



Review of the bridled nailtail wallaby recovery program

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Authors for Protected Area Solutions Pty Ltd

Fiona Leverington
Andrea Leverington
Stephen Kearney

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This independent evaluation has been undertaken as a genuine search for the truth about what the recovery program for the bridled nailtail wallaby over the past 45 years: what has happened, what has been achieved, and what could be done better in the future. While two of the authors have worked in the past with many of the people involved in the program, we have remained impartial and have not been influenced by a need for approval by DES or other participants.

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Executive summary

This project aims to assess whether the conservation status of the bridled naitail wallaby has improved, evaluate effectiveness of recovery actions and the recovery program as a whole; and the recommend actions for the future. The scope of the project includes contributions by both non-government organisations and government agencies.

The bridled naitail wallaby *Onychogalea fraenata* is a small macropod, which once ranged widely in the semi-arid regions of eastern Australia, from south of the Murray River in Victoria to Charters Towers in Queensland. It was presumed extinct from the late 1930s until it was rediscovered in 1973. Its decline was best correlated with the expansion of the pastoral industry (Evans, 1992). The massive decline in numbers of the bridled naitail wallaby was also observed in many of the other small macropods that inhabited a similar area (Ellis et al., 1992). Immediate action was taken to secure the wallaby's habitat, to find out more about its distribution and requirements, and to secure it from obvious threats. Since then, recovery efforts have included extensive research, reservation and habitat protection, captive breeding, translocation, and mitigation of threats, especially from predators. The bridled naitail wallaby is listed as Endangered under Queensland and Australian government legislation, and Presumed Extinct in the Wild under NSW legislation. Its status was changed from Endangered to Vulnerable in the IUCN Red List in 2016, as the population was considered stable. The Australian Government is likely to review its listing in the near future.

In its original distribution, the bridled naitail lived in a wide range of dry woodlands, thickets and grasslands with some adjacent cover. The last natural stronghold is in the Brigalow Belt of Queensland, a semi-arid environment with woodlands of brigalow *Acacia harpophylla* and eucalypts. Bridled naitail wallabies will eat a wide range of plants, with their diet composed of different proportions of grasses, shrubs or forbs, depending on availability, which gives them a competitive advantage in hot, dry and unreliable climates (Tierney, 1985). The primary threats to bridled naitail wallabies include cats, foxes, dingoes and wild dogs, buffel grass and drought.

At present, populations of bridled naitail wallabies are living in three locations:

- Taunton National Park (Scientific) in central Queensland: the remnant wild population
- Avocet Nature Refuge in central Queensland: a translocated population living in the wild but with a predator-proof 'nursery' area to protect some females with young
- Scotia Sanctuary, a reserve managed by Australian Wildlife Conservancy in southwestern New South Wales: a translocated population living within a predator-proof fence.

There are current plans to establish two new fenced populations in New South Wales.

Genetic diversity within populations is thought to increase the survival of species, especially their ability to withstand change and chance events such as severe droughts or disease. Studies of genetic diversity of bridled naitail wallabies have shown that the population at Taunton has retained healthy levels of diversity, while populations at Avocet and Scotia have healthy levels of heterozygosity but low levels of allelic diversity and thus limited ability to adapt to changing conditions. It is clear that lack of genetic diversity in all but the wild population is a significant threat to the survival of the species and needs to be considered when assessing the listing status of the bridled naitail wallaby. A genetic management plan has recommended steps to improve this diversity.

Extensive recovery efforts have been undertaken for the bridled naitail wallaby over the 35 years since the mammal was rediscovered. Recovery planning in different forms has been undertaken since the late 1970s, with the last plan developed for 2005-2009.

Overall, we conclude that the **impact of the recovery program has been very positive**, with the current population (2400 in total) far exceeding that which is likely to have survived without intervention. Without the early reservation and management of Taunton and other recovery efforts, it is highly probable that the species would now be extinct or in extremely small numbers. However, due to lack of genetic diversity in populations other than at Taunton, we believe that the bridled nailtail wallaby should still be regarded as Endangered, and that its survival in the wild still requires major effort by government and partners.

In this report, we have considered the recovery effort as a whole in four subprograms. Assessment of the effectiveness of each sub-program is summarised in Table 1

- Subprogram one: Research, recovery coordination and recovery planning (section 3)
- Subprogram two: Protection of the wild population at Taunton (Section 3.3.1)
- Subprogram three: Captive breeding and translocations (Section 5)
- Subprogram four: Additional land acquisitions and community corridors in the Brigalow Belt

Table 1 The effectiveness of the sub-programs of the bridled nailtail wallaby program

Subprogram	Assessment
Subprogram one: Research, recovery coordination and recovery planning (section 3)	
• Research and monitoring	Effective: Large volume of relevant and applicable research has been completed; monitoring is undertaken but more could be publicly available.
• Coordination and partnerships	Partly effective: Has excellent potential and passionate participants but is inconsistent, with many issues and changing personalities.
• Recovery plans	Recovery plan was good but out of date
• Community education	Partly effective: No current community education programs from government; minor programs from NGOs, no coordinated effort.
Subprogram two: Protection of the wild population at Taunton (Section 3.3.1)	Mostly effective: threat level still high; populations greatly increased over 1974 levels; genetic diversity good
Subprogram three: Captive breeding and translocations (Section 5)	
• Captive breeding and captive populations	Not effective: no captive breeding populations as of August 2018
• Translocation and management of population at Idalia NP (Section 5.2.1)	Not effective: population no longer exists
• Translocation and management of population at Avocet NR (Section 5.5)	Mostly effective: threat level still high; population hanging on but genetic diversity medium to low.
• Translocation and management of population at Scotia Reserve (Section 5.4)	Mostly effective: Population increase has been very good; genetic diversity is low. Attempts at wild release have failed.
Subprogram four: Additional land acquisitions and community corridors in the Brigalow Belt	
• Acquisition of further lands	Not effective: no additional lands acquired
• Working with landholders	Partly effective: work is not continuing at present

Under the Nature Conservation (Wildlife Management) Regulation 2006 the Queensland Government is required to **maintain wild populations** of bridled naitail wallabies, if at all possible. The following recommendations for the Department of Environment and Science are made on this basis.

1. Continue to support survival of the species in the wild, as per the requirements of the Nature Conservation (Wildlife Management) Regulation 2006. Allocate on-going and reliable **funding** for key actions in threat management to support, at a minimum, the populations at Taunton and Avocet. Continue as a matter of priority to protect wild populations of bridled naitail wallabies, especially through controlling cats and foxes, and where necessary dingoes and wild dogs. Respond rapidly to emerging threats.
2. Ensure sufficient **capable and qualified staff** are allocated to the conservation of the bridled naitail wallaby, that there is good cooperation among staff from different areas of operation, and that positions are always backfilled. Empower local staff to make decisions and have financial responsibility as appropriate to their level of competence. Provide local contingency funds to cover urgent on-ground needs as they arise in line with recovery objectives.
3. Re-invigorate a strong, diverse and balanced **recovery group**, using the Australian Government guidelines (Commonwealth of Australia, 2017). The group must meet regularly and have a clear understanding of the objectives and actions for the recovery of the species. Consider appointing an independent chair of the recovery group, elected by members (as specified in the guidelines), rather than relying on the Queensland Government staff to undertake this role. Ensure this group is able to make decisions and is able to affect outcomes in a timely manner when issues arise, including through out-of-session discussions. An important role of this group is to update the recovery plan as outlined below. Members should be supported to attend meetings, depending on their institutional resources. Another important role of the group is the open sharing of information, including problems and solutions: cross-visits by land managers to other sites could be supported. An annual report of the species' status at all sites should be prepared and this should be publicly available on websites of all the organisations concerned.
4. Urgently update the **recovery plan** to outline objectives, key actions and strategies over the next 10-20 years. Ensure that information about the proposed populations in NSW is included, and that the recovery plan incorporates principles and actions for adaptive management. Identify key risks that may impede achieving the outcomes and undertaking the actions. Develop risk management strategies to deal with such issues in the plan.
5. Develop **strong partnerships**, in particular with people and organisations with a long-term commitment to involvement and protection of the species. Ensure these partners understand their responsibilities and agree on the outcomes to be achieved. Develop memorandums of understanding or similar documents with partners. Treat all partners with respect and consider that some who make very valuable contributions may have limited time and financial resources. Ensure contributors are acknowledged frequently for their efforts. Support the work of non-government organisations and conservancies to protect the species and actively seek opportunities for cooperation and sharing of information.

6. Develop a very clear strategy for any **captive breeding**, including the purpose and time frame of the captive breeding, the genetics and source of founders for the captive breeding, the number of individuals required, and the locations to which the progeny will be sent. A risk management strategy should be developed for captive breeding addressing issues such as failure to breed, successful breeding leading to excess progeny, and disease.
7. **Secure facilities** suitable for captive breeding to enable successful reintroduction of the species to suitable locations as outlined below and in the genetic management plan. A modern and appropriate captive breeding agreement must be made available to partners willing and able to undertake captive breeding according to the requirements for the translocation of bridled nailtail wallabies. The agreements need to have flexibility to cope with changed circumstances, and support needs to be provided where necessary in a short timeframe. Consider actions in the case of organisations withdrawing from captive breeding at short notice.
8. Secure **additional translocation sites** within Queensland, where possible using existing protected areas (managed by QPWS or conservancies) where there are suitable facilities and pest control programs. Engage with Bush Heritage Australia to determine the appropriateness of Goonderoo as a translocation site. Review information about other protected areas within the bridled nailtail range that have suitable habitat and already have strong predator control. Consider properties that have different climatic conditions to that of Taunton, to take the best advantage of variable seasons. Consider additional acquisitions where appropriate, and work with local landholders to secure corridors for safe dispersal of animals. Follow the most up-to-date advice for translocation, and ensure that releases occur in good conditions and with extensive predator control.
9. Boost **public education** and communication about bridled nailtail wallabies, to raise awareness and encourage support for the species. This may include supporting some animals to be displays in captivity (ambassador species), and this may include those from poorer genetic stock, that have been deemed to be unsuitable for future wild release. Continue to cooperate with programs involving volunteers, including those working through other agencies.
10. In recognition of the need for additional **funding**, develop a prospectus for how philanthropic organisations, industry and the public can contribute to recovery of the species through programs prioritised by the recovery group. Develop a range of projects for university students to undertake that support the recovery objectives.
11. Retain the **listing** of the species as Endangered until additional wild populations are established and fully stabilised through a range of seasons.
12. Continue to **support research and to apply new information** and innovative ideas in bridled nailtail wallaby management and recovery, especially relating to threat mitigation techniques. Fully engage with research relating to feral predators and about the ecology of dingo populations, and incorporate this into approaches for new and existing populations of bridled nailtail wallabies. Also research methods to encourage or facilitate animals to disperse to areas of suitable habitat (for example at Taunton and Avocet/ Goonderoo, where this does not appear to occur as much as expected).

13. Implement the **genetic management plan**, including the establishment of populations in Pilliga and Mallee Cliffs that are from genetic stock with higher allelic diversity. Consider removal of some animals from the wild at Taunton during conditions where populations appear to be exceeding the local carrying capacity. Continue to monitor genetic make-up of populations, and immediately obtain necessary information for the optimal management of the animals recently removed from Safe Haven.
14. Document all learning relating to captive breeding, translocation and management of wild populations in a succinct set of **guidelines** for future managers.

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1. Introduction

1.1 Project overview and scope

The project aim is an assessment of whether the conservation status of the bridled nailtail wallaby has improved and the effectiveness of various recovery actions individually and cumulatively; and the development of recommendations for the future. The **key requirements** of the project are to:

- Review strategies, tactics and actions undertaken for the recovery of the species and performance indicators including but not limited to:
 - compliance with strategic and legislative framework
 - role and responsibilities, including the department's role in recovery group
 - value and effectiveness of partnerships for species recovery
 - annual cost to the department for current actions
 - roles and responsibilities operating on protected area managed by Queensland Parks and Wildlife Service (QPWS): Taunton National Park (Scientific)¹ and privately-owned land under Nature Refuge (Avocet Nature Refuge)
 - approach to release sites
 - effectiveness/appropriateness of captive breeding to recover this species – options and alternatives
 - role of meta-population plan (in progress)
 - data collection, analysis and information management
- Make recommendations based on findings to address questions:
 - Should recovery efforts continue?
 - What recovery efforts are most effective and should continue?
 - If so, what role should DES play?
- Compile a report that
 - reviews the current program
 - provides for recommendations outlined above
 - provides a draft plan for the implementation of the recommendations, including responsibilities and timeframes.

The scope of the project includes assessment of the recovery program as a whole and includes work by non-government agencies as well as government organisations.

¹ In this document we will refer simply to 'Taunton' which has been over time a property, a scientific reserve, a national park and a national park (Scientific). Avocet Nature Refuge will be referred to as Avocet.

1.2 Approach

The methodology for this project was presented to and approved by the Department of Environment and Science (DES) in June 2018. The methodology required an understanding and interpretation of many factors and aspects:

- the *biological* story,
- the history of *actions*,
- the *social, economic, climatic and governance environment* over the period under consideration; and critically,
- the *likely chain of causes, events and outcomes*.

There was also a requirement to make *recommendations for future actions*.

This methodology overall was based on **impact evaluation**, which is a key part of an **adaptive management** approach. The study combined biological evaluation on the success of the species recovery, with social science evaluation of the process, and used a '**mixed methods**' approach combining qualitative and quantitative data to develop the story and to give the best guidance for the future. **Impact evaluation** goes beyond the tasks of evaluating the context, inputs, processes, outputs and outcomes of programs, to also assess the causal effects. That is, we were considering not only whether the status of the species has improved, but the extent to which this is due to the recovery efforts.

As this recovery program is a complex interaction of projects conducted by different people and organisations, it was necessary to study the impacts of each individual subprogram, and then to assess the effectiveness of the program as a whole.

Step one: Evaluation question: *What is the problem and what is the history of the recovery program?*

The first step was to research and document the history of the recovery program, including the recovery plans, the program's past and current objectives, and environmental and governance factors influencing its implementation. This research also included an overview of the ecology and conservation requirement of the species. Methods for this step included: literature search of both published and unpublished information, interviews with key people, review of DES files and reports, and review of other information provided.

Information answering this question is included in Sections 2 to 6, which outline the overall program and the history of four subprograms.

Step two: Evaluation questions: *What is the current status and trend of the species? How has this changed over time? What are the past, current and anticipated threats to the bridled nailtail wallaby and its habitat? How are these being mitigated? Are threats getting worse or being controlled?*

This second step involved a more in-depth analysis of the current status of the bridled nailtail wallaby, and of the past, current and projected future trends of the population. The evaluation compiled available data from the recovery partners. Indicators sought were:

- Current status in each of the sub-populations, including their numbers, sex and age ratio, health and fecundity, and genetic diversity
- Trends in each subpopulation over relevant time, with an understanding of translocations and breeding history.

- Genetic health of each subpopulation (interpretation of genetic diversity and known implications).

Information relevant to each population is considered separately in Sections 4 and 5. The overall status and trend of the species is then discussed in Section 7.2.

Step 3: Evaluation questions: *To what extent is the current status and trend attributable to the recovery program? Which aspects of the recovery plan have contributed to different extents and how? What additional impacts can be attributed to the recovery program (both intended and unintended)?*

The basis of impact evaluation was to compare the project 'outcomes' – that is, the species recovery, with what would have happened without the project. This step considered and then ruled out alternative explanations for changes (Baylis et al., 2016, Ferraro and Hanauer, 2014). In the case of the threatened species under consideration, a real counter-factual study cannot be obtained, so it was necessary to construct a simple model to project what might have happened with no intervention.

These questions have been addressed in Section 7, which also considers some more detailed questions about the recovery program:

Have the recovery actions been appropriate?

Have recovery objectives been achieved?

Have threats been reduced?

Is the bridled naitail wallaby less threatened?

Has the total population of bridled naitail wallabies increased?

Is the population healthy?

Is the meta-population resilient?

Step 4 Evaluation questions: *To what extent has the bridled naitail wallaby program demonstrated efficient and economical use of resources? Are the roles and responsibilities of the bridled naitail wallaby program partnerships relevant and effective in achieving improved conservation of the wallaby? How could these be improved? Is the role of DES in bridled naitail wallaby recovery aligned with the department's strategic priorities and obligations under the NCA and other legislation?*

Methods used were semi-structured interviews based on questionnaire, search of documentation and files, and development of a 'rich story' through analysis.

These questions are addressed in Section 8.

2. Bridled naitail wallaby – introduction to the species

2.1 A brief history

The bridled naitail wallaby *Onychogalea fraenata* is a small macropod which once ranged widely in the semi-arid regions of eastern Australia, from south of the Murray River in Victoria to Charters Towers in Queensland. It is also known as the *merrin* and *flashjack*. The presumed historical distribution is shown in Figure 2.

Gould first described the wallaby in 1840, writing that it has “..large ears, full eyes, delicate limbs and lengthened tail ... conjoined with the soft grey fur of its face and body, beautifully relieved by diverging lines of black and white rendering it one of the most graceful objects that can be conceived” (cited by Tierney, 1985, p. 26).

The bridled naitail wallaby was reportedly common in some areas: for example, in northern Victoria it was described as the most common of all the smaller species of the Kangaroo tribe; and it was frequently seen on the Darling Downs, in Central Queensland and in parts of Southern Queensland (Tierney, 1985). It is thought to have been extensively hunted, with bounties offered in New South Wales under the name of ‘pademelon’ and pelts ‘frequently seen’ in sales in Queensland (Tierney, 1985). Its population appears to have declined dramatically by the first decades of the 20th century: it was noted to be declining in sales in the Tamworth area in 1909, was no longer recorded in sales in NSW in 1918, and had become infrequently seen in Queensland by 1930 (Gordon, 1976). It was considered ‘on the verge of extinction’ in 1923 (Le Souef, 1923) and was presumed extinct from the late 1930s until it was reported in 1973 (Gordon and Lawrie, 1980, Gordon, 1976). Reasons for its decline are not clear: hunting and clearing may have played a part, but in central Queensland its disappearance from many areas preceded broadscale clearing. Gordon and Lawrie (1980) concluded that the bridled naitail wallaby is more sensitive to European settlement than many other mammals, and that its preference for the same country as stock may have exposed it to more impacts than species that can survive in poorer country. Its decline was best correlated with the expansion of the pastoral industry (Evans, 1992). The massive decline in numbers of the bridled naitail wallaby was also observed in many of the other small macropods that inhabited a similar area (Ellis et al., 1992).

The role of foxes and cats in the species’ decline is not known. However, the bridled naitail wallaby is within the ‘critical weight range’ (35g–5.5 kg) of the mammal species that have been most vulnerable to extinction in Australia (Burbidge and McKenzie, 1989), and there is strong evidence that predation is the primary driver of this extinction (Woinarski et al., 2015).

The rediscovery of the bridled naitail wallaby in central Queensland was a result of keen observation, combined with a magazine article about threatened species:

*“In 1973 brothers Darryl and Doug Challacombe of Duaringa noticed an unusual wallaby while fencing near Dam 3 on ‘Taunton’ station. On discussing the wallaby at home, Darryl’s wife recalled seeing a picture of an extinct wallaby, bridled naitail wallaby (*Onychogalea fraenata*), with similar markings to the wallaby sighted at Taunton in an article on extinct fauna published in the Woman’s Day. The Challacombes contacted the NSW NPWS who then alerted the QNPWS to the sighting. QNPWS officers Greg Gordon and Bruce Laurie conducted a survey of the area and confirmed the wallaby was indeed the bridled naitail wallaby.” (Cameron, 2005).*

Sch 4 - Personal Information

In the early days after this rediscovery, immediate action was taken to secure the wallaby's habitat, to find out more about its distribution and requirements, and to secure it from obvious threats. This 'common-sense approach' for a species where information was lacking (Evans, 1992) may well have saved it from imminent extinction. Since then, recovery efforts have included extensive research, reservation and habitat protection, captive breeding, translocation, and threat mitigation, especially from predators.

