mouse (*Pseudomys shortridgei*) in Western Australia	South Coast, Wheatbelt	Avon Wheatbelt, Coolgardie, Esperance Plains, Mallee	South Coast	3
Genetics of Pilbara threatened bats	Pilbara	Pilbara	Rangelands	4
Ecology, threats and monitoring of the Pilbara olive python (*Liasis olivacea barroni*)	Midwest, Pilbara	Gascoyne, Pilbara	Rangelands	5
Felixer grooming trap trial: Feral cat control for threatened fauna conservation in the southern forests.	Warren	Jarrah Forest	South West	6
Investigation into the decline of chuditch (*Dasyurus geoffroii*) in the south-west of Western Australia	Midwest, South Coast, South West, Swan, Wheatbelt	Avon Wheatbelt, Coolgardie, Esperance Plains, Geraldton Sandplains, Jarrah Forest, Mallee, Swan Coastal Plain, Warren	Avon, Swan, South Coast, South West, Wheatbelt	7
Conservation of the night parrot	Goldfields, Kimberley, Midwest, Pilbara	Carnarvon, Gascoyne, Gibson Desert, Great Sandy Desert, Great Victoria Desert, Little Sandy Desert, Murchison, Pilbara, Tanami	Rangelands	8

Project Title	DBCA Region	IBRA/IMCRA	NRM Region	Page
Understanding and reducing python predation of the endangered Gilbert's potoroo	South Coast	Warren	South Coast	9
Dirk Hartog Island National Park ecological restoration project – fauna reconstruction	Midwest	Yalgoo, Shark Bay	Rangelands	9
South-west threatened fauna recovery project: southern jarrah forest	South West	Jarrah Forest	South Coast, South West	11
Improving the use of remote cameras as a survey and monitoring tool	All DBCA Regions	Gascoyne	All NRM Regions	12
Monitoring of threatened birds on Dirk Hartog Island	Midwest	Geraldton Sandplains	Rangelands	13
Barrow Island threatened and priority fauna species translocation program	Goldfields, Pilbara	Gascoyne, Murchison, Pilbara	Rangelands	13
Conservation and management of the bilby in the Pilbara	Pilbara	Pilbara	Rangelands	14
Conservation of south coast threatened birds	South Coast, Warren	Esperance Plains, Jarrah Forest, Warren	South Coast, South West	15
Genetic assessment for conservation of rare and threatened fauna	Kimberley, Pilbara	Central Kimberley, Dampierland, Northern Kimberley, Pilbara	Rangelands	16
Rangelands restoration: reintroduction of native mammals to Matuwa (Lorna Glen)	Goldfields	Gascoyne, Murchison	Rangelands	17
Ecology and management of the northern quoll in the Pilbara	Pilbara	Pilbara	Rangelands	18
Impact of cane toads on biodiversity in the Kimberley	Kimberley	Central Kimberley, Northern Kimberley, Ord Victoria Plain, Victoria Bonaparte	Rangelands	19
Development of effective broad-scale aerial baiting strategies for the control of feral cats	Midwest, Pilbara, South Coast	Carnarvon, Gascoyne, Gibson Desert, Murchison	Swan, Rangelands	20

Biodiversity Information Office

Project Title	DBCA Region	IBRA/IMCRA	NRM Region	Page
BIO biodiversity data platform	All DBCA Regions	All IBRA Regions	All NRM Regions	22
BIO data collation program	All DBCA Regions	All IBRA Regions	All NRM Regions	23

