PRIORITY THREAT MANAGEMENT OF INVASIVE ANIMALS
to protect biodiversity

LAKE EYRE BASIN

OVERVIEW

Pulchera Waterhole, Ethabuka Reserve
A semi-permanent wetland fed by the ephemeral Mulligan River where many threatened bird species are recorded

ADAM KEREZSY

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LAKE EYRE BASIN

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We acknowledge that this report would not have been possible without the invaluable input of experts and stakeholders in the culture, heritage, land management, agriculture, ecology and conservation of the Lake Eyre Basin. Participants volunteered their time to attend two workshops and participate in follow-up consultations.

Of the 34 experts and stakeholders involved, the following people agreed to be acknowledged: **Jane Addison** CSIRO Land and Water **Robert Brandle** South Australia, Department of Environment, Water and Natural Resources **Andrew Burrows** Desert Channels Queensland **Chris Dickman** University of Sydney **Angus Duguid** Department of Land Resource Management, Northern Territory Government **Glenn Edwards** Department of Land Resource Management, Northern Territory Government **Angus Emmott** Naturalist, grazier and biologist **Matt Gentle** Queensland Department of Agriculture and Fisheries **Travis Gotch** South Australia, Department of Environment, Water and Natural Resources **Nerissa Haby** South Australia, Department of Environment, Water and Natural Resources **John Hodgon** Queensland Parks and Wildlife Service **Adam Kerezsy** Dr. Fish Contracting **Mark Kleinschmidt** Desert Channels Queensland **David Lord** Thackaringa Station **Greg Patrick** South Australia, Department of Environment, Water and Natural Resources **Chris Pavey** CSIRO Land and Water **John Pitt** Primary Industries and Regions South Australia **Tony Pople** Queensland Department of Agriculture and Fisheries **David Roshier** Australian Wildlife Conservancy **David Schmarr** South Australian Research and Development Institute **Jennifer Silcock** University of Queensland and Queensland Herbarium **Marie Vitelli** AgForce. We acknowledge the participation of the Australian Government Department of the Environment, and the Lake Eyre Basin Scientific Advisory Panel and Community Advisory Committee.

The authors would also like to acknowledge **Craig Salt** (Sustainable Consulting) for his exceptional facilitation of the two workshops and **Glenn Walker** for his images of the LEB. Finally we are grateful for the financial support of the **Invasive Animals CRC** and the **Queensland Department of Agriculture, Fisheries and Forestry**. Thank you to the **Department of the Environment**, Commonwealth of Australia, Canberra for permitting us to use and for extracting the data we needed to create the habitat distribution models from the Australian Natural Heritage Assessment Tool (ANHAT) database. Thank you also to **Dr Jeremy VanDerWal** (James Cook University) and **Dr. Kristen Williams** (CSIRO Land and Water) for permitting us to use their bioclimatic and substrate predictor datasets to build the habitat distribution models.

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Front cover: Yellow-footed Rock-Wallaby
(Petrogale xanthopus xanthopus) has disjunct populations in South Australia and NSW (Vulnerable EPBC Act 1999)

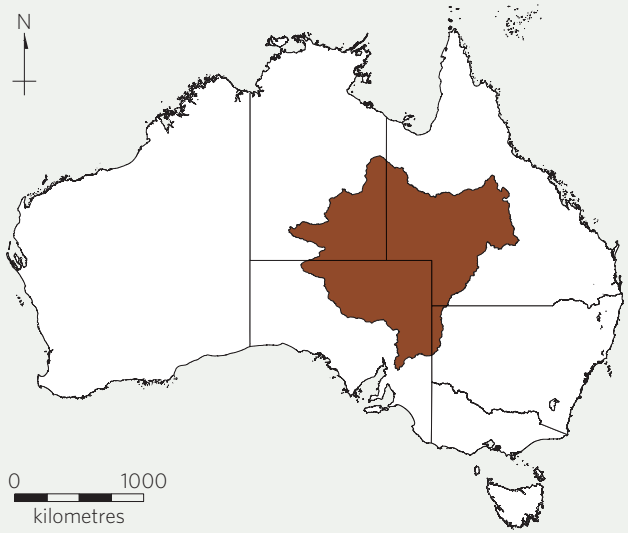
ANGUS EMMOTT

Overview

For the first time, we show how considering climate change impacts over the next 50 years alters decisions on how to mitigate threats to biodiversity today.