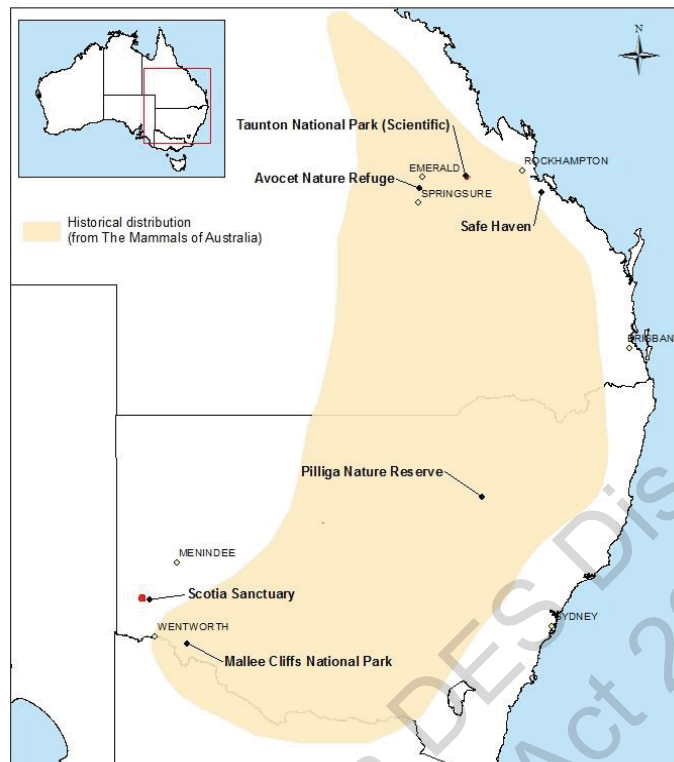


Figure 2: Distribution of bridled nailtail wallabies historically and in 2018.
Source: (Lowry and Ryan, 2018)

2.2 Status of the bridled nailtail wallaby

IUCN Red List

The bridled nailtail wallaby was listed as Endangered between 1982 and 2016. Its listing was changed to vulnerable in 2016, as there had been no decline in numbers over the previous ten years and the population was regarded as stable (Burbidge et al., 2016). The assessment was largely based on the study of a recommendation made in The Action Plan for Australian Mammals 2012, which recognised the bridled nailtail wallaby as an example of successful recovery planning and actions (Burbidge et al., 2014). Its vulnerable listing is attributed to its small population size and small number of localities (Burbidge et al., 2016): the IUCN criteria for vulnerable met by the bridled nailtail wallaby are:

D. Population very small or restricted in the form of:

1. Population size estimated to number fewer than 1,000 mature individuals.
2. Population with a very restricted area of occupancy (typically less than 20 km²) or number of locations (typically five or fewer) such that it is prone to the effects of human activities or stochastic events within a very short time period in an uncertain future, and is thus capable of becoming Critically Endangered or even Extinct in a very short time period.

The species is listed on CITES Appendix I (CITES, 2010). CITES (the Convention on International Trade in Endangered Species of Wild Fauna and Flora) is a multilateral treaty of which Australia is a signatory. CITES aim is to ensure that international trade of wild animals and plants does not threaten their survival. Appendix I includes species threatened with extinction, and trade of these species is permitted only in exceptional circumstances.

Australian Government Environmental Protection and Biodiversity Conservation Act 1999: The bridled nailtail wallaby has been listed as Endangered by the Australian Government since 1980. The main factor that caused the species to be eligible for listing in the Endangered category was a severe reduction in population size and distribution. (Threatened Species Scientific Committee, 2016). However, the current conservation advice for the species notes the report to the IUCN downgrading its status to vulnerable, and the Australian status will also be reviewed (Threatened Species Scientific Committee, 2016).

Queensland Nature Conservation Act 1994: This species is listed as endangered in Queensland (Nature Conservation Act 1992) and is ranked as a critical priority under the [Back on Track species prioritisation framework](#) (Department of Environment and Resource Management, 2010)

New South Wales Biodiversity Conservation Act 2016: The bridled nailtail wallaby in NSW is listed as extinct under Schedule 3.

Victoria Flora and Fauna Guarantee Act 1988: the species is listed as threatened under Section 10.

2.3 Biology

The biology and habitat requirements of the bridled nailtail wallaby are relatively well known, as there have been extensive studies on the species at Taunton (Evans and Jarman, 1999, Johnson, 1997, Evans, 1992, Tierney, 1985, Fisher et al., 2001, Fisher and Goldizen, 2001, Fisher, 2000) with additional studies on captive populations and at translocation sites (Kingsley et al., 2012, Hayward et al., 2012, Sigg et al., 2005, Pople et al., 2001, Johnson, 1997, DeLisle, 1997, Moore et al., 2015). The 2005 recovery plan (Lundie-Jenkins and Lowry, 2005) provides a good summary of information obtained up until that date, and further information is detailed in Lowry and Ryan (2018).

The bridled nailtail is a small wallaby, with males weighing an average of 5-6 kg (some up to 8kg) and females 4-5 kg. This is within the 'critical weight range' of Australian mammals with very high extinction rates (Burbidge and McKenzie, 1989), though males are on the upper limit and grow larger than this range. Life expectancy in the wild is five to six years. The bridled nailtail is generally a solitary animal, though it sometimes forms small groups of four to five. It feeds in or close to the shelter of trees and shrubs except when food is scarce, when it will range further from cover. Its normal defence when faced with danger is to hide rather than to flee (Lowry and Ryan, 2018). Home ranges are estimated at about 25ha for females and 60ha for males (Evans, 1992). Densities of the Taunton populations have been estimated at 0.2-0.6 individuals per ha, and at Scotia 0.1-0.4 with a mean of 0.27 per ha (Australian Wildlife Conservancy on behalf of NSW National Parks and Wildlife Service, 2018).

Breeding behaviour has been studied both in the field and in captivity. The wallaby has a much higher potential breeding rate than other wallabies of a similar size (Johnson, 1997): females can reach maturity at less than five months and males can breed at 18 months (Fisher and Goldizen, 2001). Wallabies in the wild breed continuously, and in good conditions can raise three young

per year, with mating often taking place while pouch young were still present (Johnson 1997). This gives an intrinsic population growth rate of 28% (Fisher, 2000), and the rapid breeding rate means that the bridled naitail wallaby population can recover rapidly after declines, such as after droughts or predation events, when good conditions are restored.

The gender ratio of offspring can vary according to the condition and stress level of the mother: in crowded captive population it was found that 75% of pouch young were male and that the male offspring bias was five times that of adjacent wild-living wallabies (Moore et al., 2015).

2.4 Habitat requirements

In its original distribution, the bridled naitail wallaby lived in a wide range of dry woodlands, thickets and grasslands with some adjacent cover. Their last natural stronghold is in the Brigalow Belt of Queensland, a semi-arid environment with woodlands of brigalow *Acacia harpophylla* and eucalypts. After its original rediscovery, surveys showed that within the area it was found, the wallabies were living in only some of the land systems: the 'better country' with more fertile soils. They were absent from land systems with less fertile, shallower soils, even where the scrubs otherwise seemed suitable (Gordon and Lawrie, 1980).

At Taunton, bridled naitail wallabies were observed by Tierney (1985) to prefer:

- margins of wooded country, where they could utilise their preferred foods, including forbs and grasses, and retreat to shelter;
- regrowth in preference to full forest cover with little understorey;
- areas with shelter in the form of hollow logs and dense thickets of low shrubs or grasses.

Bridled naitail wallabies at Scotia use all the vegetation types including mallee woodland, with understory of spinifex or shrubs, belah woodland, myoporum shrubland and regenerating woodland (Berry et al., in review).

Bridled naitail wallabies shelter during the day and move about very little, except to seek shade or sun depending on the season. At dusk, they move out of the sheltered areas to feed, and return at dawn, but are rarely observed more than 200m from the edge of dense vegetation (Kingsley et al., 2012, Tierney, 1985). Young wallabies (those that have left the pouch but are still suckling) are left in sheltered cover during most of the day and night and often feed at a distance away from their mothers. This 'hider' strategy of maternal care is different from most larger macropods where young follow their mothers (Fisher and Goldizen, 2001) and means that suitable shelter close to feeding areas is critical for survival in the wild.

Shelters used by bridled naitail wallabies vary depending on what is available and include hollow logs, fallen logs and debris, dense shrubs, long grass, and at Scotia burrows of burrowing bettongs (Kanowski et al., 2018).

2.5 Food and water

Bridled naitail wallabies will eat a wide range of plants, with more than 60 species of food recorded at Taunton. Their diet is composed of different proportions of grasses, shrubs or forbs, depending on availability, which gives them a competitive advantage in hot, dry and unreliable climates (Tierney, 1985). Their preference is for plants with high nutritional value and low fibre, such as forbs and herbs including pigweeds, other small succulents and a number of daisy species, but they also eat grasses and browse on shrubs including eremophilas. In dry times, shrubs comprise more of the diet (Evans, 1992); these would have a higher moisture content than dried grasses (Tierney, 1985). The diet of bridled naitail wallabies at Scotia has changed

over time and they now feed in more open areas, indicating that to some extent their choice of foods may have been dictated by avoidance of predation (Berry et al., in review) .

When on a diet of forbs, grasses and browsed shrubs, the wallabies rarely drink. However, in drought times and when feeding only on dry grass and shrubs or on artificial foods such as rabbit pellets or lucerne hay, they may require additional water.

2.6 Threats – past, present and future

Threats to the bridled naitail wallaby have been listed in recovery plans for the species and in the Back on Track plan for the Fitzroy Basin (Department of Environment and Resource Management, 2010), which listed cats, feral dogs/ dogs, buffel grass and foxes as primary threats. This section presents an overview of known threats.

2.6.1 Habitat clearing, alteration and competition with livestock

The dramatic decline in bridled naitail wallaby numbers occurred in the early years of last century, before there was extensive clearing in regions such as the Brigalow Belt, so it is not thought that habitat clearing caused the initial crash in populations in central Queensland. While the wallabies can survive in partly cleared land and regrowth, they still require shelter and will not survive after extensive broadscale clearing. Their population in the area around Taunton appears to have declined after they were first recorded in 1973, when clearing was taking place on nearby properties (Lundie-Jenkins and Lowry, 2005). Shelter from predators is critical for this species, due its strategy to hide rather than flee when threatened. As well as loss of habitat and food sources, their ability to disperse and move around the landscape would also have been severely compromised by the rapid destruction of Brigalow Belt ecosystems in the 1960s and 1970s. For example, decline in habitat quality decreases the ability of bridled naitail wallabies to avoid predation from dingoes (Tierney, 1985). The construction of railways, towns, mines and roads could also have impacted their survival and natural dispersal patterns.

It has been postulated that their preference for ‘better’ country saw them in direct competition with sheep throughout much of their range (Gordon and Lawrie, 1980), as sheep eat similar food to the bridled naitail wallabies (Lundie-Jenkins and Lowry, 2005), though they seem to be able to co-exist with cattle as long as they still have access to shelter.

Sheep

As discussed above, competition with sheep and sheep grazing, combined with the associated habitat alteration and low tolerance of graziers for wallabies on their properties, may have contributed to the former decline in populations. This is not a current threat to any of the bridled naitail wallaby populations.

Cattle

Cattle and bridled naitail wallabies can co-exist, but cattle tend to remove long grass, understorey plants and the lower growth of many trees, which reduces the shelter available to wallabies. Their pads are favoured by feral animals for movement, and they introduce weeds. While bridled naitail wallaby habitat generally benefits from the removal of stock, controlled grazing has been recommended to reduce the biomass of buffel grass, and grazing managed for this purpose has been occurring at Taunton National Park (Scientific) since 2009 (Melzer, 2015a). Bridled naitail wallabies eat a wider variety of plant species than cattle, but the two species can compete for food, especially under dry conditions, when cattle consume more browse material and both grass and forbs can be scarce (Ellis et al., 1992, Melzer et al., 2009).

Rabbits

It was also noted that rabbits became a severe problem throughout much of the wallabies' range with early settlement and could also have contributed to their decline through competition for food and removal of shelter.

2.6.2 Competition

Bridled nailtail wallabies at Taunton live in areas also occupied by large number of black-striped wallabies, and they both like to feed on the borders of scrub and grassy country. However, the two species appear to have a high tolerance for each other and their preferred foods differ, with black-striped wallabies mostly feeding on grasses and sedges. Competition for food may increase in drought times (Evans, 1992). Competition for shelter is low and there is little overlap in preferred shelter sites (Evans, 1992). Studies have also noted that dingoes prefer black-striped wallabies as prey (Evans, 1992).

In other parts of their former range and in translocations sites such as Idalia, bridled nailtail wallabies could be in competition for food with red kangaroos, wallaroos and other species, and this will always be exacerbated in dry conditions and when dingoes are eliminated from the system.

2.6.3 Drought and climate change

Droughts are frequent in Taunton and throughout the former range of the bridled nailtail wallaby, so understanding and managing the consequences of drought for bridled nailtail wallabies in the wild are important. In the past, the wide range of the species meant that local declines due to drought would not affect the overall population, but with only small isolated populations, drought can be disastrous. It is also possible that populations in the past would have moved to more favourable localities in dry times. In the drought of the early 1990s, many dead wallabies were observed on roads in the area as well as within Taunton (L. Pitt quoted by Cameron 2005), suggesting that they may have been attempting to disperse in search of better conditions. This has not occurred since supplementary feeding during times of drought was implemented in 1994.

Climate change is predicted to result in exacerbation of threats to the wallaby, especially given its small isolated population, through more severe and protracted droughts, more very hot days and longer hot periods, and increased risk of severe hot fires. Any future strategies for conserving bridled nailtail wallabies should take these predictions into account.

A study at Taunton in severe drought conditions in the early 1990s noted that drought did not appear to affect the survival of adult wallabies, but caused heavy mortality in juveniles (Fisher et al., 2001), though this conclusion was not supported by the ranger's observations of many dead wallabies in 1993 (L. Pitt quoted in Cameron 1995), before supplementary feeding was implemented. Severe drought conditions at Idalia in 2013 did appear to cause severe mortality in the wallaby populations. Their diet would have been only dry grass and shrubs for a protracted period, with forbs and green grass disappearing almost entirely. There was supplementary feeding of lucerne hay but it is not known if this would have fully met their dietary requirements.

Drought at Scotia has also reduced bridled nailtail wallaby numbers with a substantial drop between 2016 and 2017 (Recovery Group Minutes, 24 May 2017). Reproduction success is reduced in dry times, followed by some deaths (J. Kowalski pers. comm). Supplementary feeding

is no longer undertaken at Scotia, and it is thought that animals which were previously fed might not have survived when this feeding ceased (Recovery Group Minutes, 24 May 2017).

There are also compounding factors with drought as a threat (see Figure 4). Reduction in vegetation cover during droughts reduces shelter and makes the wallabies more vulnerable to predation. Competition with other species, including both native macropods and cattle, increases (Evans, 1992, Ellis et al., 1992) as forbs and green grass are scarcer.

2.6.4 Fire

Fire is a natural part of the environment throughout much the range of the bridled nailtail wallaby. However, the small isolated populations, and the increased incidence of more severe fires in the landscape, mean that its remaining habitats need to be carefully managed to minimise impacts of fire. Buffel grass *Cenchrus ciliaris* is known to enhance fire risk and if not carefully managed this causes serious damage to fire-sensitive vegetation such as brigalow and soft-wood scrubs.

2.6.5 Pest plants

The major pest plant problem in habitat of the wild wallabies at Taunton is buffel grass, which can dominate the understorey, increase frequency and severity of fires, impede wallaby movement and eliminate most palatable grasses and herbs. This threat is further discussed in Section 3.3.1. Other pest plants include prickly pear *Opuntia spp.*, 'mother of millions' *Bryophyllum delagoense*, parthenium and crownbeard.

2.6.6 Predators

The rapid increase in population of bridled nailtail wallabies within predator-proof areas (see Section 5) is testament to the serious impact of feral predators on survival of the animals in the wild. Across Australia's threatened and near threatened mammals, the most significant threats are predation by feral cats, inappropriate fire regimes, predation by foxes and habitat loss and fragmentation (Burbidge et al., 2016). As well as direct effects, the three predator species discussed below carry parasites that threaten Australian mammals (Section 2.6.8).

Foxes

Bridled nailtail wallabies are very susceptible to predation by foxes, which killed most of the first group released at Idalia (Pople et al., 2001) and have resulted in failure of releases into the wild at Scotia (Hayward et al., 2012).

It has been suggested that one reason for the survival of the remnant wallabies in the Taunton area was the absence of foxes. Evans (1992) records the presence of 'occasional foxes' at Taunton, but a recent report notes that they have never been recorded there through the intensive predator monitoring (Lowry and Ryan, 2018).

Cats

An early management plan for Taunton suggested that feral cats were common but not considered a significant threat to bridled nailtail wallabies (QPWS, 1988). However, subsequent research showed that they take many young wallabies: the wallabies' solitary nature and habit of freezing when threatened make them easy prey (Horsup and Evans, 1993, Wang and Fisher, 2012, Fisher, 1995). During drought in Taunton, cats were the main cause of death of young and sub-adult wallabies, and this can contribute to population decline (Fisher et al., 2001).

Cats generally take prey up to 2kg, the size of young wallabies, but larger feral cats may be able to take female adult wallabies. In semi-arid environments cats often seek the very types of cover and shelter that young wallabies rely on during the day and night.



Figure 3: Feral cat with freshly killed juvenile bridled nailtail wallaby.

Source: Augusteyn and Hemson (2015)

Dingoes and wild dogs

Dingoes were shown to be a significant predator of bridled nailtail wallabies early in the management of the species (Evans, 1992, Fisher et al., 2001), especially during drought. Baiting and opportunistic shooting programs had been carried out prior to the acquisition of Taunton. It appears that control ceased for some time after acquisition but recommenced in 1984 (Tierney, 1985). Predation by 'wild dogs' is still regarded as a major threat to bridled nailtail wallabies at Taunton (Melzer, 2015a).

However, dingoes have a much longer history of occupation in Australia than foxes and cats, and there are mixed opinions about their ecological role in the conservation of threatened species. Both on a broad and fine-grained scale in Australia, there is strong evidence that uncontrolled dingo populations are associated with fewer foxes and cats, a lower and more seasonally stable population of larger macropods, a resultant higher cover of ground plants, and fewer extinctions of mammals (Johnson, 2015).

Foxes are generally thought to be a higher threat to bridled nailtail wallabies than dingoes: they occur in densities 10-20 times higher than dingoes (cats may be even higher) and these two species are responsible for extinctions of at least 20 mammals in Australia (Johnson, 2015). Therefore, if the presence of a natural population of dingoes decreases or eliminates the presence of foxes, has some dampening on the operations of cats, and keeps the number of their preferred larger macropods at sustainable levels, they may play a positive role in conservation of threatened macropods. It is also asserted that as long as populations are functioning as wild groups and do not contain newly feral dogs, there is little difference in their ecological functioning whether they are all purebred dingoes (Johnson, 2015).