Ecosystem Science

Project Title	DBCA Region	IBRA/IMCRA	NRM Region	Page
Evaluating the application of eDNA and metabarcoding as biodiversity and monitoring tools	All DBCA Regions	All IBRA Regions	All NRM Regions	25
Lifeplan: A planetary inventory of life	Swan	Swan Coastal Plain	Swan	26
Tracking the condition of Ramsar wetlands in Western Australia	Kimberley, South Coast, South West, Swan, Warren, Wheatbelt	All IBRA Regions	Avon, Northern Agricultural, Swan, Rangelands, South Coast, South West, Wheatbelt	27
Investigating the causes of change in forest condition	South West	Jarrah Forest	South West	28
Understanding the implications of a drying climate on forest ecosystem function to inform and improve climate change adaptation	South West, Swan, Warren	Jarrah Forest	Swan, South West	29
Hydrological function of critical ecosystems	South West	Jarrah Forest, Swan Coastal Plain	South West	30
Responses of terrestrial vertebrates to management in the jarrah forest	Warren	Jarrah Forest, Warren	South West	31
Western Australian flora surveys	All DBCA Regions	All IBRA Regions, All IMCRA Regions	All NRM Regions	32
Long-term stand dynamics of regrowth forest in relation to site productivity and climate	Swan, Warren	Jarrah Forest, Warren	Swan, South West	33
Western Australian wetland fauna surveys	All DBCA Regions	All IBRA Regions, All IMCRA Regions	All NRM Regions	33
FORESTCHECK: Integrated site-based monitoring of the effects of timber harvesting and silviculture in the jarrah forest	South West, Swan, Warren	Jarrah Forest, Warren	Swan, South West	34
Hydrological response to timber harvesting and associated silviculture in the intermediate rainfall zone of the northern jarrah forest	Swan	Jarrah Forest	Swan, South West	35
Genetic analysis for the development of vegetation services and sustainable environmental management	Goldfields, Midwest, Pilbara, South Coast, South West, Warren, Wheatbelt	Avon Wheatbelt, Coolgardie, Esperance Plains, Geraldton Sandplains, Jarrah Forest, Mallee, Murchison, Swan Coastal Plain, Warren	Northern Agricultural, Rangelands, South Coast, South West, Wheatbelt	36

Fire Science

Project Title	DBCA Region	IBRA/IMCRA	NRM Region	Page
Development of a systematic approach to monitoring and reporting on the outcomes of prescribed burns and bushfires	All DBCA Regions	All IBRA Regions	All NRM Regions	38
Evaluation of synergies among fire and weed management in urban biodiversity and fire management	Swan	Geraldton Sandplains, Swan Coastal Plain	Northern Agricultural, Swan	39
Long term response of jarrah forest understorey and tree health to fire regimes	South West, Swan, Warren	Jarrah Forest	South West	40
North Kimberley Landscape Conservation Initiative: monitoring and evaluation	Kimberley	Northern Kimberley	Rangelands	41
Fire regimes and impacts in transitional woodlands and shrublands	Goldfields, South Coast, Wheatbelt	Avon Wheatbelt, Coolgardie, Mallee, Yalgoo	Rangelands, Wheatbelt	42

Kings Park Science

Project Title	DBCA Region	IBRA/IMCRA	NRM Region	Page
Conservation biotechnology	All DBCA Regions	All IBRA Regions, All IMCRA Regions	All NRM Regions	44
Conservation genetics	All DBCA Regions	All IBRA Regions	All NRM Regions	45
Orchid conservation and recovery	South Coast, South West, Swan, Warren, Wheatbelt	Avon Wheatbelt, Esperance Plains, Geraldton Sandplains, Jarrah Forest, Mallee, Swan Coastal Plain, Warren	Avon, Northern Agricultural, Swan, South Coast, South West	46
Restoration science	All DBCA Regions	All IBRA Regions, All IMCRA Regions	All NRM Regions	47
Seed science	All DBCA Regions	All IBRA Regions	All NRM Regions	48

Marine Science

Project Title	DBCA Region	IBRA/IMCRA	NRM Region	Page
Benefits of marine parks for marine fishes in a changing climate	All DBCA Regions	All IMCRA Regions	All NRM Regions	50
Primary productivity and energy transfer between marine ecosystems.	Pilbara	Pilbara, Pilbara (Nearshore)	Rangelands	51