In this document we recommend an appraised set of strategies for managing invasive animals to conserve threatened flora and fauna of Australia's iconic Lake Eyre Basin (LEB). The basin is one of the largest internally-draining river systems in the world, comprising one-sixth of the Australian continent (*Figure 1*). Overall, we find that ignoring climate change while deciding how to invest efforts and budgets to control invasive animals will not identify the most efficient opportunities for conserving biodiversity.

Figure 1 The Lake Eyre Basin (LEB) spans one-sixth of the Australian continent



Data sourced from Interim Biogeographic Regionalisation for Australia (IBRA) and Department of Sustainability, Environment, Water, Population and Communities, Australia Commonwealth Government. Compiled by John Hayes and Jennifer Firn.

We report on 11 management strategies for invasive animals (*Table 1*, p.8), which were drawn from the collective experience and knowledge of 34 experts and stakeholders representing federal, state and local governments, indigenous landholders, pastoralists, and non-government organisations, and nine members from the LEB advisory committees (Scientific and Community).

Assisted by models of current distributions of threatened species and their projected distributions under a future climate scenario, these experts estimated costs, feasibilities and benefits for each strategy. This was aimed at improving the persistence of 148 native species listed as threatened, along with additional species considered of concern by experts. We then evaluated the relative cost-effectiveness of each strategy, calculated as the expected benefits, divided by the expected management costs (Carwardine *et al.*, 2012).

Finally, we provide support to assist decision-making and investment using two analytical approaches:

1. ecological cost effectiveness ranking, a prioritised list of the 11 strategies; and
2. complementarity, bundles of strategies to optimise the number of threatened species saved depending on budgets.

For details on the methods used, please see the full study available at csiro.au/en/Research/LWF/Areas/Ecosystems-biodiversity/Monitoring-biodiversity/Conservation-decisions

Camel with satellite collar, Simpson Desert
Feral camel (Camelus dromedaries) impact on natural habitat and farm infrastructure, but are also valued culturally and economically with a growing meat industry

JOHN PITT

Grey falcon
(Falco hypoleucos) is an endemic rare falcon of the interior and north of Australia (Vulnerable IUCN Red List)

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Key findings

USING A RANKING APPROACH

The five most cost-effective strategies within the Lake Eyre Basin are the control of pigs, horses and donkeys, cane toads, camels, and rabbits. Combined, these strategies have an estimated average annualised cost of $16 million over 50 years (*Table 2*, p.12).

The most cost-effective strategy is the management of feral pigs, at approximately $2 million (average annualised cost) in specific locations within the LEB (*Table 2*, p.12).

- Invasive predator control is one of the top ranked strategies for the protection of threatened mammals.
- The total cost of implementing all strategies over the next 50 years is estimated at $33 million under climate change (*Table 2*, p.12).
- Managing invasive animals will also provide significant agricultural co-benefits, increasing production by around 1% to 15% (*Table 3*, p.15).
- The control of highly competitive invasive aquatic animals such as gambusia, tilapia and red claw is critical to ensure the conservation of threatened aquatic flora and fauna. Research projects on control methods, and modelling/risk assessment to predict the impact of changes to natural river flows are high priorities.
- The feasibility (the probability of success and likelihood of uptake) of most of the strategies will increase with climate change as invasive animal populations were expected to decline in density and range due to lower rainfall and unpredictable climatic events, making them easier to locate and control.
- The establishment of an 'Institution for facilitating natural resource management' would assist managers to find the funds needed to respond early to rising crises, by enabling funding to be carried over into future years when conditions may be more conducive for high invasive animal populations.

Key findings

USING A COMPLEMENTARITY APPROACH

Because many of the strategies benefit the same species, selecting multiple strategies to implement from the prioritised list may not be the most efficient use of resources. Therefore we have developed a complementarity approach that evaluates strategies at the same time, so that bundles of strategies can be selected to optimise outcomes according to budgets (Chades *et al.*, 2014).

We use this approach to recommend bundles of strategies that maximise the number of threatened species potentially secured at a minimum cost.