While the role of the dingo in Australian ecosystems is regarded by many people as being positive, it remains a significant predator of native mammals. When a species is at extremely low populations, as has been the case with bridled nailtail wallabies in the wild, any predation may be deleterious to their survival (Johnson, 2015), and modelling shows that small translocated populations cannot withstand even low levels of predation (McCallum et al., 2001).

Native predators

Wedge-tailed eagles are known to take young bridled nailtail wallabies (E. Mulder personal communication, 2018), and were also responsible for two deaths of adult male wallabies released at Scotia (Hayward et al., 2012). Pythons are also a potential predator.

2.6.7 Reduced genetic diversity

Genetic diversity within populations is thought to increase the survival of species, especially their ability to withstand change and chance events such as severe droughts or a new disease. Small populations are vulnerable to loss of genetic diversity, and populations founded from a few individuals are likely to have low diversity, which can continue to decline over a few generations due to 'genetic drift' (Greenbaum et al., 2014). Two factors of genetic diversity that need to be considered are heterozygosity (the chance that two individuals will have different alleles² at any locus on a gene, which is vital for population fitness); and allelic diversity (the range of alleles present in the population). Allelic richness is the raw material for evolution by natural selection, so a decrease means the population is less able to adapt to changed conditions (Greenbaum et al., 2014). Bottlenecks in populations, when numbers decrease and then increase again, can also cause a loss of diversity, particularly of alleles, but may not be serious if they only last for one generation (Weeks, 2018).

Studies of genetic diversity of bridled nailtail wallabies (Sigg, 2005, Seddon, 2008) and the history of captive breeding and translocations have been analysed by Weeks (2018) who concluded that:

- All translocated and captive breeding populations currently lack an adequate founder base and are not sufficiently diverse for confidence in their long-term survival.
- The wild population at Taunton has retained healthy levels of diversity but further monitoring is needed.

It was noted that the Taunton population has a healthy level of heterozygosity but the allelic diversity was not at a desirable level (Sigg, 2005): this may have decreased further since the population declined significantly to a bottleneck of possibly less than 100 individuals in 2007-2009, before increasing again. However, rare alleles were present in this population but absent in all others (Seddon, 2008).

Considering this evidence, it is clear that lack of genetic diversity in all but the wild population is a significant threat to the survival of the species.

2.6.8 Parasites and disease

The two most significant disease threats to bridled nailtail wallabies are believed to be from toxoplasmosis and hydatids, both introduced parasites (Turni and Smales, 2001). Both parasites can seriously impact small populations of mammals, especially during times of stress such as

² Animal chromosomes usually have two sets of genes (one from each parent), and these can have different forms known as alleles. If two alleles in a gene are different, the animal is known as heterozygous for that gene. There can be many different alleles for a gene within a population even though there may be little visible difference among the animals.

drought. Toxoplasmosis is carried by cats, and its spores can survive for up to two years in the soil. It causes lethargy, blindness and death and can make native species less wary of predators. Toxoplasmosis is suspected to have caused declines in several native species, and the parasites were recorded in 15% of bridled naitail wallabies at Taunton (Turni and Smales, 2001). Hydatid cysts are carried by both domestic or feral dogs and dingoes, and were found in 21% of a sample of bridled naitail wallabies (Turni and Smales, 2001).

Other parasites recorded on bridled naitail wallabies include ticks, lice and nematodes (Turni and Smales, 2001, Evans, 1992). Tick loads at Taunton are high and may be of concern; possibly due to the high incidence of ticks when a high biomass of grass is present (Melzer, 2015a). Other diseases include lumpy jaw (Evans, 1992), which mainly affects animals in captivity or close proximity, or fed unsuitable food, but can also affect wild-living animals, especially in times of drought (Borland et al., 2012). The deaths of twelve relocated animals at Idalia were attributed to lumpy jaw (Pople et al., 2001).

2.6.9 Synergistic effects

A schematic summary of the threats to bridled naitail wallabies shows the inter-relationship between the key threats to bridled naitail wallabies (Figure 4). Examples of the interactions include:

- Cats are devastating predators, but they also spread disease (toxoplasmosis) which make animals more susceptible to predation.
- Buffel grass chokes out palatable species, and also exacerbates fire risk.
- Drought reduces edible foods and also removes shelter, making animals more vulnerable to predation.

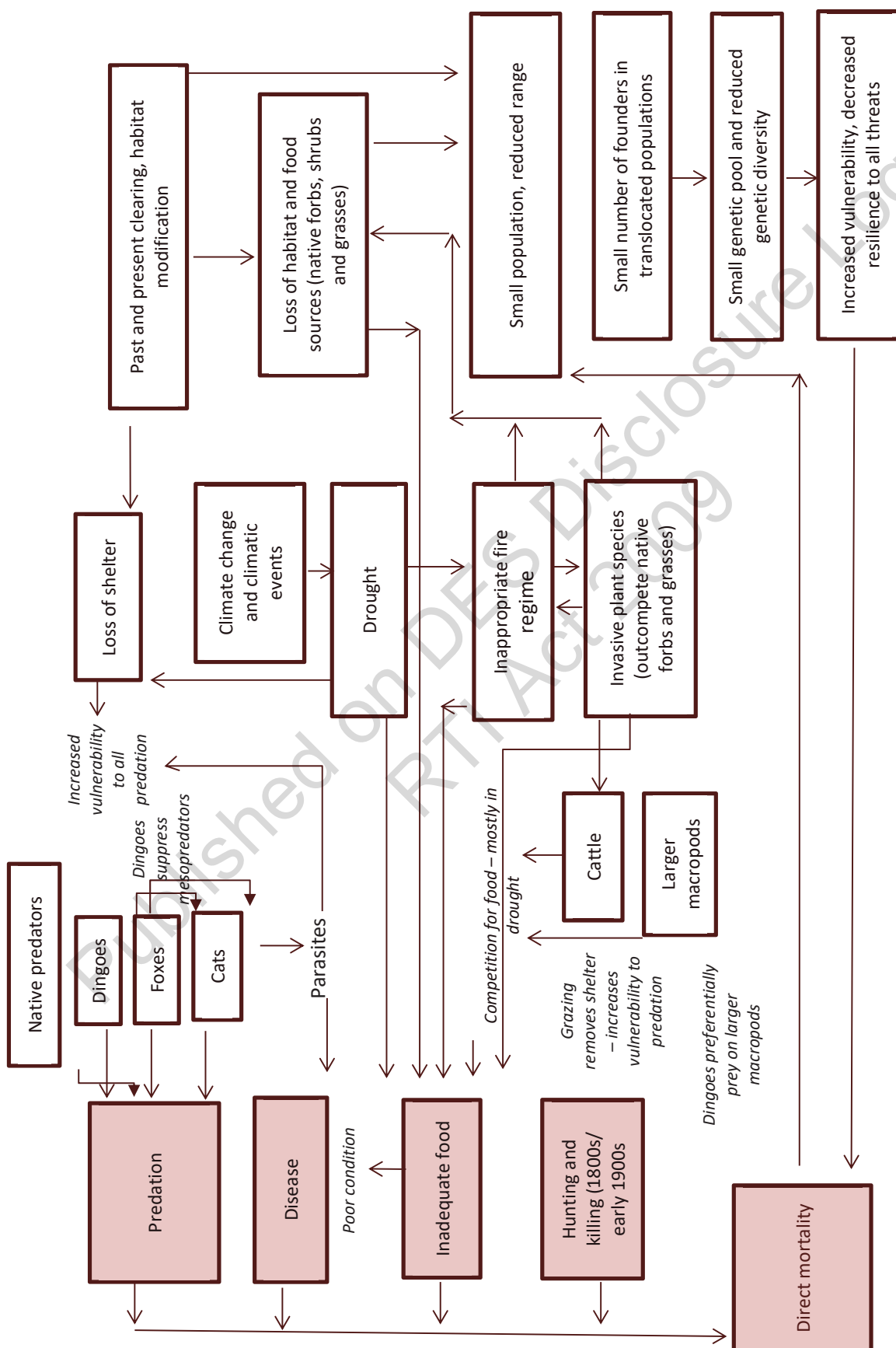


Figure 4: Summary of threats

2.7 Outline of recovery efforts

Threat mitigation strategies relating to the defined threats are shown schematically in Figure 16. Extensive recovery efforts have been undertaken for the bridled nailtail wallaby over the 35 years since the mammal was rediscovered. These were summarised up to 2005 (Lundie-Jenkins and Lowry, 2005, Cameron, 2005) and updated by Lowry and Ryan (2018).

An evaluation of the recovery planning process was conducted as a case study by the Threatened Species Recovery Hub in 2017 (Guerrero et al., 2017). Nine people were interviewed in relation to the bridled nailtail wallaby, and the study found that institutional weaknesses, lack of resources, and lack of collaboration and coordination undermined the process (Table 2).

Table 2: Strengths and weaknesses of the recovery process

Source: Guerrero et al., 2017. Numbers in brackets are number of respondents nominated characteristic.

Aspect	Strengths	Weaknesses
Institutional context		Departmental restructures and staff changes (6) Politics (5)
Inputs	Availability of research and specialist knowledge (6)	Under-resourcing (7) Personal characteristics, preferences and interests (7) Lack or limited knowledge (5)
Planning and implementation processes	Commitment and dedication of people (6)	Lack of coordination (8) Lack of effective collaboration (8)
Outputs	Adaptive management (5)	Inaction (5) Waste of resources (5)

The report identified that one of the greatest specific weaknesses has been the Departmental resources, changes in direction and personal views of staff in critical positions. When staff have left, moved on, or gone on extended leave, the program has suffered. This reflects a lack of coordination within and between Queensland Government agencies, and has resulted in a waste of resources. A significant comment from the report referred to “the remarkable dedication and passion and interest by a few of the people that have been involved in it for a long period of time” (Guerrero et al., 2017, p. 24).

In this report, we have considered four subprograms of the recovery effort:

Subprogram one: Research, recovery coordination and recovery planning (section 3)

- Research and monitoring
- Coordination and partnerships
- Recovery plans
- Community education and support

Subprogram two: Protection of the wild population at Taunton (Section 3.3.1)

Subprogram three: Captive breeding and translocations (Section 5)

- Captive breeding and captive populations
- Translocation and management of population at Idalia NP (Section 5.2.1)
- Translocation and management of population at Avocet NR (Section 5.5)
- Translocation and management of population at Scotia Reserve (Section 5.4)

Subprogram four: Additional land acquisitions and community corridors in the Brigalow Belt

- Acquisition of further lands
- Working with landholders

3. Subprogram one: Research, recovery coordination and planning

3.1 Research and monitoring

Planning and recovery actions for the bridled nailtail wallaby began immediately upon its rediscovery, with the Fauna Conservation Branch of the Queensland Department of Primary Industries, and subsequently the Queensland National Parks and Wildlife Service (formed in 1975) taking a lead role through research and population monitoring.

The first research efforts were to determine the numbers and distribution of the species in and around Taunton. Within limited resources available, research focussed on seeking local knowledge of the wallabies rather than on systematic searches of the region (Gordon and Lawrie, 1980). A survey was conducted of possible reports and habitats in the region, which found that all reliable sightings were within 10km of Taunton (Figure 5). Only half a dozen live specimens were captured by QNPWS between 1973 and 1976 (Gordon, 1976).

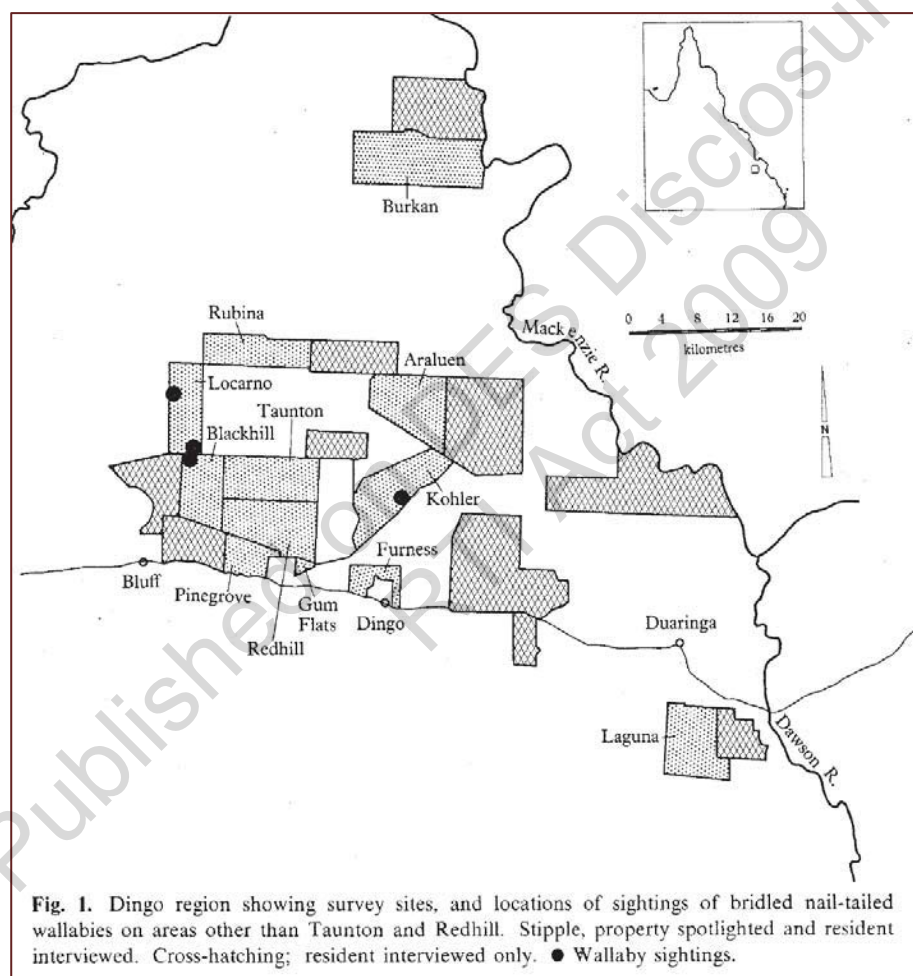


Figure 5: Search sites for the bridled nailtail wallaby after its rediscovery.

Source: Gordon and Lawrie 1980

The researchers' first recommendation was the purchase of Taunton (see Section 4), due to the immediate threat of clearing of the remainder of the property. At this time the Brigalow Scheme was in action and huge swathes of vegetation were being cleared with encouragement from the government.

The next phase of research examined the general ecology and habitat requirements of bridled naitail wallabies on Taunton (Tierney, 1985). The first interim management guidelines for the species included recommendations that research should be conducted into the food, habitat requirements and general field biology of the species (Gordon and Wilkinson, 1979). It was also recommended that field trials investigate effects of cattle and fire. Important early field studies included investigation of diet, competition and home ranges (Evans, 1992, Ellis et al., 1992, Dawson et al., 1992); studies into distribution, density and breeding and maternal behaviour (Fisher, 1999, Fisher et al., 2001, Fisher and Goldizen, 2001, Fisher, 2000); and mating and reproductive strategies (Sigg et al., 2005). It was also recommended early on that the health of wallabies be monitored (Evans, 1992), and studies were conducted on parasites (Turni and Smales, 2001). Reproduction was also studied in captive animals (Johnson, 1997).

A strategic framework for research was presented in 1992, which included assessment of translocation sites, population census on Taunton, and surveys in the Taunton area (Cameron, 2005). Research projects listed in 1993 included translocation to Idalia NP (population modelling and genetics, site preparation and predator management) and issues at Taunton (habitat, competitive interactions, predator-prey relationships and demography) and off-reserve dispersal.

A greater focus on reintroductions and translocations became a feature of research as there were attempts to establish new populations. Modelling was undertaken to predict the effect of predators (McCallum et al., 2001) and researchers followed processes, successes and issues with the translocations to Idalia (Pople et al., 2001, DeLisle, 1997, Nixon, 2015), Avocet (Kingsley et al., 2012, Elphinstone, 2014) and Scotia (Hayward et al., 2012, Moore et al., 2015). Research was also conducted into the genetic makeup of the founder and translocated populations (Sigg, 2005, Seddon, 2008).

Research priorities listed in the 2005 recovery plan (Lundie-Jenkins and Lowry, 2005) were:

- Collation and interpretation of existing research findings to provide specific management recommendations
- Identification of key habitat and resource requirements
 - Identification, mapping and modelling of critical habitat
 - Developing practical tools for assessing the suitability and appropriate management of remnant habitats
 - Characterisation and restoration of habitat for the bridled naitail wallaby
- Monitoring and experimental management of buffel grass on Taunton National Park (Scientific)
- Dynamics and management of introduced predator populations
 - Population dynamics of introduced predators and its implications for survival and management of bridled naitail wallabies
- Biology
 - Diet and nutritional requirements of bridled naitail wallabies introduced to different environments
- Socio-economic investigations to support management
 - Factors/psychology influencing land management decisions
 - Incorporating Aboriginal and historical European knowledge to effectively manage the bridled naitail wallaby
 - Identifying appropriate/adequate incentives to encourage habitat retention

A meeting about bridled naitail wallabies in 2008 identified that there was a lack of monitoring and assessment in the management activities such as pest control at Taunton (Melzer, 2008).

QPWS staff developed an approach where monitoring and evaluation became a routine component of management, and over the last decade many reports demonstrate management directions and the effectiveness of different activities. These have been summarised with clear justification and assessments of outcomes as well as processes (Melzer, 2015a, Melzer et al., 2009) – an approach that is often espoused but rarely delivered in protected areas. For example, the effects of cattle grazing and of predator control have been monitored and a clear adaptive management approach adopted (Melzer et al., 2015, Augusteyn and Hemson, 2015). In addition, QPWS has prepared a guide and protocols relating to research at Taunton (Melzer, 2015b).

At Scotia, AWC monitor the population of bridled naitail wallabies. They perform an annual review of program outcomes and have a clear feedback loop to management. Research is also being undertaken into the differences in vegetation between inside and outside the predator-proof fence (J. Kanowski personal communication, 2018) and a recently submitted paper investigates habitat utilisation by bridled naitail wallabies and other reintroduced species (Berry et al., in review).

Research priorities for the bridled naitail wallaby listed in the 2016 conservation advice (Threatened Species Scientific Committee, 2016) are:

- *Investigate the effectiveness and cost-benefits of intensive predator control at a local and regional scale.*
- *Assess effectiveness and cost-benefits of methods for controlling invasive weeds.*
- *Assess options for increasing the area of suitable habitat at sites with bridled naitail wallaby subpopulations.*
- *Develop a long-term (e.g. 10–20 years) translocation plan for the species that includes consideration of the genetic diversity contained within the existing subpopulations.*
- *Investigate options for linking and enhancing current subpopulations.*
- *Assess the effectiveness and cost-benefits of supplementary feeding of unfenced subpopulations during low rainfall periods.*

3.1.1 Population census

A seemingly basic but essential component of research and monitoring is regular population census: as Evans (1992, p.109) wrote: *'Monitoring of macropod populations, particularly of bridled naitail and black-striped wallabies, is a crucial part of the future management strategy on Taunton. By monitoring population levels, the "health" of the bridled naitail population can be followed and the effects of management activities assessed. A relative increase or decrease in the use of certain habitats may indicate changing habitat suitability, whilst an overall decline in populations (over and above that expected due to environmental fluctuations) is an alarm signal for a more serious problem.'*

As the bridled naitail wallaby is a shy animal and hides in dense undergrowth during the day, population counts are not straightforward. A number of research projects and adaptive management programs have compared the range of methods used for population census (Tierney, 1985, Evans, 1992, Nixon, 2015, Fisher, 2000), and more recent reviews (Melzer, 2015a, Augusteyn and Hemson, 2015) include methods using new technology that were not available to early researchers. Techniques that have been used and evaluated are summarised in Table 3.