Project Title	DBCA Region	IBRA/IMCRA	NRM Region	Page
Do marine reserves adequately represent high diversity cryptobenthic fish assemblages in a changing climate?	Pilbara	Ningaloo	Rangelands	52
Understanding the key ecosystem services provided by the seagrass meadows of Western Australia	South West, Swan	Carnarvon, Geraldton Sandplains, Pilbara, Swan Coastal Plain, Warren, Yalgoo	Northern Agricultural, Swan, Rangelands	53
Distribution and abundance estimate of Australian snubfin dolphins at a key site in the Kimberley region, Western Australia	Kimberley	Bonaparte Gulf, Kimberley, Northwest Shelf, Cambridge-Bonaparte, Canning, King Sound	Rangelands	54
Habitat use, distribution and abundance of coastal dolphin species in the Pilbara	Pilbara	Pilbara, Pilbara (Offshore)	Rangelands	55
The influence of macroalgal fields on coral reef fish	Pilbara	Carnarvon, Pilbara (Nearshore)	Rangelands	56
Understanding movements and identifying important habitats of sea turtles in Western Australia	Kimberley	All IMCRA Regions	Cocos Keeling Islands, Rangelands	57
Marine monitoring program	All DBCA Regions	All IBRA Regions, All IMCRA Regions	All NRM Regions	58
North West Shelf Flatback Turtle Conservation Program	Kimberley, Pilbara	Northwest Shelf	Rangelands	59
Spatial and temporal patterns in benthic invertebrate communities of the Walpole and Nornalup Inlets Marine Park	Warren	WA South Coast	South Coast	60
Spatial and temporal patterns in the structure of intertidal reef communities in the marine parks of south-western Australia	Swan	Central West Coast	Swan	61

Perth Zoo Science

Project Title	DBCA Region	IBRA/IMCRA	NRM Region	Page
Anstisia frog breed and rear for release program	South West, Swan	Jarrah Forest, Swan Coastal Plain	Swan, South West	62
Behavioural observations of Perth Zoo collection animals for animal welfare purposes and establishment of baseline data	Swan	Swan Coastal Plain	Swan	63
Dibbler breed for release program	Midwest, South Coast, Swan	Esperance Plains, Geraldton Sandplains, Jarrah Forest, Swan Coastal Plain	Northern Agricultural, Swan, South Coast	64

Project Title	DBCA Region	IBRA/IMCRA	NRM Region	Page
Memory of recent actions in large-brained mammals (*Elephas maximus*)	Swan	Swan Coastal Plain	Swan	64
Numbat breed for release program	Swan, Warren, Wheatbelt	Avon Wheatbelt, Jarrah Forest, Swan Coastal Plain, Warren	Northern Agricultural, Swan, South West	65
Western ground parrot husbandry	South Coast, Swan	Esperance Plains, Mallee, Swan Coastal Plain	Swan, South Coast	66
Western swamp tortoise breed for release program	Swan, Warren	Geraldton Sandplains, Jarrah Forest, Swan Coastal Plain, Warren	Swan, South West	67