- We discover that without management intervention, 29 species are likely to be lost from the LEB over the next 50 years under climate change.
- Without management intervention, critical weight range mammals (17 species) are estimated to have a 31% probability of persisting functionally in the landscape over the next 50 years under climate change. The implementation of all 11 strategies increases estimates of their persistence to over 50%.
- For the minimum species persistence threshold of >50% chance of survival over 50 years with climate change, the majority of threatened flora and fauna may reach this threshold with the implementation of two strategies – predator and pig control – at an average annualised cost of $12 million (*Figure 2*, p.11).
- 84 species are estimated to reach a higher persistence threshold of 70% or greater chance of survival over 50 years with the implementation of two strategies – pig and rabbit control – at an average annualised cost of $7 million (*Figure 2*).
- Under climate change, no threatened native animal species are estimated to have a >85% chance of survival over 50 years, even if all strategies are implemented.

How to use this information

Effectively responding to the threat of invasive animals under climate change, within financial and logistic constraints, is crucial for successfully meeting the challenge of protecting Australia's biodiversity and presents significant agricultural benefits.

The Lake Eyre Basin covers an estimated 120 million ha and spans three states and the Northern Territory.

Red-finned blue-eye
(Critically Endangered IUCN Red List)

ADAM KEREZSY

This makes trans-boundary cooperation pivotal to the effective management of natural resources including invasive animals and threatened species. The Lake Eyre Basin Intergovernmental Agreement (LEBIA) was established in 2001 to limit cross border impacts.

We did not directly consider the effectiveness of current or future management delivery models, although this is a crucial component of successful invasive species control and eradication for biodiversity benefits. Workshop participants suggested that future planning approaches should integrate the priorities that resulted from this process. In particular, the LEBIA was highlighted as being critical as a strategy adopted by the Ministerial Forum under its 'Water and Related Natural Resources Policy' is to '(i) identify opportunities for improved coordination and consistency of approaches to aquatic and terrestrial weed and feral animal management activities'.

The Lake Eyre Basin Rivers Assessment (LEBRA) could also be used to integrate the information discovered in this project. The information collection and monitoring required and recommended as part of these invasive animal management strategies could be implemented through the LEBRA, which aims to assess the condition of catchments across the Basin under the Agreement. At regional scales, further important avenues for integrating this research include the state, local government, NRM region, catchment and even property-level planning that is undertaken by governments, NGOs, landholders and management groups.

Because uncertainty exists about most conservation strategies, including the best measures to control invasive animals, an adaptive management framework is essential (McCarthy & Possingham, 2007). Working with a variety of landholders and land managers will be necessary to achieve invasive animal control. A well-coordinated implementation strategy developed in collaboration with stakeholders will also increase the likelihood of realising the estimated agricultural co-benefits from invasive animal control (*Table 3*, p.15).

Caveats

A number of caveats apply to our recommendations. Due to the lack of empirical data, expert and local knowledge was used to generate these recommendations and therefore may not always be formed on the basis of published, peer-reviewed scientific research or on the real costs of management strategies. Workshop participants gave estimates for the persistence of species groups for which they were confident in having the knowledge to do so; therefore, we have variable numbers of estimates for

each species group. We were unable to create species habitat distribution models for all threatened species on the list due to lack of quality data, and the technique applied is only robust for terrestrial species. We assumed that strategies could be funded or not funded, but in reality strategies could be partially funded. Our approach also does not consider interactions between invasive animal threats, nor additional threats such as habitat clearing, fire, cattle grazing or invasive plants. We conservatively assume that any combination of strategies delivered the maximum benefit of the independent strategies being combined, where in reality a combined strategy may deliver a higher benefit than the maximum of individual strategies.

Concluding Remarks

We provide a basin-wide picture of the conservation significant flora and fauna most at risk of extinction, and provide a cost-effective approach for selecting invasive animal control strategies in the LEB to best protect them.

Climate change and invasive animals are considered two of the leading causes of biodiversity loss (Monastersky, 2014). As we show here, in combination over the longer term these threats will have a profound impact on threatened native species already disadvantaged by habitat and environmental conditions (Isaac & Cowlishaw, 2004).

The Blanche Cup mound springs, South Australia
(Endangered ecosystems EPBC Act 1999)

ANGUS EMMOTT

Table 1 Description of the 11 management strategies recommended by the workshop participants for the control of invasive animal species to protect biodiversity in the Lake Eyre Basin

1 Institution for facilitating natural resource management (overarching strategy)

- A general contingency fund to respond to unanticipated threats such as new pests or unexpected outbreaks.