Table 3: Census techniques used for bridled naitail wallabies

Technique	Comment	Current use
Walking spotlights	In the early times at Taunton, this technique was used in the part of the park most occupied by bridled naitail wallabies (Tierney, 1985)	
Spotlighting from vehicles	This became difficult at Taunton at times due to dense, tall buffel grass but remains a primary technique. When covering a large area, stratified sampling techniques are used Spotlighting with thermal imaging cameras	Annual spotlights conducted at Taunton– to be used as primary technique from 2018
Spotlighting with thermal imagery	Enables better detection at greater distances or where there is denser grass cover	Used at Taunton
Capture-mark-recapture and capture-mark-resight	Resource-intensive (requires pre-feeding) and intrusive may alter animals' behaviour Provides population data and also enables collection of other information including health and breeding status	Has been used at all sites and is undertaken at least annually at Taunton Used annually at Avocet
Scats counts	Considered but abandoned due to time-consuming nature	Not used
Camera traps	Non-intrusive; collect information on all species including predator activity; less resource-intensive than other methods and can be used over wide area	Used at all sites – parkwide grid at Taunton
Hair sampling	Resource intensive and expensive; can be used over wide area and provides accurate data including possible DNA analysis	Recommended as part of an overall strategy (Melzer 2015)
DNA sampling	Enables accurate studies of population structure and genetic analysis	Important as part of the management of the meta-population (Weeks 2018) – has been conducted across all populations
Radio tracking	Can provide information about home ranges, movement and fate of animals including those released into the wild or new sites	Used for special research studies and to monitor releases and establishment of new populations

3.1.2 Genetic research

Three reports on genetics of the bridled nailtail wallaby have been compiled (Seddon, 2008, Pacioni and Armstrong, 2013, Sigg, 2006), and the results of this and other research have been used to develop a genetic management plan for the species (Weeks, 2018). The results of these studies are summarised in Table 4. Unfortunately, the most recent investigation into genetics was not able to be used due to doubts about the veracity of specimens and processing (Weeks, 2018).

Table 4: Genetic makeup

Compiled from information in Weeks (2018), Seddon (2008), Sigg (2005) and Pacioni and Armstrong (2013)

	2017 population	No. founders	Ho Observed heterozygosity	Allelic richness	Number of 'private' alleles	
Taunton NP (Scientific) Surrounding area and immediate surrounds	500 - 600	n/a	.794(n=100) ^S .758 (n=39) ^{Se} .760 (n=27) ^P	7.21 ^S 7.3 ^P	2.57 ^S 3 ^{Se} 2.1 ^P	
Idalia	0 – 10?	16	.795 (n=167) ^S .764 (n=15) ^P	6.3 ^S 5.8 ^P	1 ^S .6	
Avocet	100 ³	7	.736 (n=39) ^S .762 (n=11) ^P	4.9 ^P	0 ^{Se} .5	
Scotia	1720 ⁴	12	.706 (n=17) ^S .702 (n=29) ^P	4.2 ^P	0 ^{Se} .1	
Captive breeding	30	10-15	.769 (n=29) ^{Se} Kial .731 (n=42) ^{Se} Fleays	n/a	n/a	

Genetic research is critical for decision-making in relation to captive breeding and translocations, and for management of the entire bridled nailtail wallaby metapopulation.

3.1.3 Assessment of research and monitoring

Inputs of finances and human resources into research have been variable. Much of the input has been through student (mostly post-graduate) labour and external sources, meaning that any contribution from governments and other management agencies generates value with a high multiplier effect. The provision of on-ground support such as accommodation, transport, research permits and field assistance can make research more possible, and sites including Taunton and Idalia have been able to provide good bases for students.

Within the QPWS and Threatened Species Program, focus on research has decreased over the years and research is no longer part of the organisational mandate, though monitoring and adaptive management is fully endorsed. The ability to support external researchers and to interpret and use their information is thus critical, and it should be noted that this support requires medium to long-term commitment. In contrast, the conservancies in Australia have an active commitment to research to support their operations.

³ Op cit

⁴ L. Kemp cited by Weeks (2018)

Research **processes** have been generally effective, but this has been variable. Until the mid-2000s, research priorities and projects were guided by the recovery teams and there was generally good cooperation evident between researchers and managers, though a few issues arose⁵. It is inevitable that at times there will be differing priorities of academic institutions, post-graduate students on tight deadlines, and management agencies, and these different needs can create some tensions. From the mid-2000s there was a decline in this cooperation and research has been conducted more on an agency or location-specific basis. The 2005 recovery plan states that 'Research proposals relating to the bridled naitail wallaby will be reviewed by the recovery team' (Lundie-Jenkins and Lowry, 2005, p. 20), but as the recovery team was then disbanded, such reviews did not occur. The 2016 conservation advice priorities for research gave some guidance, but most of these topics are perhaps well enough known to need little more information.

Over time the ability to conduct population census and to monitor both bridled naitail wallabies and other species, such as predators, has greatly improved. In addition, the ability to conduct genetic studies to aid in decision-making has developed. The commitment to an adaptive management approach and to regular evaluations of progress is another major advance and is leading to more objective and science-based decision-making.

Research **outputs** have been effective and relevant. From the time of its rediscovery, concerted efforts have been made to understand its biology, distribution, habitat and food requirements, and population dynamics. Threats especially from predators, parasites and drought were also studied. The shift in research focus from basic understanding of the species to research relevant to translocations was useful and important in guiding future actions.

Many papers and theses have been published on the bridled naitail wallaby, however more information, including reports, could be provided and communicated to the public (for example through the DES and other partners' websites).

The **outcome** of the research into the bridled naitail wallaby is a highly effective contribution to the species recovery, providing applicable and useful results for management. An additional positive outcome is that many people, including emerging scientists, have learned and developed through their involvement with bridled naitail wallaby research. A primary weakness over the past ten years is that available information from research in relation to the genetic makeup of populations was not better utilised to make decisions about captive breeding and translocations.

3.2 Coordination and partnerships

After meetings of a scientific advisory group in 1992, the Bridled Naitail Wallaby Recovery Team was formed in March 1993 to develop, guide and implement the recovery plan, and the group first met in April 1994 (Cameron, 2005). The group was very active during the 1990s and the early 2000s in driving and monitoring translocations and research. A recovery team report in August 2001 notes the maintenance of a 'large but effective recovery team' as an achievement. However, the recovery team was disbanded in the mid-2000s. It was reconvened as the Bridled Naitail Recovery Group in 2012 and is meeting every six months.

⁵ Information from DES files include some cases of conflicts and difficulties, which will not be discussed in detail.

The recovery group meetings are chaired by a Queensland Government officer from the threatened species program. The 2013 Terms of Reference states the function of the recovery group as follows:

“The primary function of the Bridled Nailtail Wallaby Recovery Group is to review and coordinate implementation of the Bridled Nailtail Wallaby Recovery Plan. To achieve this, the Bridled Nailtail Wallaby Recovery Group will:

- Hold regular meetings which will have the primary purpose of sharing information, coordinating implementation activity and reporting to partners on progress and implementation issues, as a means of ensuring effective implementation of the recovery plan.*
- Provide advice to the Department of Environment and Heritage Protection as appropriate about bridled nailtail wallaby conservation issues.*
- Seek funding from relevant sources to support recovery plan objectives and actions; and*
- Undertake an annual review of the implementation of the recovery plan.*
- Will contribute to any future review of the national recovery plan.”* (Lowry and Ryan, 2018)

Partners in the recovery process have changed over the years but have included⁶:

Queensland Government – currently the Department of Environment and Science

- Queensland Parks and Wildlife Service and its various departments: management of Taunton NP (S) and Idalia NP
- Threatened Species Program (TSP) (part DES, NPSR, DERM, EPA, DEH, and others and at times part of QPWS): lead role in the recovery of the species
- Nature refuge branch (also part of various departments and at times part of QPWS).

Members from QPWS and the Threatened Species Program are represented on the recovery group, with the chair of the group from the TSP.

Australian Government – currently Department of Environment

At times, the Australian Government has played a very significant role in supporting the recovery process of the bridled nailtail wallaby. For example, under the Endangered Species program, funding was available for the development and implementation of the Recovery plan, from 1992 to 2003, when Natural Heritage Trust grant funding moved from supporting statutory bodies to community groups through the Natural Resource Management groups. Further changes in the direction of the Australian Department of Environment with respect to the prioritisation and funding of the recovery of threatened species resulted in the development of the 2015 Threatened Species Strategy (Australian Government, 2015).

Twenty priority mammals have been identified for action. Effective and up-to-date recovery plans for all priority species are anticipated by 2020. The bridled nailtail wallaby is not one of these species and therefore may not be a priority for action. However, AWC has been supported in their work in creating safe havens for species, including Scotia.

The Australian Government is not currently represented on the recovery group, but has been invited.

⁶ Information in this section obtained from Melzer(2015), publications held by J.Lowry, and interviews.

NSW Office of Environment

The NSW Government, in partnership with AWC, is involved in the recovery of bridled naitail wallabies through the *Reintroducing locally extinct mammals* project, and is now represented on the recovery group.

Academic institutions

A number of academic institutions have been involved in the bridled naitail wallaby recovery program over time, including through many student thesis projects. Institutions include:

- University of Queensland- extensive involvement including research into the species at Taunton, Idalia, Gregory mine site and Avocet.
- University of Central Queensland- including student work on corridors and conservation agreements
- University of New England
- Queensland University of Technology
- Griffith University
- Arthur Rylah Institute for Environmental Research: a centre for applied ecological research, with an emphasis on flora, fauna and biodiversity issues.
- Threatened Species Research Hub – conducted research into the governance aspect of bridled naitail wallaby recovery.

There are no representatives from academic institutions of the current recovery group.

Australian Wildlife Conservancy

Australian Wildlife Conservancy (AWC) is a private charitable organisation which owns and manages Scotia Wildlife Sanctuary on the New South Wales-South Australian border <http://www.australianwildlife.org/sanctuaries/scotia-sanctuary.aspx>. This includes a large area fenced from predators, which has the largest population of bridled naitail wallabies. Plans in the near future are to re-introduce bridled naitail wallabies in partnership with NSW NPWS, to two further fenced areas within public reserves in NSW: Pilliga forests <http://www.australianwildlife.org/sanctuaries/pilliga.aspx> and Mallee Cliffs national Park <http://www.australianwildlife.org/sanctuaries/mallee-cliffs.aspx>.

AWC is represented on the recovery group.

Bush Heritage Australia

Bush Heritage Australia (BHA) is also a private charitable conservation organisation. It has supported activities at Avocet Nature Refuge, and owns a property (Goonderoo) nearby which is suitable for bridled naitail wallabies. It is hoped that a wild population will become established there. <https://www.bushheritage.org.au/places-we-protect/queensland/goonderoo>

Bush Heritage Australia is not represented on the current recovery group.

Fitzroy Basin Association

From 2012-2017, the Fitzroy Basin Association (FBA) <https://www.fba.org.au/about/about-fba/> received about \$1.5 million in funding from the Australian Government Clean Energy Future Biodiversity Fund to restore habitat and enhance the resilience of the bridled naitail wallaby. The FBA and its delivery partner, Capricornia Catchments, were involved in leading a number of projects including:

1. Overall program – management of funding agreement (govt liaison & reporting) and contractor management (genetics work, QPWS, cat-detection dog, supporting captive breeding, support at Avocet)

2. Off-park corridor and habitat restoration projects, including bridled nailtail wallaby monitoring
3. Off-park predator control projects – 1080 baiting, wild dog and feral cat trapping

Fitzroy Basin Association is represented on the recovery group.

Zoos and wildlife parks

In the 1990s, the Western Plains Zoo was heavily involved as part of the bridled nailtail recovery planning process, and officers were on the recovery team while the zoo played a role in the translocation of the species. No zoos are currently represented on the recovery group.

Volunteers and NGOs

Wildlife Preservation Society of Queensland is a community environmental organisation with branches across Queensland. The Upper Dawson Branch has been actively involved in assisting with the recovery of the bridled nailtail wallaby. Queensland Wildlife Preservation Society <http://wildlife.org.au/big-win-for-small-wallaby-october-2017/> has been involved at Taunton including through fundraising projects.

Wildlife Preservation Society of Queensland is represented on the recovery group

Australian Animals Care & Education Inc. (AACE) <https://www.aace.org.au/> is a private organisation supported by the community, which is dedicated to *rescue and rehabilitation of injured, ill or orphaned native Australian wildlife*. Their facility 'Safe Haven' is 2km south of Mt Larcom in Central Queensland – it was previously situated at Kial near Maryborough. This organisation has played an important role both in captive breeding and in humanitarian/ animal welfare protection for the bridled nailtail wallabies. When a number of other projects failed for various reasons (for example, the translocation programs at Gregory Mine and at Idalia), AACE stepped in to take and rehabilitate animals, and provided a high level of support to the recovery program.

The Captive Breeding Agreement between Safe Haven and the Queensland Government was originally signed in 2008 and expired in 2015. In September 2018, AACE notified that they would no longer breed bridled nailtail wallabies, and there are no longer any held at Safe Haven. The AACE has been represented on the recovery group.

Conservation and Wildlife Management Queensland Division of the Sporting Shooter Association of Australia (SSAA) <http://cwm.ssaqld.org.au/2013/> organises, trains and supervises skilled volunteers to assist with feral animal control programs on Taunton and Avocet.

The SSAA is represented on the recovery group.

Wild Mob is a not-for-profit organisation, which organises volunteers (who pay a fee to be involved) to assist at Avocet Nature Refuge (see Section 5.5). Wild Mob resourced the construction of the nursery there and its volunteers help with its operation <https://wildmob.org/conservation-programs/nailtail-nursery/>. Wild Mob and its volunteers also play a vital role with monitoring, general maintenance and feral animal surveys. A Memorandum of Understanding (2014-2019) articulates the roles and responsibilities of the parties (The Department, Wild Mob and the Avocet landholder).

Concerns have been raised with the consistency of Wild Mob to support the activities at some critical times, due to a lack of volunteers. In this situation, Bush Heritage Australia volunteers have provided support, but this has raised issues with non-paying volunteers working alongside paying volunteers.

Wild Mob is represented on the recovery group.

Landholders in the vicinity of the bridled naitail wallaby populations have also made important contributions, particularly around Taunton and Avocet. A landscape approach to predator control is essential, and landholders close to Taunton are also participating in projects to restore corridors for bridled naitail wallabies.

Hugo Spooner, the landholder from Avocet, has made an outstanding contribution over the past twenty years to the conservation of the bridled naitail wallaby. He is represented on the recovery group.

3.2.1 Assessment of coordination and partnerships

Inputs into coordination and partnership have been very variable. Expectations of all partners are not always clearly articulated and monitored, and resentments arise from self-funded partners when they feel that their financial and time contributions are both excessive and underappreciated. DES files contain a number of letters from key partners, including AACE, Avocet landholder Hugo Spooner, and Western Plains Zoo, indicating a high level of dissatisfaction with the lack of support and the slow responses from the Queensland Government. Much of this dissatisfaction seems to be quite justified. In some cases the amount of money needed to keep actions happening is quite minor, and to partners it seems unreasonable that the government cannot quickly mobilise the small sums involved. However, tight funding and lack of delegation to officer level means that providing even minor sums for essential purchases can be a challenge.

Processes associated with coordination and partnerships is also highly variable. Changes in staffing in the Queensland Government, especially at higher levels, and to a lesser extent in some partner organisations, result in changes in direction and support. For example, interest by universities has waxed and waned, and has often been led by academic interest as much as the recovery requirements of the species. There is a feeling among stakeholders that partnerships have never been in an agreed framework for involvement, with a lack of overarching governance in place. Feedback from some partners suggests that while on-ground relationships with Departmental staff are good, the relationship with more senior staff in central office appears poor. Very long response times to requests over time exacerbate the situation and have resulted in some unfortunate outcomes for the bridled naitail wallaby⁷. It should be noted that at the local level, relationships have generally been very good. All people interviewed had only praise for the efforts of the sole Rockhampton-based threatened species staff member.

Outputs and outcomes have been effective and relevant, although at times sporadic and inconsistent. Partners such as the Fitzroy Basin Association, universities, AACE, AWC, BHA and Wild Mob, and Hugo Spooner from Avocet Nature Refuge, have been instrumental in ensuring the long-term survival of the species. However, relationships with partners has been driven by personalities in many cases, and the outcomes from partnerships have often not been well

⁷ Death of bridled naitail wallabies at Western Plains Zoo after AACE had constructed 40 quarantine pens for them while there were discussions about who would pay for transport to the AACE sanctuary appears to be an example, as referenced by letter from AACE to Minister Steven Miles, December 2016.

documented. On reviewing the evidence, it appears that much better outcomes could have been achieved, both in terms of the bridled naitail wallaby and social capital (cooperation, trust and goodwill), if relationships had been handled better by senior staff.

3.3 Recovery plans

Recovery plans have guided actions in relation to the bridled naitail wallaby since the first plan was drafted in 1979 (for example, Gordon and Wilkinson, 1979, Davidson, 1991, University of Queensland and the Queensland Department of Environment and Heritage, 1993, Lundie-Jenkins, 1999), though not all actions have been fully implemented. The most recent recovery plan, approved in 2005 (Lundie-Jenkins and Lowry, 2005), was only current until 2009, and the time since then has been characterised by a lack of coordination and cooperation, though the situation has improved more recently since the renewal of the recovery group in 2012.

Other plans relevant to the recovery effort are the management plans for Taunton (DERM, 2011, QPWS, 1988) and Idalia (Queensland Department of Environment and Heritage, 1998) and plans for other translocation sites (Australian Wildlife Conservancy on behalf of NSW National Parks and Wildlife Service, 2018).

As well as matters relating to coordination and research, the three primary strategies for species recovery have remained similar since 1992 (1992 Workshop recommendations – conservation of the bridled naitail wallaby, cited by Cameron, 2005):

- “1. Manage Taunton to ensure the persistent stable population of BNWs and develop an increased understanding of the ecology and biology of the wallaby to aid in their recovery.*
- 2. Facilitate dispersal of BNWs from Taunton to adjacent potential habitats.*
- 3. Establish self-sustaining populations in suitable habitat geographically distant from Taunton.”*

3.3.1 Assessment of recovery planning

Recovery plans dating back to the late 1970s have carried consistent themes and messages, with only slight variations as the community gained better understanding of the biology, population dynamics of the bridled naitail wallaby and of the threats that it faces.

The recovery plans have provided good guidance and *when backed up by functioning recovery team, funding for implementation, institutional support and enthusiastic individuals*, they have helped to set excellent standards for species recovery work. This was most evident when the Australian Government in partnership with QPWS supported recovery planning and the implementation of actions, and when regular reporting on the implementation was required⁸.

The most recent recovery plan of 2005-2009 (Lundie-Jenkins and Lowry, 2005) is a strong, well-written and comprehensive document, but the disbandment of the recovery team, change of focus within the Threatened Species Program, separation of land managers from Threatened Species Program and lack of commitment and funding for its implementation meant that it has been less effective. The lack of review and renewal since 2005 is a weakness in the recovery process.