Plant Science and Herbarium

Project Title	DBCA Region	IBRA/IMCRA	NRM Region	Page
A digital Flora of Western Australia – a guide to the State's botanical species diversity	All DBCA Regions	All IBRA Regions, All IMCRA Regions	All NRM Regions	68
Molecular characterisation of stinking passionflower (*Passiflora foetida*)	Pilbara	Pilbara	Rangelands	69
Herbarium collections management	All DBCA Regions	All IBRA Regions, All IMCRA Regions	All NRM Regions	70
Taxonomy of selected families including legumes, grasses and lilies	All DBCA Regions	All IBRA Regions, All IMCRA Regions	All NRM Regions	71
Taxonomy of undescribed taxa in the Ericaceae subfamily Styphelioideae, with an emphasis on those of conservation concern	All DBCA Regions	All IBRA Regions	All NRM Regions	72
The Western Australian Herbarium specimen database	All DBCA Regions	All IBRA Regions	All NRM Regions	73
The Western Australian Plant Census and Australian Plant Census	All DBCA Regions	All IBRA Regions, All IMCRA Regions	All NRM Regions	74
Systematics of the triggerplant genus *Stylidium*	All DBCA Regions	All IBRA Regions	All NRM Regions	75
Taxonomic resolution and description of new plant species, particularly priority flora from those areas subject to mining in Western Australia	All DBCA Regions	All IBRA Regions	All NRM Regions	76
Taxonomic review and floristic studies of the benthic marine algae of north-western Australian and floristic surveys of Western Australian marine benthic algae	Kimberley, Pilbara, South Coast, South West, Swan, Warren	Central Kimberley, Dampierland, Esperance Plains, Gascoyne, Geraldton Sandplains,	Northern Agricultural, Swan, Rangelands, South Coast, South West	77

Project Title	DBCA Region	IBRA/IMCRA	NRM Region	Page
		Jarrah Forest, Northern Kimberley, Swan Coastal Plain, Victoria Bonaparte, Warren		
The Western Australian marine benthic algae online and an interactive key to the genera of Australian marine benthic algae	Kimberley, Midwest, Pilbara, South Coast, South West, Swan, Warren	Central Kimberley, Dampierland, Esperance Plains, Geraldton Sandplains, Jarrah Forest, Northern Kimberley, Swan Coastal Plain, Victoria Bonaparte, Warren	Northern Agricultural, Swan, Rangelands, South Coast, South West	78
Mating system variation, genetic diversity and viability of small fragmented populations of threatened flora, and other key plants of conservation importance	Midwest, South Coast, South West, Swan, Warren, Wheatbelt	Avon Wheatbelt, Esperance Plains, Jarrah Forest, Mallee, Swan Coastal Plain	Avon, Northern Agricultural, Swan, Rangelands, South Coast, South West	79
Translocation of critically endangered plants	Midwest, South Coast, South West, Wheatbelt	Avon Wheatbelt, Coolgardie, Esperance Plains, Gascoyne, Jarrah Forest, Mallee, Murchison, Swan Coastal Plain, Warren	Avon, Northern Agricultural, Swan, South Coast, South West	80
The population ecology of critically endangered flora	All DBCA Regions	Avon Wheatbelt, Central Kimberley, Esperance Plains, Gascoyne, Geraldton Sandplains, Jarrah Forest, Mallee, Northern Kimberley, Swan Coastal Plain, Warren	Avon, Northern Agricultural, Swan, Rangelands, South Coast, South West, Wheatbelt	81
Seed biology, seedbank dynamics and collection and storage of seed of rare and threatened Western Australian taxa	All DBCA Regions	All IBRA Regions	All NRM Regions	82
Genetics and biosystematics for the conservation, circumscription and management of the Western Australian flora	Goldfields, Midwest, South Coast, Swan, Wheatbelt	Avon Wheatbelt, Coolgardie, Esperance Plains,	Avon, Northern Agricultural, Swan, Rangelands,	83

Project Title	DBCA Region	IBRA/IMCRA	NRM Region	Page
		Geraldton Sandplains, Mallee, Murchison, Swan Coastal Plain, Yalgoo	South Coast, South West	

Remote Sensing and Spatial Analysis

Project Title	DBCA Region	IBRA/IMCRA	NRM Region	Page
Species Distribution Modelling under Climate Change	South Coast, South West, Swan, Warren			85
Novel methods combining ground-based monitoring and remotely sensed observations to inform management and measurement of ecosystem condition in the rangelands	Midwest	Geraldton Sandplains	Northern Agricultural	86
Dirk Hartog Island vegetation monitoring	Midwest	Yalgoo, Shark Bay	Rangelands	87
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