2 Predator control i.e. cat *(Felis catus)*, fox *(Vulpes vulpes)*, and dog *(Canis familiaris)* control

- Cat and fox trapping and baiting at key assets
- Fox aerial baiting
- Monitoring
- Early response 'control' team in each state
- Training of guardian dogs community program
- PhD research projects to improve control efforts.

Additional actions with climate change:

- Additional eight research projects on the impacts of climate change on cat populations and mesopredator release effects.

3 Pig *(Sus scrofa)* control

- Aerial baiting and/or shooting around water
- Monitoring program every ten years
- Special asset management
- PhD research projects to improve control efforts.

4 Cane toad *(Bufo marinus)* control

- Asset protection
- PhD research projects on control efforts
- Monitoring and trapping: localised eradication
- Surveillance and biosecurity hotspots
- Education.

5 Gambusia *(Gambusia holbrooki)*

- Chemical control (e.g. rotenone) of gambusia
- Surveillance and biosecurity
- Research program on chemical controls
- Education and public awareness campaigns
- Identification of key threats and triage ranking
- Modelling to predict the impact of changes to natural river flows brought about by irrigation projects and mining in the LEB.

6 Other aquatic species control, e.g. red claw *(Cherax quadricarinatus)*, tilapia (various species) and sleepy cod *(Oxyeleotris lineolata)*

- Research program on eDNA
- Education campaign and signage
- Surveillance and biosecurity
- Increased investment into LEBRA
- Quarantine of pristine GAB mound springs
- Translocation projects
- Protection of natural flows.

7 Horse *(Equus ferus caballus)* and donkey *(Equus asinus)* control

- Education including regular training workshops
- Monitoring program
- Public engagement program
- Aerial culling with helicopters
- Industry partners for meat production market depending on local regulations.

8 Camel *(Camelus dromedaries)* control

- Education including regular training workshops
- Commercial muster for sale
- Fencing with steel spiders for key waterhole/ cultural site protection
- Aerial culling with helicopters
- Monitoring program for control efforts
- Public engagement program.

9 Goat *(Capra hircus)* control

- Education including regular training workshops
- Monitoring program of control efforts
- Public engagement program
- Industry partners for meat production market depending on local regulations
- Incentive/assistance program to encourage mustering of goats
- Aerial culling with helicopters
- Fencing with steel spider structures to protect biodiversity assets.

10 Rabbit *(Oryctolagus cuniculus)* control

- Monitoring program
- Biological control
- Habitat modification (warren destruction)
- Fumigation
- Baiting with 1080
- Education and regular training workshops
- Engagement staff and programs.

11 Total combined strategies

- All strategies 1 to 10 combined.

Kite, heron and egret, Cooper Creek

GLENN WALKER

Yellow Spotted Monitor *(Varanus panoptes) can die from consuming large cane toads (Vulnerable NT)*