⁸ File records, for example for the period 1989-1992

While the recovery plan stressed the importance of additional sites for translocation, only minor mentions were made of Scotia: at the time there were a number of other active captive populations and proposals, and AWC had only recently taken over the sanctuary. The importance of the Scotia population was not then recognised, and the lack of a revised recovery plan in subsequent years has meant that this has not been properly integrated into planning for the future of the species.

It is understood from Recovery Group minutes that the development of recovery plans is no longer considered a priority by the Queensland Government. However, the recovery group emphasised the utility of a current recovery plan for a number of reasons:

- better ability to access funds from the Commonwealth,
- basis for decision-making about development proposals within or near habitat,
- guidance for decisions about translocations
- guidance for pest management programs. (Bridled Nailtail Wallaby Recovery Group, 2018)

In our opinion, there is a critical need for a strategic, long-term plan that considers all populations in Queensland and NSW, captive breeding, and translocation of the species.

3.4 Community education and support

The importance of community education in supporting the management of threatened species is demonstrated through the inclusion of education of landholders about threatening processes and the conservation of habitat. Community education has also featured in recovery plans from 1994 onwards (develop conservation agreements, interpretation and public education programs).

The Queensland Government has previously attended field days and undertaken school talks to promote community awareness of the bridled nailtail wallabies, but these activities have been severely curtailed through lack of funding and staff availability. For example, Community Nature Conservation initiatives which had been successfully developed and implemented were significantly scaled down in line with reduced budget allocations in 1999-2000, and this section of the government became focussed only on nature refuges.

Non-government organisations such Queensland Wildlife Preservation Society, Bush Heritage Australia, Australian Wildlife Conservancy and Wild Mob undertake community education programs through their members and webpages. The Fitzroy Basin Association provided community engagement through the provision of fencing and corridors through private land adjacent to Taunton.

David Fleay Wildlife Park has bridled nailtail wallabies on display for educational purposes. Bridled nailtail wallabies at zoos (such as the Western Plains Zoo, Rockhampton City Zoo) Australian Walkabout Park (formerly Calga Springs), Gosford and Waterfall Springs Wildlife Sanctuary in Kulnura NSW and at sanctuaries (Genaren Sanctuary) also displayed animals for educational purposes. However, none of these facilities now have bridled nailtail wallabies.

3.4.1 Assessment of community education

Community education is assessed as being only partially effective as there is a lack of coordinated effort and no funding for a strategic program. Most community education is undertaken by non-government organisations, and so is at least partly from the perspective of promoting the organisation concerned. Overall, promotion of the bridled nailtail wallaby as an iconic threatened species in need of community support is poor.

4. Subprogram two: Protection of wild population - Taunton

Taunton National Park (Scientific)⁹ is the refuge where most of the remnant population of bridled nailtail wallabies was found in 1973. The park and its surroundings remain the only known location of wild wallabies and contain the most genetically diverse wallaby population. The history of management in Taunton has been compiled by Cameron (2005) and Melzer (2015).

Soon after the bridled nailtail wallaby rediscovery, a physical survey of the district, complemented by gathering of oral and written reports, confirmed that Taunton was the best option for conservation of the species. The Fauna Conservation Branch (which later transitioned to the new Queensland Parks and Wildlife Service) recommended urgent action to acquire the property and reserve it, as the area was at high risk of being completely cleared (Gordon, 1976).

The context in which the remnant population was found was one of dramatic habitat transformation in the Brigalow Belt. Clearing in the Fitzroy Basin (part of the Brigalow Belt Bioregion) occurred in several distinct phases (Yu et al., 2013).

- In the first phase, from settlement until the late 1950s, clearing was localised, though grazing had spread across the catchment area. It was estimated that about 15% had been cleared by 1961 (Fensham and Fairfax, 2003).
- In the second phase from 1961 to 1988 there was systematic and intensive land clearing at about 2.5% per year. Nearly 70% of the basin was cleared over this period.
- In the third phase, another 11% of the Basin was cleared between 1988 and 2009.
- By 2013, nearly 90% of the Basin was cleared.

Taunton was a Brigalow Development Scheme ballot block (5345ha) taken up under the Brigalow and other Lands Development Acts 1962-1967 as a Freeholding Lease in April 1969. Development clearing commenced on Taunton in mid-1972 and by 1979 almost half the block had been cleared and 74% of the cleared area sown with buffel grass (Tierney, 1985). Most of the clearing was by tractors and chains. There was a very high risk of further clearing, which was only stalled because of a lack of dozer contractors and money.

In 1978, the Queensland Government acquired the property with dollar-for-dollar funding support from the Australian Government. Taunton Scientific (Conservation of the Bridled Nail-Tailed Wallaby and its Habitat) Reserve No. 184 (Portion 25, Parish of Walton) was gazetted on 24 March 1979. It was subsequently proclaimed a Fauna Reserve under the *Fauna Conservation Act 1974-1979* in December 1979, and became a National Park (Scientific) in 1994 after the *Nature Conservation Act 1992* came into force (Cameron, 2005).

The need for a larger extent of protected area was recognised, and surveys indicated that a sizable bridled nailtail wallaby colony lived in sections of Red Hill station adjoining the southern boundary of Taunton Scientific Reserve. In 1981 Queensland National Parks and Wildlife Service began actions to acquire parts of Red Hill, and the blocks were purchased in 1984. A land swap of a cleared paddock was used to secure additional brigalow from Duckworth Station. The reasons given for the additional acquisitions were to add to the biodiversity of the original reserve; the need to extend the habitat range for the survival of the bridled nailtail wallaby; and the fact that Red Hill was a critical BNW habitat and 'an exceptional effort is justified to obtain it'. In 1987 two gazetted roads traversing through the reserve were closed and converted to National Park tenure (all information from QPWS files, reported by Cameron 2005)

⁹ Referred to as Taunton in this document except where specifically describing its legal status at a particular time

Taunton's status as a national park (scientific) means that its management is focussed on research and conservation of the species, rather than a broader approach to conservation that includes visitor management and management of multiple values. At Taunton, visitors apart from staff, volunteers and researchers are excluded, and management activities include habitat manipulation and supplementary feeding when needed. In the IUCN protected area categories system Dudley, 2008 #2592, the reserve has been allocated as a Category 1a (strict nature reserve) (Dudley, 2008, Department of the Environment and Energy, 2016). However, given its species focus and scope of management activities, it would be more appropriately allocated as a Category IV (habitat/species management area).

Over time there has been a shift in the population density of bridled naitail wallabies from rosewood and Dawson gum forest (central-west) in the 1970s to eastern side of Taunton between Steel Yards and Bald Hill (Figure 6, Figure 7, Figure 8).

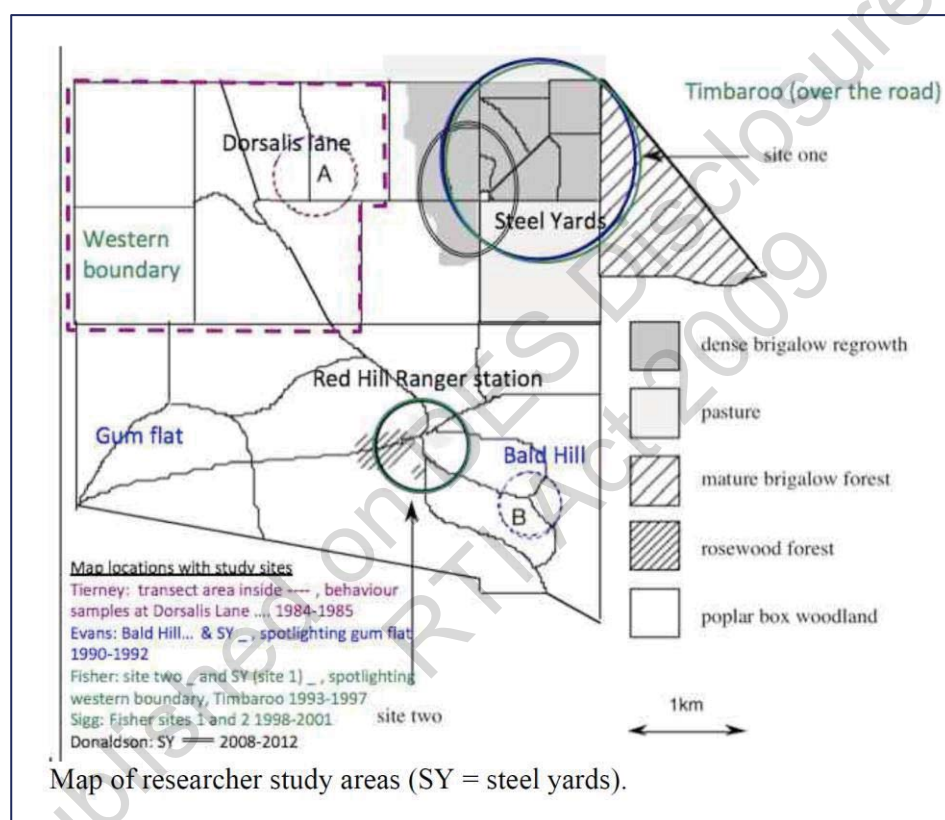


Figure 6: Comparison of population and study sites
 Source: Fisher (no date)

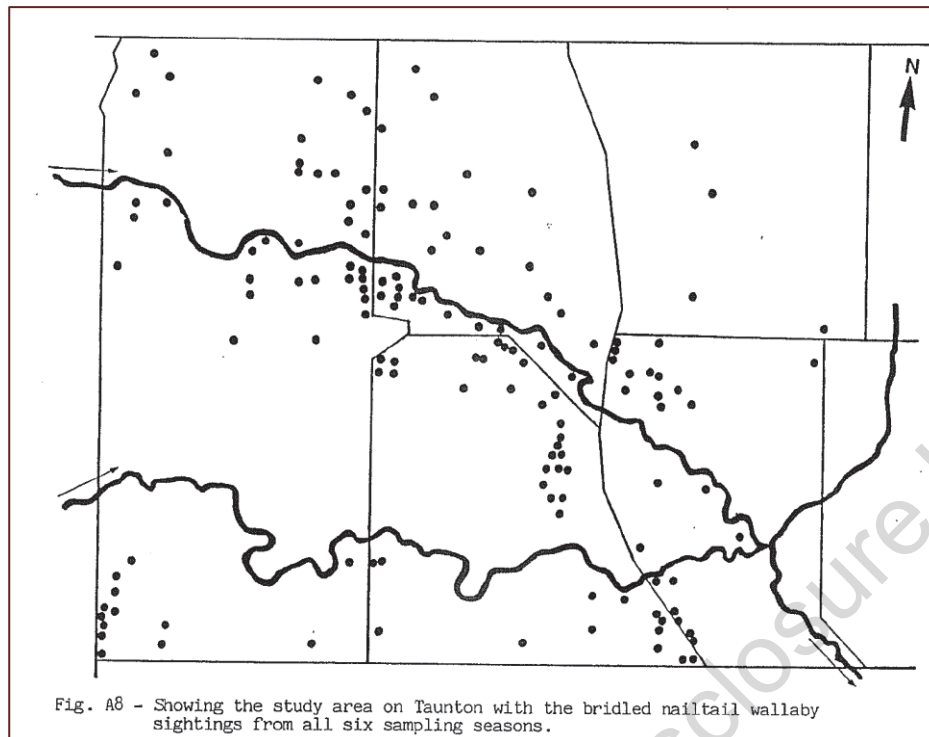


Figure 7: Sightings of bridled naitail wallabies 1981-1982

Source: (Tierney, 1985, p. 246)

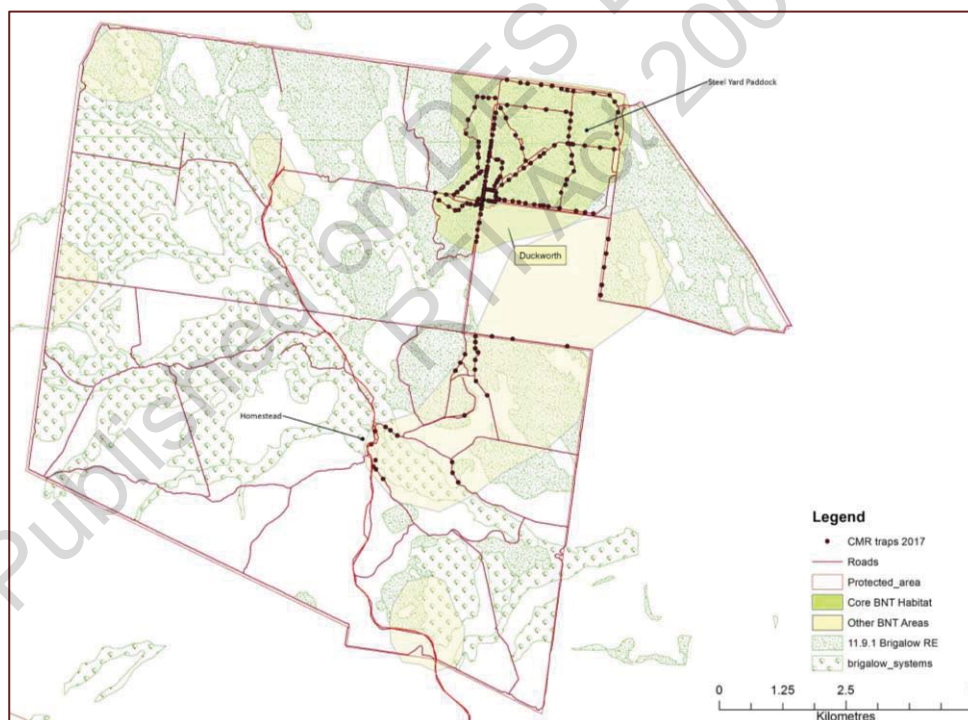


Figure 8: Core habitat areas and capture-mark-recapture sites on Taunton National Park (Scientific) in 2018

Source: Lowry and Ryan (2018)

4.1 Management plans

The first interim management plan for the bridled naitail wallabies dealt mainly with managing Taunton to provide for their survival (Gordon and Wilkinson, 1979). The basic underlying management principle was to 'promote the reversion of vegetation on Taunton to a more natural state'. It also outlined the need for:

- research into food & habitat & general field biology for bridled naitail wallabies.
- field trials to test effect of cattle grazing & fire (or their exclusion) for the regeneration of plant communities on Taunton.
- periodic low-level photography to monitor vegetational changes over time.
- relocation of both captive and wild BNWs.
- actions to restore vegetation to natural condition.
- upgrading of boundary fences & fire breaks.
- elimination of exotic fauna and control on competing native fauna.
- clearing requirements on adjoining leases be excluded where this is BNW habitat.
- closure of road reserves through Taunton to limit unauthorised access.
-

Later management plans for Taunton were produced in 1989, 1996, 1998 and 2011. The current management plan makes it clear that conservation of the bridled naitail wallaby is its primary goal, along with conserving representative samples of the region's ecosystems (DERM, 2011). Desired outcomes focus on a viable and resilient population within the park but also support translocations to other sites, provided this can be done without damaging the viability of the wild population (Table 5).

Table 5: Desired outcomes and actions for Taunton for 2011-2021 (DERM, 2011)

Desired outcomes for 2011-2021	Actions and guidelines
A viable and resilient population of bridled naitail wallabies persists in the park and on adjacent lands	A7. Continue to implement the bridled naitail wallaby recovery plan to guide management of the species and enhance its habitat on Taunton National Park (Scientific). A8. Develop and implement an appropriate monitoring protocol to determine and monitor the abundance and distribution of bridled naitail wallabies over the whole park.
Self-sustaining and expanding wild populations of bridled naitail wallabies exist remotely to Taunton National Park (Scientific).	A9. Further translocation of wallabies from wild population on Taunton National Park (Scientific) should occur only where the viability of the Taunton population is assured.

Key management issues and actions on Taunton in relation to bridled naitail wallabies include the following:

4.2 Grazing

The issue of grazing on Taunton has been a regular point of discussion. Cattle were removed from Taunton and eventually from Red Hill after purchase, and it was considered that allowing intensive cattle grazing throughout the property would be detrimental to the species' survival (Tierney 1994, internal memo recorded by Cameron 2005). A number of requests by local landholders to agist stock on Taunton were rejected, including pleas during drought conditions, when the impact on wallabies through competition would be most likely.

However, the use of grazing as a management tool was proposed, due to the need to reduce the impact of buffel grass. Grazing for this purpose was first trialled in 1981, and is currently regarded as being important in the management of the park (Melzer, 2015a). This grazing is strictly limited to selected areas and its effect is monitored.

4.3 Buffel grass

Buffel grass *Cenchrus ciliaris* is the most serious pest plant issue at Taunton, as in many other protected areas in the Brigalow Belt. It is a serious environmental weed in many parts of Australia due to its tendency to form thick monocultures in the understorey, dominate vegetation, reduce species diversity, and enhance frequent and rapid fires. It is widespread in Taunton where it has spread through cleared and grazed areas and along roads, tracks, and firebreaks, as well as occurring in scattered clumps in otherwise undisturbed vegetation (Melzer et al., 2015). In 2009, it was estimated that buffel grass was the dominant grass species over 50% of the park and common over about 70% of the park (D. Beard personal communication, cited by Melzer (2012)).

Buffel grass is regarded as a major problem for bridled naitail wallabies because:

- the dense swards impede the wallabies' movement, though scattered clumps of buffel grass can provide shelter
- it eliminates other herbaceous species and reduces the available food, especially forbs and palatable grasses
- it increases fire risk and intensity
- it prevents regeneration of brigalow, eremophilas and other vegetation in which the wallabies shelter (Melzer et al., 2015).

Buffel grass and other weeds have been sprayed outside the grazing areas (Melzer et al., 2015).

Since control through cattle grazing was introduced in the northern half of the park in 2012, the growth of buffel grass and the associated fire risk have decreased (Lowry and Ryan, 2018).

4.4 Predator control

4.4.1 Dingoes and wild dogs

There had been some dingo control at Taunton prior to acquisition. Dingoes were not mentioned as a threat in early reports about Taunton, (Gordon and Wilkinson, 1979, Gordon, 1976) but Tierney (1985) records dingoes as predators of bridled naitail wallabies. He suggested that dingoes played a role in culling 'unfit' wallabies (Tierney, 1985). Baiting resumed in 1984, and appears to have been conducted for variable periods after that time. By 1987 reports considered that dingoes were impeding the recovery of bridled naitail wallabies, that they were the main threat to the species, and that dingo control should be a priority for management (Tierney and Strong, 1987).

Dingoes' preferred prey at Taunton were reported to be larger macropods, with bridled naitail wallabies, bettongs, possums and other small mammals comprising less than 20% of their diet (Evans, 1992). In the early 1990s, Evans (1992) did not believe that dingoes constituted a serious threat to the wallaby population, noting that wallaby numbers were stable to increasing during the time that dingo control had been ceased (1989 to 1992). and that they may suppress numbers of cats and foxes as well as reducing the numbers of black-striped wallabies.

Dingo baiting presumably resumed after 1992. It ceased for 18 months in 2007-2008, as the population of wallabies was declining in spite of the baiting and there was concern about whether the baiting was causing mesopredator release (Augusteyn and Hemson, 2015). Baiting resumed in November 2008 after a park management workshop considered the issue (Melzer, 2008). The issue of mesopredator release has not been fully resolved, but one study undertaken at Taunton found no evidence that cats were avoiding areas with dingoes (Wang and Fisher, 2012), though the times of their activity avoided those when dingoes were present. No foxes have appeared at Taunton in spite of the current emphasis on dog control (Augusteyn pers. comm., October 2018)

Dingo/ wild dog control is a regular scheduled activity at Taunton according to set protocols (QPWS, 2016) and is believed to be a major contribution to the increase in bridled nailtail wallabies.