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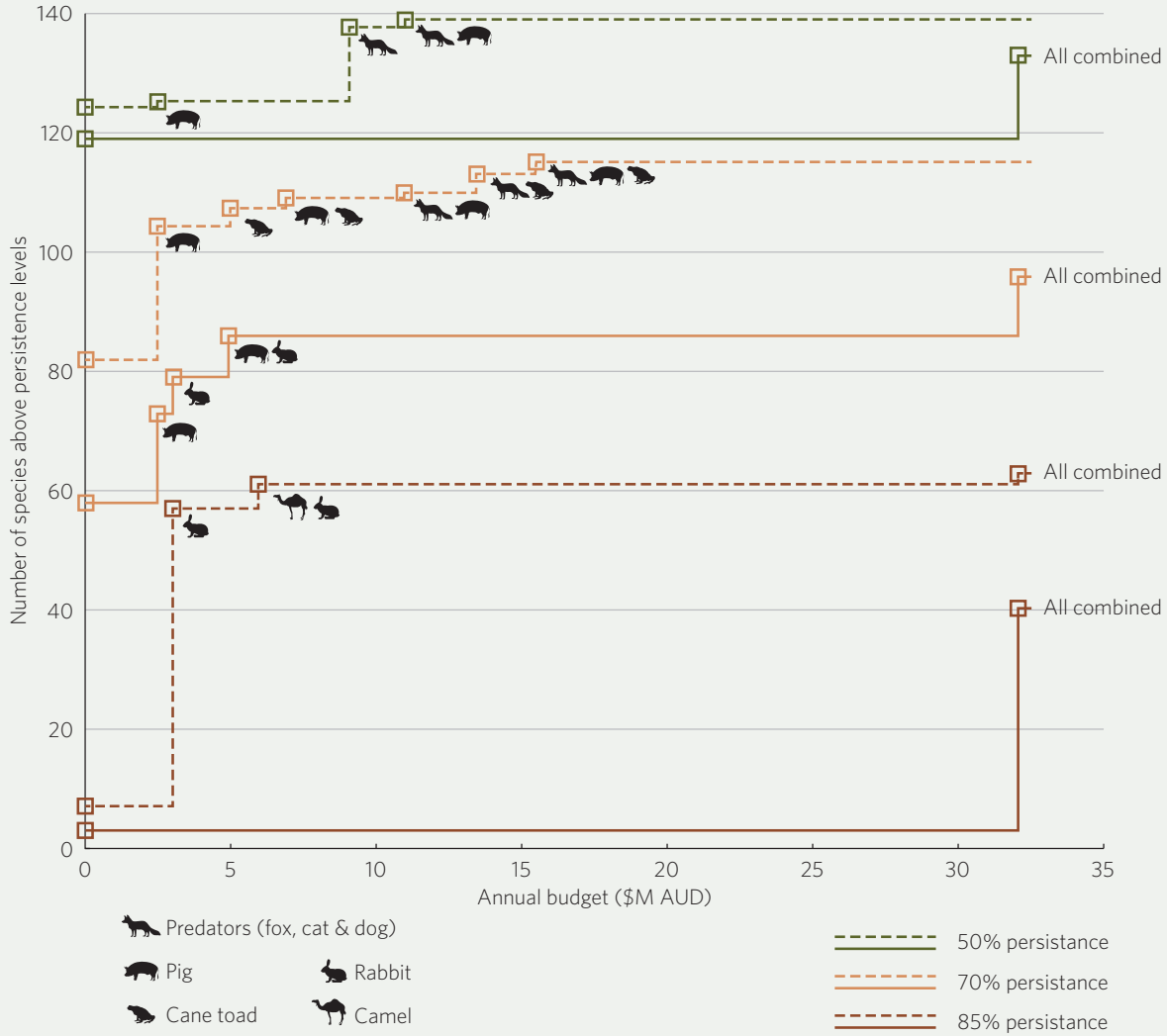
Figure 2 Results from the complementarity approach. Lines show the combination of strategies needed to secure threatened species above three persistence thresholds (50%, 70% and 85%) depending on budgets. Solid lines show results considering climate change and dashed lines without considering climate change.



This complementarity analysis accounts only for the benefits of strategies that improve the persistence of species to exceed each threshold. As shown by the cost-effectiveness ranking approach, there are benefits to undertaking all strategies, but not always sufficient benefits to improve species persistence above these thresholds.

Table 2 Summary of results using the cost-effectiveness ranking approach including the CE ranks, scores, and estimated uptake, success, persistence benefits for all species groups and costs

Strategy	CE rank	CE score	Uptake (proportion 0-1)	Success (proportion 0-1)	Expected benefit (50 years)	Rank expected benefit	Expected NPV (50 years)	Average annualised cost
Pigs	1 (1)	1.93 (1.79)+	0.93 (0.925)	0.76 (0.75)	543 (504)	3 (3)	$28M ($28M)	$2M ($2M)
Horses & donkeys	2 (2)	1.38 (1.43)+	0.8 (0.8)	0.9 (0.8)	581 (562)	2 (2)	$41M ($41M)	$3M ($3M)
Cane toads	3 (3)	1.12 (1.22)-	0.88 (0.88)	0.8 (0.77)	438 (476)	5 (4)	$39M ($39M)	$3M ($3M)
Camels	4 (4)	1.04 (1)+	0.9 (0.95)	0.8 (0.7)	425 (410)	6 (5)	$41M ($41M)	$3M ($3M)
Rabbits	5 (5)	0.73 (0.57)+	1 (1)	0.5 (0.5)	471 (363)	4 (6)	$64M ($64M)	$5M ($5M)
Gambusia	6 (6)	0.42 (0.55)-	0.67 (0.67)	0.56 (0.63)	83 (109)	8 (9)	$20M ($20M)	$2M ($2M)
All strategies	7 (7)	0.38 (0.38)	0.9 (0.9)	0.8 (0.8)	1698 (1652)	1 (1)	$442M ($439M)	$33M ($32M)
Predators	8 (8)	0.31 (0.29)+	0.72 (0.62)	0.84 (0.87)	374 (353)	7 (7)	$123M ($120M)	$9M ($9M)
Other aquatic	9 (9)	0.19 (0.28)-	0.89 (0.89)	0.64 (0.69)	81 (119)	9 (8)	$43M ($43M)	$3M ($3M)
Goats	10 (10)	0.15 (0.19)-	0.5 (0.5)	0.25 (0.2)	63 (80)	10 (10)	$44M ($44M)	$3M ($3M)
Institution for NRM	na	na	0.6 (0.6)	0.6 (0.6)	na	na	$2M ($2M)	$141,000

Estimated: uptake (%), success (%), average expected benefits, average net present value, annual equivalent value, and cost effectiveness. A discount rate of 7% was used to calculate expected NPV and average annualised costs (Council of Australian Governments 2007). Appraisal values estimated not under the climate change scenario are shown in brackets for comparison. CE = cost-effectiveness, NPV= net present values, NRM = Natural Resource Management, M= millions.

Mulligan group mound spring
Found at edge of the Simpson Desert, the spring shows damage by pigs and cattle

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Dingo (Canus lupus dingo)
The guardian dog program proposed in the predator strategy could help to conserve this species (Vulnerable, IUCN Red List)

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Table 3 Estimated agricultural co-benefits of the management of invasive animals for protecting biodiversity

Strategy	Agricultural co-benefits	Benefit value
Pigs	Biosecurity benefit as pigs are potential vectors of disease that impact on the health and survival of livestock	< 1% per annum increase in cattle productivity
Cane toads	None estimated	
Camels	Reduced fence and farming structure damage	Increased income of 2–5% per annum
	Reduced water loss from dams and contamination of water holes	Increased productivity of 5% per annum with increased conservation of dams and water holes
Horses & donkeys	Reduced fence and farming structure damage	Increased income of < 1% per annum
	Reduced water loss from dams and contamination of water holes	Increased productivity of 2% per annum with increased conservation of dams and water holes
Gambusia	Research on chemical control could be a benefit for abalone aquaculture	Increased income of < 1% per annum
Rabbits	Increased productivity in semi-arid sheep and cattle country because of more fodder	Increased income of 15% per annum
Predators (cats, dogs and foxes)	Reduced livestock losses including sheep and cattle	Increased income of 10% per annum for sheep
	Fewer landholder distractions therefore increased productivity	Increased income of 2% per annum for cattle
	Biosecurity benefits as cats and dogs are potential vectors of disease that impact on the health and survival of livestock	< 1% per annum increase in livestock productivity with the prevention of disease
Other aquatic species (e.g. red claw, tilapia and sleepy cod)	Increased quality of waterholes which are essential for rangeland farming	No estimate provided
Goats	Increased productivity particularly for landholders raising sheep	Increased income of 10% per annum for landholders particularly in the semi-arid regions of the LEB where goats are present
	Increased goat sales by landholders	
	Biosecurity benefits as goats are potential vectors of disease that impact on the health and survival of livestock	

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ISBN 978-1-4863-0559-9

Citation Firn, J, Maggini, R, Chades, I, Nicol ,S, Walters, B, Reeson, A, Martin, TG, Possingham ,HP, Pichancourt, J, Ponce-Reyes, R, Carwardine, J 2015 ***Priority Threat Management of Invasive Animals to Protect Biodiversity in the Lake Eyre Basin – Summary version*** CSIRO Brisbane

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Red claw crayfish in the Thomson River *(Cherax quadricarinatus), a native of far north Australia but is an invasive species in the LEB. Red claw directly competes with common yabbies (Cherax destructor, Vulnerable IUCN Red List)*

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Invasive
Animals CRC

Waddi Wood trees (Acacia peuce) at Boulia (Qld)

Waddi Wood trees are found at just three highly disjunct areas on the edges of the Simpson Desert (Vulnerable EPBC Act 1999). Grazing and trampling are serious threats to its persistence.

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