4.4.2 Feral cats

Feral cats have been a significant predator at Taunton and were responsible for a high mortality of young wallabies (Fisher, 1999) – for example by 1996 it was noted that there was 100% mortality of young wallabies in the Red Hill section (Cameron, 2005). High levels of cat activity were thought to be responsible for a marked decline in bridled nailtail wallaby numbers in 2011-2012 (Lowry and Ryan, 2018). Feral cats are a problem through direct mortality and through spread of toxoplasmosis (Section 2.6.8).

The current goal of the cat control program is to reduce cat density in the bridled nailtail wallaby area of occupancy if possible or at least to keep the rate of cat turnover in that area high enough to minimise the probability of cats being able to specialise on BNTs as prey. (Augusteyn and Hemson, 2015)

The possibility of a 'nursery pen' at Taunton to protect females with young (see Section 5.5 for information about the facility at Avocet) has been raised and the concept has been supported by the bridled nailtail wallaby Recovery Group (Melzer, 2015a). However, it is considered more effective to maintain good predator control than to establish a nursery (R. Melzer pers. comm. 2018).

4.4.3 Enhanced predator control

'Pulse' baiting to coincide with major periods of dingo activity began in 2008 and had resulted in a decline in dog numbers by 2010 (Augusteyn et al., 2010). Enhanced predator control implemented at Taunton between 2013 and 2018 has led to a continued decline in dog activity, though cats increased during the good seasons of 2012 (Figure 9). The decline in predators is thought to be the major cause of a substantial increase in bridled nailtail wallaby numbers, including those of the more vulnerable weight range (Lowry and Ryan, 2018). Current activities include regular shooting by park staff and members of the Sporting Shooters Association, trapping and baiting (Lowry and Ryan, 2018). These activities have all been carefully monitored and reported upon through the adaptive management program (for example, Melzer, 2015a, Augusteyn and Hemson, 2015).

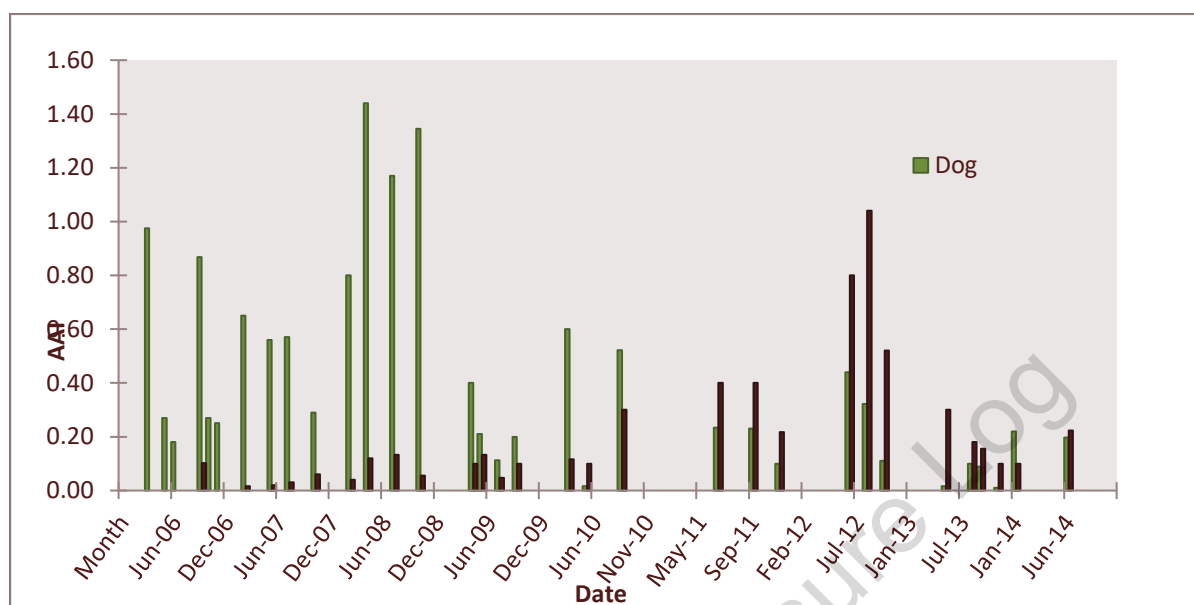


Figure 9: Dog and cat activity index at Taunton, 2006-2014

Source: (Augusteyn and Hemson, 2015)

4.5 Habitat manipulation

Bridled nailtail wallabies require dense undergrowth for shelter, and forb and grass species for food as well as browse shrubs. As they utilise the ecotone between brigalow and open country, it was recommended that a patchwork of brigalow regrowth and grassy open country was needed – but avoiding linear strips that are favoured as corridors by dingoes (Evans, 1992). Maximising habitat condition by promoting fodder species and brigalow regrowth has been a key strategy to increase and sustain the bridled nailtail wallaby population since the early 1990s. It was argued that habitat improvement trials should be conducted ‘in order to find the right percentage and type of shelter and feed which promotes greatest nail-tail numbers while minimising black-stripes’ (internal QPWS memorandum, cited by Cameron 2005). At that time 27 feed strips were trialled with different treatments aimed at promoting fodder growth. The process and results of this habitat manipulation were not well documented.

Some of these strips are now naturally regenerating with dense brigalow regrowth, and little or no buffel grass is present (Lowry and Ryan, 2018). A range of techniques, including herbicides and grazing, are being trialled to reduce buffel grass dominance and encourage the forbs and succulents favoured by the wallabies, particularly over the winter months (DERM, 2011, Melzer et al., 2015, Melzer, 2012).

This kind of manipulation would not normally be conducted on a national park, but is permissible on the national park (scientific).

4.6 Drought feeding

During times of prolonged drought, supplementary feeding is undertaken according to a documented protocol, usually with lucerne (Melzer, 2015a) and sweet potato (Lowry and Ryan, 2018). This drought feeding has been occurring when needed since about 1994 (Cameron 2005), after heavy mortality was observed in 1993 (L. Pitt quoted in Cameron 2005). Supplementary feeding has been identified as critical to the survival of the species in drought. About 40 feeding stations have been set up: these exclude larger macropods and pigs (Lowry and Ryan, 2018). Health assessments are carried out. Bridled nailtail wallabies also have access to water.

4.7 Population trends

Initial surveys in 1974 showed low population numbers, with a maximum of seven individuals sighted at Taunton and nine at Red Hill (Figure 10).

Month	Area	No. of sightings	No. of trips	Month	Area	No. of sightings	No. of trips
April	Taunton	4	1	June	Blackhill	1	1
May	Alsace Rd	0	1		Kohler	2	1
	Burkan	0	1	July	Taunton	7	1
	Rubina	0	1		Furness	0	1
	Locarno	2	1		Kohler	1	1
June	Araluen	0	2		Redhill	9	1
				August	Laguna	0	1

Figure 10: Sighting of bridled naitail wallabies in the Dingo region, April to August 1994

Source: (Gordon and Lawrie, 1980), p. 343

The population of bridled naitail wallabies has fluctuated since their rediscovery, with initial good recovery, followed by serious declines in the drought of the early to mid 1990s and further declines from 2005 to very low numbers in 2007, followed by recovery since that time. Before 2007, detailed figures are not available, and a variety of census methods were used. An overview is provided in Table 6, while the graph in Figure 11 provides more detailed estimates for the period 1992-1998.

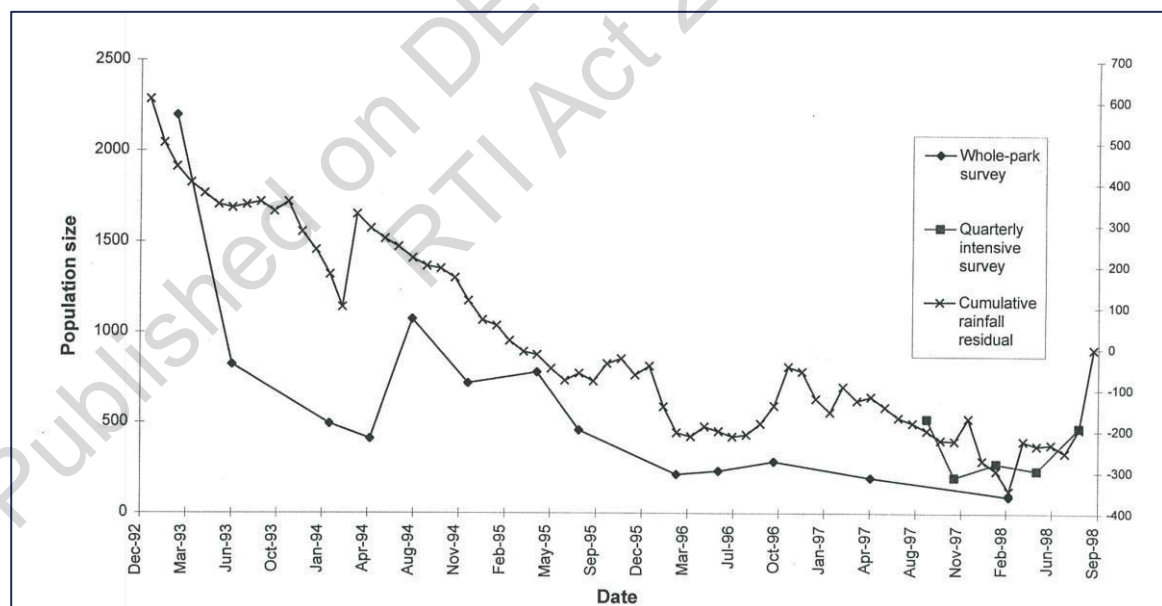


Figure 11: Population estimates of bridled naitail wallabies at Taunton, 1992-1998

Source: (Lundie-Jenkins et al., 1998)

Table 6: Population estimates pre-2007, Taunton

Time	Population estimate	Source	Note
1970s	16 animals sighted	Gordon and Lawrie 1980	This is not a population estimate – just the number seen
1985	136	Tierney 1985, p.77	
1991	1430	Evans 1992	
1994	400	Bridled Nailtail Wallaby Recovery Team	Severe drought 1992
1996	'critically low'	Bridled Nailtail Wallaby Recovery Team	
1996	200	Fisher (Fisher, 1999)	
1998	400- 600	Minutes - Bridled Nailtail Wallaby Recovery Team Meeting (26 March 1996), Rockhampton.	
2005	400	Lundie-Jenkins and Lowrie (2005)	Comment that numbers have remained 'relatively stable' since 1994

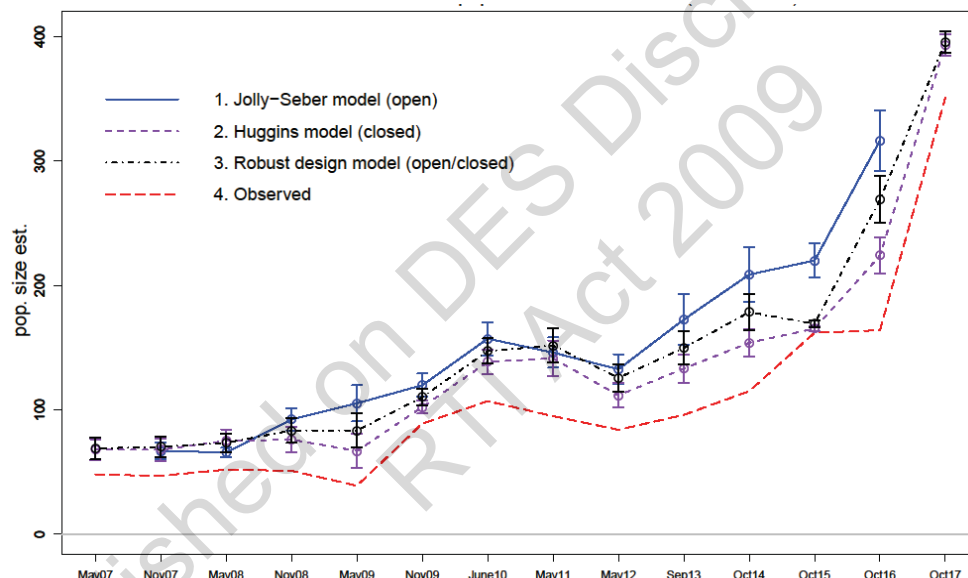


Figure 12: Population trends for bridled nailtail wallabies at Taunton, 2007-2017

Source: QPWS data cited in Lowry and Ryan, 2018.

The population in the 'core' area was estimated to be 392 in October 2017, and the total population about 500-600 if animals in neighbouring properties are included (Lowry and Ryan, 2018). An issue with population growth appears to be reluctance of animals to naturally disperse into seemingly suitable habitat in other parts of the park, even when population pressure on resources in the core area is obvious (Fisher, no date), B.Harris pers. comm., 2018).

4.8 Assessment of the conservation of Taunton NP (Scientific)

As a Government protected area set aside specifically for the conservation of bridled nailtail wallabies, Taunton has had consistent **inputs** in terms of basic staffing and facilities, though these have been basic and at times clearly inadequate. Resources have been more adequate in the last 5-6 years, mostly due to Australian Government funding and the partnership with FBA, The intensive program of predator control from 2012-2018 appears to have been instrumental

in reducing predator pressure and facilitating recovery of the species from the low population levels of 2007-2009. Consistency of inputs is vital if this improvement is to be maintained.

Planning for the protected area has been sound and well in line with recovery planning.

Processes resulting in the initial acquisition, gazettal and management of Taunton demonstrate the ability of the Queensland Government at the time to act rapidly to secure the population's last threshold. This was driven by a few passionate individuals and was absolutely critical in the survival of bridled naitail wallabies. Processes of management since then have demonstrated a lot of innovation and initiative, though at times clear documentation has been lacking. In the past there was at times a lack of monitoring of these initiatives, and poor feedback between actions, effects and revised actions: this situation has been remedied through the adaptive management process now adopted (Melzer, 2015a) and clear documentation of procedures (QPWS, 2016). Currently, processes of predator control, habitat management, drought feeding and population monitoring appear sound. There also needs to be expert consideration and rapid response to population trends, for example consideration of how to act when populations in the existing occupied area become too high for the available resources. Close cooperation within DES including park staff, district staff, ecosystem management unit and the threatened species program is essential .

Outcomes at Taunton have varied from poor to excellent. For at least two periods over the past 30 years, seasonal influences and predators have threatened to reduce the population to a level below viability. However, outcomes now appear to be reasonably sound, with a healthy increasing population. Continual effort will be essential to maintain this situation.

5. Subprogram three: Captive breeding and translocations

5.1 Introduction and approach

The 2005 recovery plan spells out the need for a **coordinated captive breeding program** to:

1. *Maintain a genetically viable and demographically stable population of captive bridled nailtail wallabies (and maintain a well-documented studbook for the species) to ensure conservation of this unique species in the event that some catastrophe should befall wild populations;*
 2. *Provide genetically diverse captive-bred animals, of known ancestry, as founder stock for reintroductions to secure and/or managed habitats;*
 3. *Provide captive stock, which can be utilised for specific research to aid in the management of this threatened species, including research into important aspects of the species' biology and ecology (nutrition, reproduction and threatening processes);*
- Captive populations may also be displayed to promote awareness of the species as well as the importance of biodiversity and threatening processes; and help to generate funds for in situ conservation of the species. (Lundie-Jenkins and Lowry, 2005).*

A draft captive breeding management had been drawn up, and the Queensland Government (EPA) and Western Plains Zoo were to coordinate the process. The importance of genetic management of the meta-population was stressed.

The need to establish additional populations of bridled nailtail wallabies through **translocation** has long been recognised when planning for the species' conservation (for example, Evans, 1992, Tierney, 1986). Recovery plans have all supported the need for translocation efforts, which have been undertaken since the early 1990s with varying degrees of success. The 2005 recovery plan states that translocation is a 'necessary conservation measure', and the recovery criteria require two or more additional populations to be established by 2009, preferably two in New South Wales and one on private land.

...Since each small population is at risk from chance environmental factors, the long-term survival for the species necessarily relies on not 'placing all the eggs in one basket'. The second populations must be geographically remote to avoid localised effects such as drought and wildfire, and to prevent the spread of disease between populations. The establishment of a second population is viewed as the single most important step in reducing the threat of extinction to the species (Evans, 1992)

Four types of translocation for conservation are recognised by the IUCN (Table 7). Translocation efforts for the bridled nailtail wallaby according to this typology have been *reintroductions* to within its former range and *assisted colonisations* to just outside its former range.

Table 7: IUCN typology of conservation translocation

Source: (IUCN, 2015)

Conservation translocation is the intentional movement and release of a living organism where the primary objective is a conservation benefit		
Population restoration is any conservation translocation to within indigenous range	<i>Reinforcement is the intentional movement and release of an organism into an existing population of conspecifics. Reinforcement aims to enhance population viability, for instance by increasing population size, by increasing genetic diversity, or by increasing the representation of specific demographic groups or stages.</i>	<i>Reintroduction is the intentional movement and release of an organism inside its indigenous range from which it has disappeared. Reintroduction aims to re-establish a viable population of the focal species within its indigenous range.</i>
Conservation introduction is the intentional movement and release of an organism outside its indigenous range	<i>Assisted colonisation is intentional movement and release of an organism outside its indigenous range to avoid extinction of populations of the focal species.</i>	<i>Ecological replacement is the intentional movement and release of an organism outside its indigenous range to perform a specific ecological function</i>

Genetic management of the metapopulation was also recognised as critical in the 2005 recovery plan and it was recommended that good generic management be the basis of all captive breeding and translocation efforts (Lundie-Jenkins and Lowry, 2005).

5.2 Captive breeding and captive populations

5.2.1 QPWS facilities

Pallarenda: The first recorded captive breeding of the species was undertaken at Pallarenda Research Station at Townsville, where a colony was established in 1991. This population was the basis for research (Johnson, 1997) and has provided animals for establishment of both further captive populations and of wild populations. The colony was disbanded in 2004.

David Fleay Wildlife Park: David Fleay Wildlife Park is an educational and animal-breeding facility, owned and managed by QPWS at Burleigh Heads on the Gold Coast. The 2005 recovery plan lists 35 individuals held there (though an internal memo discusses the problem of holding 70 individuals after very successful breeding), and in 2008, samples were taken from 42 individuals (Seddon, 2008). In 2018, only four males and five females were held at the facility. This population is considered as an educational display population and it is unlikely these animals will participate in breeding for translocations and improving genetics (Lowry and Ryan, 2018). Previous attempts to breed bridled naitail wallabies here had mixed success. At times there were problems due to unsuitable conditions, including a hard surface (E Rush personal communication, 2018).

Others: QPWS maintained a small population of bridled naitail wallabies at Charleville QPWS office from 1993 to 2001. The population is thought to have derived from five bridled naitail wallabies. All Charleville bridled naitail wallabies were transferred to other facilities in 2001.

Four bridled naitail wallabies were kept at Warwick Hermitage until 1993, when it is thought foxes ate them. A small number of wallabies were also kept at the Moggill office.

5.2.2 University of Queensland – Gatton Campus

Animals were transferred from David Fleay Wildlife Park to the Gatton Campus of the University of Queensland and were successfully breeding. In April 2018, the university advised that they no longer hold any bridled naitail wallabies (Lowry and Ryan 2018).

5.2.3 Western Plains Zoo

In 1992, a small population of bridled naitail wallabies was sent to Western Plains Zoo at Dubbo, and further animals were later sent from Pallarenda in 1995 and 1996, following the initial death of eight wallabies. The animals were successfully bred and were released into a 130ha fenced enclosure. While there was a close partnership between the zoo and other partners in the recovery team, the relationship deteriorated and in 2007 the zoo advised that they no longer wished to maintain the bridled naitail wallaby population. The fenced enclosure had been compromised and many bridled naitail wallabies had been predated or died during drought, despite supplementary feeding. The 110ha enclosure has recently been improved to make it predator proof for the introduction of bilbies in 2018 and Wildlife Plains Zoo has expressed interest in breeding bridled naitail wallabies in the future.

5.2.4 Other zoos and wildlife areas

In the early 2000s, small numbers of bridled naitail wallabies (all from captive stock) were kept at Rockhampton City Zoo, Australian Walkabout Park (formerly Calga Springs), Gosford and Waterfall Springs Wildlife Sanctuary in Kulnura NSW. All these animals have since died.

Bridled naitail wallabies were translocated from Pallarenda to Western Plains Zoo in 1995 and 1996. Following the initial death of eight wallabies, the translocation was successful, with expectations of the wallabies being released into a large predator proof enclosure. The breeding program and exhibits were closed down in 2007, with eight animals returned to David Fleay Wildlife Park.

The breeding program at Rockhampton Zoo also ceased in 2004.

Genaren Sanctuary, which held a number of captive-bred translocated wallabies in semi free range predator-free enclosures in 1999, closed down following a change in sanctuary ownership. There was a breach in the enclosure and all bridled naitail wallabies were killed.

5.2.5 Gregory Mine

In 1997, the translocation of bridled naitail wallabies to a fenced enclosure (60 ha) at the Gregory Mine site was funded by BHP Billiton and managed by the University of Queensland. After six years, BHP ceased funding the research. On inspection of the population by threatened species officers, it was discovered that the animals (about 150) were in very poor health due to a reduction in the nutritional quality of the natural food and lack of adequate management. Forty of these animals required euthanasia, 22 were translocated to Avocet, and the remainder were rehabilitated at the Kial sanctuary (the previous AACE facility before Safe Haven) before eventually being released at Avocet. The enclosure was shut down in 2005 (Lundie-Jenkins and Lowry 2005).

Reasons suggested for the failure of this site include the lack of support for the caretakers of the animals, and differences in strategic direction between the University of Queensland, who were focused on reproductive biology, and threatened species staff who were focussed on the successful translocation of the species (A Melzer personal communication, 2018). The failure of this translocation also highlights issues with short term funding agreements with external providers.

5.2.6 Kial / Safe Haven

Safe Haven is an animal refuge run by Australian Animals Care & Education Inc. (AACE) (See Section 3.2). The facility is 2km south of Mt Larcom in Central Queensland – it was previously situated at Kial near Maryborough. The site includes many breeding pens and enclosures, and held 30 bridled nailtail wallabies: 14 males and 16 females, with mixed origins, including four wild-born animals from Taunton. The founder base is estimated to be 10-15 individuals, which is higher than any of the other populations except for Taunton (Weeks, 2018), but there is no estimate of the population's allelic diversity.

Care and rehabilitation have been provided for animals at this centre, including stressed and unwell animals recovered from the Gregory Mine site, and the small remaining population removed from Idalia National Park. In addition, Safe Haven has undertaken captive breeding with the aim to reintroduce animals to the wild and to supplement existing populations with more genetically diverse stock.

There has in the past been a captive breeding agreement between AACE and the Queensland Government, but none is currently in place. For this facility to provide a role in captive breeding to supply animals for future release, a new agreement would be needed. As discussed above, AACE withdrew from the captive breeding role in 2018. The wallabies in their care have been relocated to Avocet, where they are being held in pens prior to soft release. This means there is no current facility in Queensland that can support the captive breeding of bridled nailtail wallabies. While interest for captive breeding has been expressed by University of Queensland Hidden Vale Wildlife Centre, the existing facilities have been assessed by Departmental staff to be unsuitable (Lowry and Ryan 2018).

5.2.7 Assessment of captive breeding programs

Inputs to captive breeding programs have been sporadic and often inadequate to support private people and organisations who have worked in this area. Information about the genetic structures of all populations has not been sufficiently complete or up to date for people to make informed decisions.

Planning for captive breeding is essential and has been poor to non-existent since 2005.

The **process** of management of captive breeding has been very poor, especially since 2005, when the scene was set for good cooperation and professional overseeing of a sound breeding program based on science. Poor management of captive breeding has led to a lot of frustration and bad relationships, a waste of potentially good genetic resources, and to extensive breeding of bridled nailtail wallabies with a lack of genetic variation. Many of these problems could have been avoided if the recovery plan recommendations of 2005 had been implemented and all partners had fulfilled their expected roles.

A letter from AACE to the Minister of National Parks and the Great Barrier Reef in 2016 outlines the history of captive breeding from their viewpoint and contains a disturbing list of

inefficiencies and failures. The Queensland Government relied on support from this organisation, especially in housing animals which were not required elsewhere, but gave little in return. The withdrawal of AACE from captive breeding of this species in August 2018 is of concern, especially since other breeding facilities have closed.

Outcomes from the poor management of captive breeding are evident in the current status of the population, where wild-living bridled nailtail wallabies have to be moved to restart the process of developing genetic diversity in the translocated populations. Unfortunately, other outcomes have included many wallaby deaths, the loss of potential genetic material, and very poor relationships with a number of key stakeholders.

5.3 Idalia National Park translocation

5.3.1 Background

Idalia National Park (Idalia) covers an area of 144,196 hectares on the junction of the Mulga and Mitchell Grass bioregions. It was gazetted in 1990 and is managed by the Queensland Parks and Wildlife Service. The national park is on the western edge of the mapped previous extent of the bridled nailtail wallaby: it is not known whether the animal occurred here naturally in past. The introduction of the bridled nailtail wallaby to Idalia is thus described as a translocation (assisted colonisation) rather than a re-introduction, which raised concerns about the population's viability (Pople et al., 2001). Average annual rainfall at Idalia is 451mm, well below that of Taunton (692mm) and is also more variable (Pople et al., 2001).

The first suggestion of Idalia as a translocation option for bridled nailtail wallabies appears to have been in 1991, after a *Bioclim* analysis was conducted (A. Melzer pers. comm 2018). Discussions about it are recorded in minutes of recovery meetings in 1991 and 1992 – the option was not supported by all people, but plans were drawn up and supported by the recovery team. It was considered as a suitable site due to the fact that it was on the edge of the known previous range, it was on a staffed protected area, there were low levels of predators, particularly foxes, and most of the plant species eaten by the bridled nailtail wallabies at Taunton were also present (Pople et al., 2001).

A series of predator-proof enclosures totalling 10ha were constructed in 1993. A trial relocation from the Pallarenda colony was attempted in 1993, but foxes killed four of the six released animals, despite no foxes being recorded in spotlighting. After intensive predator control, the translocation program began in 1996, and 133 animals were released on the national park over six release events between 1996 and 1998. These animals consisted of four cohorts: captive-bred at Pallarenda and directly released, captive-bred at Pallarenda and acclimatised for six months, caught at Taunton and moved directly to Idalia (wild-released), and bred in the enclosures at Idalia (Pople et al., 2001). All were held in pens at release sites for a week before release. A further nine wallabies bred at Kial were released in 2010 (J. Lowry personal communication, 2018). The reintroduction at Idalia was deliberately conducted as an experiment to compare the success of captive and wild-bred wallabies, and those which had time to acclimatise in the site before release. It was shown that animals bred at Idalia had the highest survival rate (Pople et al., 2001).

During the late 1990s the population thrived and estimated numbers may have reached 1000 by 2001 (Lowry pers. comm., 2018). This period included five consecutive years (1996-2001) of above-average rainfall (Bureau of Meteorology 2018). Animals bred well and survival rate was high, though 11 are thought to have died from lumpy-jaw and the captive-bred animals were more vulnerable to predation (Pople et al., 2001). The animals sheltered by day in both brigalow

regrowth and woodlands dominated by poplar box and brigalow: they were not recorded in the tableland areas dominated by bendee, mulga and lancewood (Pople et al., 2001). This is consistent with the observations in the Taunton area (Gordon and Lawrie, 1980). It was noted that forbs were a large part of the wallabies' diet at Idalia, and this raised some concern as forbs have been observed to decline from more than 50% of ground cover to less than 10% in dry periods (Pople et al., 2001).

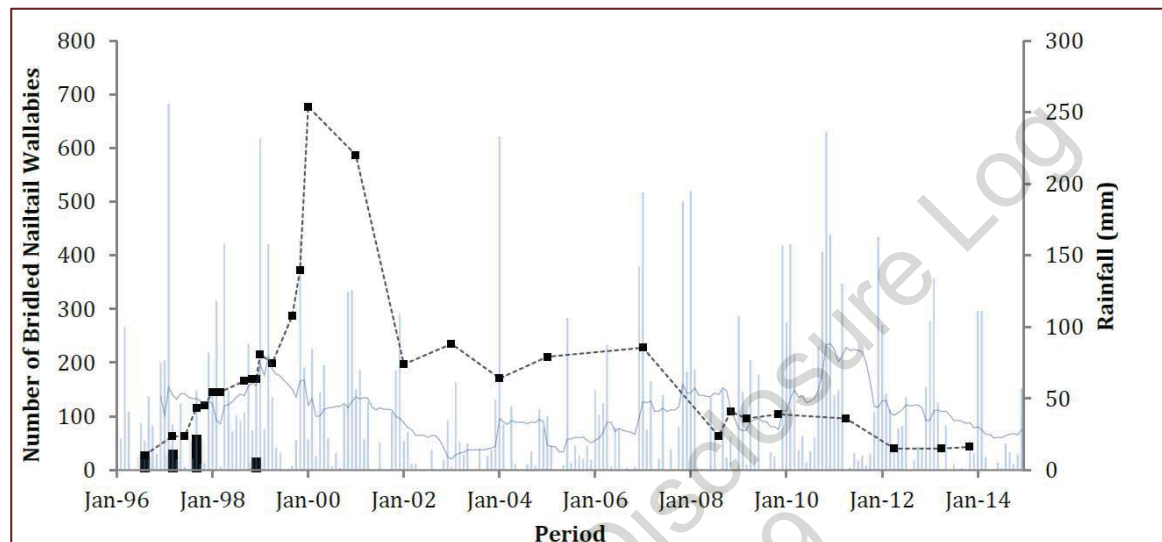


Figure 13: Estimates of the population size of bridled naitail wallabies, releases and monthly rainfall at Idalia National Park 1996-2015

Source (Nixon, 2015). Black bars indicate wallaby releases (the final release was in 1999). Monthly rainfall (blue bars) data comes from Springleigh, QLD (**Bureau of Meteorology, 2015**) for 1996-2014, a 12-month moving average is fitted to the monthly rainfall to show long term rainfall trends. Note that some of this information is not consistent with other information about populations in this section

After estimates of up to 1000 bridled naitail wallabies in 2001 (J. Lowry personal communication cited by Weeks 2018), the population then declined to around to 150-250 in 2002-2003 after a severe and protracted drought. Supplementary food was supplied in 2003 and the population appeared to stabilise, then when conditions improved 150 bridled naitail wallabies that had been captive-bred on the park were released (Lowry 2015). The population in July and November 2007 was estimated at 228 then 193 animals (Lowry, 2007), and between 40-60 in 2012-2014. By 2015, only eight were detected in the core area (Lowry and Ryan, 2018). In late 2015, most of the surviving wallabies were trapped and removed from the park.

5.3.2 Reasons for failure

While the period from 2002 to 2013 included some dry years, the data from Isisford (70 km away) indicates that this is not exceptional: of the 164 months during these years, only 18 (11%) received under the 10th percentile and only one year was extremely dry. 2002 and 2003 were exceptionally dry, but 2010-12 when the animals declined seriously were wet. During droughts, feeding was undertaken with lucerne hay and animals had access to dams.

Regular predator control was undertaken at Idalia, with ground and aerial baiting, shooting and trapping (Melzer, 2015a). However, this activity was reduced during a period of staff difficulties between about 2010 and 2014 (S. Hume personal communication, 2018). Predators were cats and dingoes: no foxes were recorded in over 400 camera nights from 2000 onwards (S. Hume personal communication, 2018).

A number of factors have been attributed to the failure of the translocation to Idalia, and it is most likely that a combination of factors contributed. The site lies to the west of the known historical distribution of the species: under good conditions of management and weather, the wallabies thrived, though caution was always advised in celebrating the success seen in the early years (Lundie-Jenkins and Lowry, 2005). Drought, combined with predators, was probably the immediate cause of the decline, as a lack of food and reduced shelter made the animals more vulnerable to attack. Under poor conditions the wallabies may have ventured further from cover to find sufficient food. Idalia has a high population of other macropods including red kangaroos and wallaroos, which can eat all available plant matter as droughts progress (C. Mitchell pers. comm). In the drought conditions in 2015, it was noted that all macropods had decreased dramatically (from hundreds seen in spotlight transects to only 10) and many were dying, including along the netted boundary fence which prevented movement and migration of red kangaroos and other large macropods. The period of decline also saw an increase in feral cattle (Nixon, 2015), which would have competed for the limited food resources and removed the undergrowth critical for shelter.

The better seasons from 2009-12 heralded an increase in feral predators across western Queensland, which caused concerning declines in many species. With the absence of permanent experienced staff during much of the period 2010-2014, predator control was conducted only occasionally, by QPWS staff travelling from other areas, so the level of predation may have increased to an unsustainable level.

However, over-riding these immediate causes was a failure in governance caused by a combination of coinciding factors in the period after about 2009-10¹⁰:

- Priorities in threatened species management moving away from on-ground actions to planning and prioritisation projects, with a lack of continuing support for the translocation effort;
- A deepened division between the Queensland government departments with a split between on-park and off-park responsibilities, heightened from 2012 through deliberate decisions of the government at the time to reduce cooperation;
- Absence of several key passionate individuals due to illness and family responsibilities, with no adequate back-filling of these positions;
- Lack of funding and support for the program, low staff morale, and legal proceedings leading to a long-term absence of permanent knowledgeable staff onsite.

This led to a virtual absence of management presence and the demise of most of the population. While staff attempted to remedy the situation in 2015, this coincided with a severe drought period.

5.3.3 Assessment of the Idalia translocation

Inputs of money and staff early in the translocation process (mid-1990s) were very good, with funding for predator control and a high degree of involvement from the recovery team. Many people were highly invested in ensuring the trial was successful, and there was enthusiastic support from on-ground park staff as well as researchers and threatened species staff. By 2010-2013, these resources had withered to very little support, relying on meagre human resources from already stretched park staff and very little input from other sources – due to a range of factors including illness and family responsibilities. The very high level of input needed from park staff, on top of their other duties, to look after the bridled nailtail wallabies and control

¹⁰ This is the opinion of the authors based on information obtained from a number of current government employees

predators, may not have been factored into any decision-making. There was no resilience within the system to provide backup when people were sick or unavailable.

Planning for the translocation appears to have been under-documented and there is no detailed justification available about the decision to choose Idalia over other sites which may have been more favourable. The translocation project meant that for over 20 years, management of Idalia was highly focussed on bridled naitail wallabies, though they were not previously recorded for the area and were not a basis for the park's gazettal or previous management directions.

Processes in some phases of the project could have been better documented, and the sequence of events after about 2005 is difficult to track. As discussed above, processes early in the period, especially 1993-2005, were well supported and the project appeared to be a great success. Researchers carefully documented early survival of the different release cohorts (Pople et al., 2001). However, subsequent years saw a deterioration in resourcing, and there was no backup when a few critical people were unable to work at Idalia. There was limited ability to respond to deteriorating situation until the crisis point had been passed. In the opinion of the authors, a failure of governance and process was the major contributing factor to the demise of the population. This failure was not documented, so the learnings are not available for future application.

Outcomes of the project in the long term were negative especially since the opportunity to use the failure as a learning experience have not been maximised.

5.4 Scotia Sanctuary

5.4.1 Background

Scotia Sanctuary was established in 1994 with help from the Australian Government's National Reserve System Program. It consists of two former pastoral properties: grazing ceased when it was purchased by Earth Sanctuaries Limited. In 1998, twelve bridled naitail wallabies were translocated to Scotia under an animal loan agreement with the Queensland Government. Since 2002, it has been owned and managed by AWC, with an aim to 'improve the ecological health of the sanctuary by maintaining and restoring biodiversity and ecological function, and reducing the extent of threats' (Hayward et al., 2012, p. A28). A predator-proof fence encloses 8000ha of mallee habitats into which seven regionally extinct species, including the bridled naitail wallaby, have been introduced. As Scotia is not within the known former range of the bridled naitail wallaby, this can be regarded as a translocation (assisted introduction) rather than a reintroduction¹¹ (IUCN, 2015).

Bridled naitail wallabies were originally kept in a large (150 ha) captive breeding area. In this area they were fed supplementary food (rabbit pellets) and given access to water (E. Mulder personal communication, 2018). In 2004, 40 wallabies were released into Stage 1 (4200ha) and 257 into Stage 2 (3800ha) of the wider fenced area (Hayward et al., 2012).

The populations in Stages 1 and 2 are now free-living, with access to water but no supplementary food. Trapping is no longer carried out and population censuses are conducted by spotlight to minimise interference. While the bridled naitail wallabies do not have to avoid feral predators, wedge-tailed eagles do take young wallabies, so wariness is still required – thus

¹¹ It appears that there is some contention about whether Scotia was within the former range of the bridled naitail wallaby. However, given that a population there is now well established, the point is not particularly relevant to future planning and actions.

natural selection still operates to favour wary and hardier individuals (E. Mulder pers. comm 2018). The perimeter of the fence is checked every two days: breaches are extremely rare and rapidly controlled (J. Stevenson pers. comm 2018).

Within the predator-proof fence, survival and increase of the bridled naitail wallabies has been very successful both within the breeding enclosure and in Stages 1 and 2. The population reached a high of about 3700 in 2012, but has declined in the subsequent drier times to a 2018 estimate of 1720 (Figure 14). This decline has been due to reduced breeding success and some deaths (J. Kanowski personal communication, 2018), but the current population is probably at a more sustainable level.

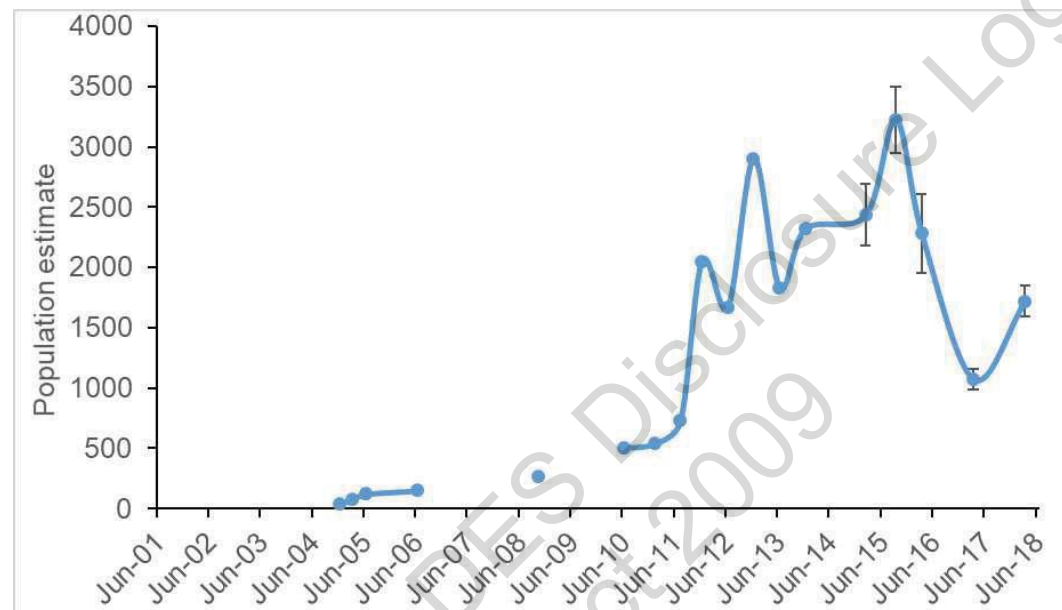


Figure 14: Estimated populations of bridled naitail wallabies over time at Scotia

Source: (Australian Wildlife Conservancy on behalf of NSW National Parks and Wildlife Service, 2018)

Attempts to release bridled naitail wallabies beyond the predator-proof fence have not been successful, due mostly to predation by foxes, dingoes and wedge-tailed eagles (Hayward et al., 2012). This was despite efforts to control predators through baiting the release site and nearby areas. The attempt involved 30 males, which were monitored with radio collars, and most travelled long distances, presumably searching for mates. The best survival rate was among those that stayed on Scotia in the unfenced area, where more intensive predator control could be carried out. All dead animals found appeared to be in good condition at the time of death, indicating that suitable food was available in the area. The release experiment was thoroughly monitored, and lessons learned were documented in a published paper: for example, it is thought that future experiments should include females so that males do not disperse as rapidly or as far (Hayward et al., 2012).

Genetic studies have shown that the bridled naitail wallaby population at Scotia lacks allelic diversity, so animals to found new populations should be a combination of individuals from Scotia and those from more genetically diverse sources (currently only the Taunton population) (Weeks, 2018). However, there is no indication that the small number of founders has affected the health or reproductive capacity of the Scotia population.

5.4.2 Assessment of the Scotia translocation

In contrast to other attempts at translocation and predator-proof fencing, the level of **inputs** at Scotia since the introductions of the bridled naitail wallabies has been consistently adequate, with the ability to rapidly respond to any issues. To date, AWC has been able to provide stable funding for long-term projects and this is considered a factor leading to the success of its programs, in addition to the employment of skilled in-house scientists (Kanowski et al., 2018)

Planning for the initial species translocation in 1998 was not thoroughly documented, and there is no public record of formal plans for the species at Scotia in the intervening time. There is only a brief reference to Scotia in the 2005 recovery plan (Lundie-Jenkins and Lowry, 2005). Objectives for the Scotia population have not yet been formally documented but are similar to those for the translocations to Pilliga and Mallee Cliffs (Section 5.6.2): documentation of the Scotia objectives will be documented in the future (J. Kanowski pers. comm). The rapid and sustained increase in population at Scotia may not have been fully anticipated, and led to the difficult issue of how to deal with an unsustainable number of wallabies. The experimental release of bridled naitail wallabies was carefully planned.

Processes at Scotia seem to have been consistent. Management here has not been subject to the frequent changes in priorities and funding levels experienced by many other agencies and organisations involved in threatened species recovery. Embedding of scientists into management processes has been important in monitoring progress and responding to issues (Kanowski et al., 2018). Some results of management have been openly published: for example, the failed experiment to release bridled naitail wallabies into the wild was well documented and lessons are available for other people to use (Hayward et al., 2012). However, reporting of other issues such as dealing with the problem of excessive populations may be less transparent.

The **outcome** of the translocation to Scotia has been outstanding in terms of population increase: about 70% of the total bridled naitail wallaby population lives there in a wild setting (though within a fenced area), and the wallabies are healthy and breeding well. The success of the population increases here led to the IUCN reclassifying the wallaby from Endangered to Vulnerable. Unfortunately, the founder population at Scotia was so small that the genetic diversity of the population is very limited. The use of the population to seed other populations is not advised, except in small numbers combined with founders from Taunton (Weeks, 2018).

5.5 Avocet Nature Refuge

Avocet Station is a private cattle grazing property in the Brigalow belt of Central Queensland, within the former range of the bridled naitail wallaby. Part of the property (1120ha) was declared a nature refuge under the *Nature Conservation Act 1992* in 1998. This declaration was due to a voluntary commitment of the landholder, Hugo Spooner, to conserve the area of endangered brigalow woodland. Avocet was identified as a suitable site for reintroduction of bridled naitail wallabies, which were translocated to the site after several years of planning, negotiations with the landholder and feral animal control. There were no specific records of bridled naitail wallabies on Avocet Nature Refuge, but there were anecdotal accounts of “flashjacks” in the area (Lundie-Jenkins and Lowry, 2005), which lies within the known former distribution for the species. Mean annual rainfall (574 mm) is lower than at Taunton but higher than at Idalia: the area experiences droughts and was in a dry phase when most of the reintroductions took place (Kingsley et al., 2012).

A total of 166 bridled naitail wallabies were released in four stages between 2001 and 2005 (Lowry and Ryan, 2018). The animals were sourced from the captive breeding enclosure at

Gregory Mine, although some were rehabilitated at Kial prior to their release. The wallabies were in relatively poor condition at the time of their release, and the size of release groups may have been sub-optimal for survival (Kingsley et al., 2012).

Apart from the Spooner family and the Queensland Government (QPWS/Threatened Species Program/DES), a number of other partners have been involved in Avocet, including Emerald Shire Council (now part of the Central Highlands Regional Council), Conservation and Wildlife Management (a branch of the Sporting Shooters Association of Australia), Bridled Nailtail Wallaby Trust, Australian Government, the local community, FBA, Wild Mob, Bush Heritage Australia, University of NSW and Sojitz Minerva Joint Venture mining (Lowry and Ryan, 2018).

Activities to protect the population have included predator control, supplementary feeding and regular monitoring of both the wallabies and predators. Baiting to control wild dogs, feral cats, pigs and foxes occurs on Avocet and Goonderoo up to four times per year, with the participation of neighbouring properties, particularly to coincide with juvenile wild dog and fox dispersal in October-November and pre-mating activity in March-April (Lowry and Ryan, 2018). Through the landscape-scale approach to predator control, it is hoped to create a buffer zone around the population to allow it to disperse further, but this has not yet occurred.

A major mortality factor was found to be from cats eating mostly juvenile bridled nailtail wallabies. Survival rates of juveniles were believed to be very low: in 2008 only 17% of breeding females had a young-at-foot joey, though there had been average rainfall and the mothers were in good condition (Kingsley et al., 2012). Due to the difficulty of controlling cats, a solution has been the establishment in 2014 of a 9.3 ha predator-proof 'nursery' area, funded by Wild Mob and managed under a Memorandum of Understanding between the landholder, Wild Mob and the Queensland Government. Females with pouch young and young-at-foot are captured and kept until the females have no young and the young have reached 3kg, when they are again released into the wild (Lowry and Ryan, 2018). However, the landholder feels that the feral cat issue has not been solved and that mortality is still too high (Hugo Spooner pers. comm., August 2018).

The estimated population of bridled nailtail wallabies at Avocet in 2018 is about 100 (J. Lowry personal communication, 2018). Genetic studies show that the population has lost some genetic diversity, probably due to its low population size (Weeks, 2018). While the allelic richness and presence of rare alleles may be higher than at Scotia (see Table 4), increasing these measures through introduction of new founders from Taunton has been recommended (Weeks, 2018). In 2018, wallabies were relocated to Avocet from Safe Haven following closure of the bridled nailtail breeding facility there. These animals include two males from Taunton, which will be bred according to advice from the genetic management plan.

5.5.1 Assessment of the Avocet reintroductions

The bridled nailtail wallaby reintroduction program at Avocet has had variable **inputs** since 1998 and this is difficult to quantify as sources include some resources from the Queensland and Australian governments, as well as assistance from other organisations and volunteers. It appears that significant issues have included the lack of consistency and reliability of support, and at times disagreement about responsibilities for expenditure. The landholder feels that the lack of budget for continuation of the reintroduction project has been a serious issue (Hugo Spooner pers. comm., August 2018)

Planning for the reintroduction was undertaken, but there are no formally documented plans for management of the bridled nailtail wallaby population at Avocet. Government long-term

intentions were not made clear to the landholder when the project was initiated (Hugo Spooner pers. comm., August 2018). Planned targets and objectives might have helped the program to be clearer about what was to be achieved, but the adaptive management approach has been successful (D. Ball pers. comm., August 2018).

Processes have been variable, with some difficulties in relationships over the years for a variety of reasons. If difficulties can be resolved, this nature refuge is a model of the power of partnerships and reflect great credit to the landholder and on-ground partners for commitment and long-term persistence in conservation efforts.

In spite of many hurdles and difficulties, the reintroduction at Avocet has had a moderately successful **outcome**, though fewer bridled naitail wallabies are currently living there than have been released there. Predation by feral cats is still limiting the successful increase of the population (Hugo Spooner pers. comm., August 2018).

5.6 Future translocation sites

Many other potential sites for translocation have been considered and some inspected. Two sites in New South Wales are currently being prepared by AWC for approved translocation projects in conjunction with the Office of Environment and Heritage (Section 5.6.2), while a suitable site adjacent to Avocet held by Bush Heritage Australia is also available (Section 5.6.1).

Suitable sites must have the preferred habitat and food availability, but it is also recognised that a very high level of predator control is vital, as most failures in mammal translocations in Australia have been due to predation, mostly by feral cats and foxes (Moseby et al., 2015). Even a very low level of predation on small translocated populations can be devastating (McCallum et al., 2001). The synergy of reintroducing a number of species in one location makes sense and this approach is applied by AWC in its fenced reserves.

5.6.1 Goonderoo

Goonderoo is a 593ha property close to Avocet Nature Refuge, which was purchased by Bush Heritage Australia in 1998. It has at least 100ha of suitable habitat for bridled naitail wallabies in brigalow shrubland and poplar box and baubinia communities, and it is hoped that the wallabies will establish there (Bush Heritage Australia, 2014). Management activities include controlling feral predators, controlling buffel grass, rehabilitating natural vegetation and repairing a dam <https://www.bushheritage.org.au/newsletters/2017/summer/flashjack-surveys>. Bridled naitail wallabies have yet to re-establish in the area through natural dispersal.

Bush Heritage Australia has developed a proposal for translocation into Goonderoo (Bush Heritage Australia, 2014), and is open to assist with translocations (correspondence and R. Murphy personal communication, 2018).

5.6.2 Pilliga Forest and Mallee Cliffs Reintroductions

<https://www.environment.nsw.gov.au/topics/animals-and-plants/threatened-species/saving-our-species-program/threatened-species-conservation/featured-projects/reintroducing-locally-extinct-mammals>

AWC and the NSW Office of Environment and Heritage have developed an agreement (the Extinct Mammal Agreement) which facilitates a partnership between the two organisations to assist in delivery of the NSW Government's program called 'Saving our Species'. At least six

regionally extinct mammals will be reintroduced to these locations, including the bridled naitail wallaby.¹²

At Pilliga, a 5800ha predator-proof enclosure has been completed, and conditions are being prepared for the first reintroductions. The translocation plan for the species is currently in the approval phase (Australian Wildlife Conservancy on behalf of NSW National Parks and Wildlife Service, 2018). The proposal sets out clear objectives and procedures (p.16):

The Extinct Mammals Agreement aims to establish viable, genetically diverse populations of the Pilliga species in the project area. If successful, the reintroductions will make an important contribution to the conservation of the Pilliga species, by:

- 1. establishing additional secure populations and increasing global population sizes of the species.*
- 2. helping maintain the long-term adaptive potential of the species by ensuring they are exposed to environmental conditions operating across their former ranges. Natural selection can be expected to favour different traits and genes in different environments.*
- 3. helping restore the ecosystems of the Pilliga, which have evolved in the presence of mammals that are now regionally extinct. The Pilliga mammals participate in a number of important ecological processes including herbivory, seed and spore dispersal, soil engineering and predation.*

Once secure populations of the Pilliga species have been established within the fenced area in the Pilliga these populations may be used to help establish populations outside the fence in the project area, provided densities of feral predators can be sufficiently suppressed. In the longer term, reintroduced populations may act as source populations for future releases elsewhere in NSW and nationally, assisting broader-scale recovery of these species.

An estimated target population size for bridled naitail wallabies has been set at 2100, though this will be further refined over time.

The fenced area (Figure 15) has now been prepared and translocations should commence in 2019. The planned translocation program is as follows (Australian Wildlife Conservancy on behalf of NSW National Parks and Wildlife Service, 2018, p. 47):

- *Breeding population to be established in 2019, with 40 founders: 20 from each of remnant population (Taunton Qld) and reintroduced population (AWC's Scotia sanctuary), based on recommendation of genetic management plan (Weeks 2018)*
- *Wallabies released into main fenced area once breeding population >150, while maintaining breeding population >100 (nominally 2021-)*
- *Remaining wallabies released into main fenced area when temporary fence removed (nominally 2022-)*

¹² A further site for reintroductions is Sturt National Park, in partnership with the University of New South Wales. Bridled naitail wallabies are not involved at this site.

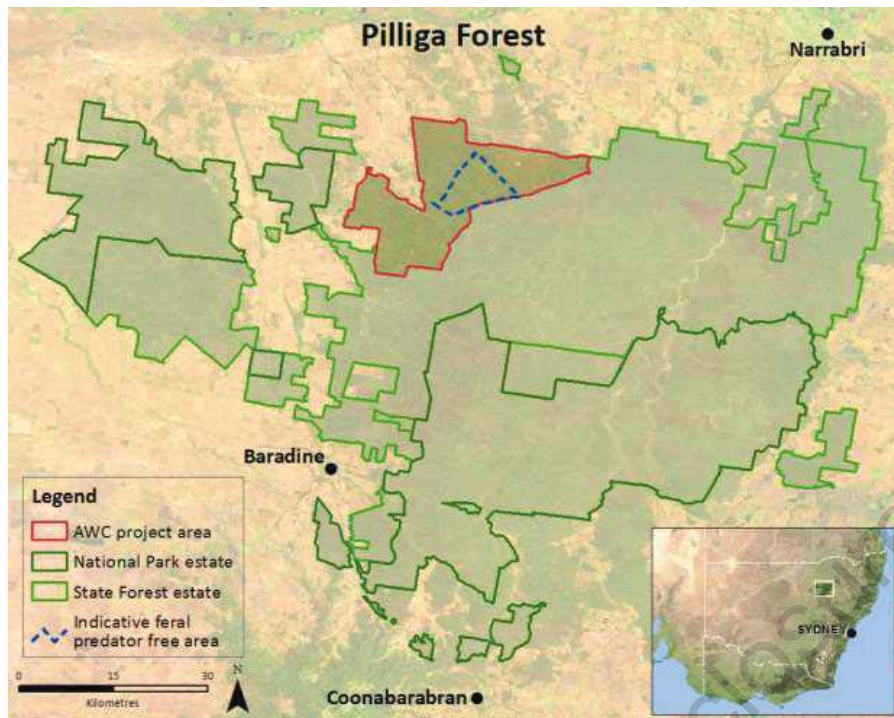


Figure 15: Location of Pilliga Forest, the AWC project area and the predator-proof fence

Source: (Australian Wildlife Conservancy on behalf of NSW National Parks and Wildlife Service, 2018, p. 2)

A similar translocation plan will be developed for Mallee Cliffs: this is about a year behind Pilliga Forest. A fenced area of 8000ha will be established in the 57,969 hectare national park.

6. Subprogram four: Additional land acquisitions and community corridors in the Brigalow Belt

6.1 Acquisition of further lands

A clear recommendation of the recovery program has been to establish more populations of bridled naitail wallabies in the general vicinity of Taunton, where it was known that small populations were surviving or moving through. For example, in 1994 a colony was 'scattered over several properties along Springton and Lorraine Creeks'¹³. It was hoped that more land could be formally acquired and managed as protected area to protect existing wallaby populations, but this has not been achieved.

In the context of high clearing rates and fragmentation of natural remnants, it has been difficult to identify additional areas for acquisition to increase the protected area estate in this part of the Brigalow Belt. The best identified properties have been cleared and opportunities lost due to slow action by the Queensland Government, especially during periods when there was a reluctance to purchase more land for protected areas.

As a contribution to the identification of potential additional areas, an analysis of coarse and fine scale habitat requirements was conducted in 2004 (Houston, 2004), resulting in recommendations for land characteristics (Table 8). However, there is no evidence that this work was ever applied.

Table 8: Characteristics of land suitable for reservation for bridled naitail wallaby conservation

Source: Houston 2004

Coarse-scale stage selection criteria: Attribute	Source	Optimal characteristics
Size		At least 10,000 ha of contiguous suitable land
Soil complexity	Land unit mapping ¹ , RE descriptions ²	3 soil types including substantial amounts of clay & texture-contrast soils
Percentage of remnant vegetation	RE mapping	> 50%
% of remnant vegetation occupying clay & texture-contrast soils	Aerial photographs and RE mapping	> 50% of the area of clay & texture-contrast soils are vegetated
Topography	Land unit mapping	Mostly mid to lower topography, includes vegetation along drainage lines
Land zones	RE mapping	At least 1000 ha in land zones 3 or 4
Vegetation types present have potential for shrub or mid-storey components	RE mapping	11.3.2, 11.4.9, 11.9.1
Water availability	Aerial photography	Ensure permanent or near permanent water is present within the area of interest

6.2 Working with landholders

Work has occurred sporadically to cooperate with landholders to improve the chances of wallabies to survive on properties adjoining Taunton. Part of the cooperative program funded by the Australia Government, which finished in 2017, was to develop six corridors to link Taunton with other patches of remnant vegetation. The project was coordinated and implemented entirely by the FBA, contractors and landholders, with the Queensland Government playing only a minor role in providing advice on plantings.

¹³ Information from QPWS files, 1994-1996, collated by Cameron 2005

Criteria for the location of corridors included: proximity to the park; the presence (current or past) of brigalow; ability to include, where possible, some existing native vegetation; and a landholder committed to allowing the regrowth of vegetation within the corridors. (Melzer, 2015a). All the corridors are fenced, but grazing is permitted in the corridors providing it does not unduly impact on the regeneration of the shrub and ground layers. Planting of native species has occurred where necessary. The project resulted in a total fenced corridor area of 2534ha. There was a commitment to undertake photo-monitoring every six months and a BioCondition assessment every 12 months (Melzer, 2015a).

6.2.1 Assessment of the landholder corridor program

No reports for the program are available: the following information was provided in interviews with the project officer (C. Tracey pers. comm, 2018) and reflect her views.

Inputs: Corridor fencing and bridled nailtail wallaby monitoring projects were adequately funded; the revegetation project was inadequately funded, mostly regarding labour costs. There was not enough funding in the budget to allow for the required amount of site visits to water and maintain the new plantings. Combined with a poor selection of project site on the target property and drier than average weather conditions, this meant the plantings were mostly unsuccessful. Assisted regeneration has proved reasonably successful at the same site as an alternative and would be recommended for future projects in the same area.

Processes: Off-park corridors and bridled nailtail wallaby monitoring was managed well; bridled nailtail wallaby habitat restoration was less effective. Project success is just evident now, another 5 years at least would allow for more comprehensive monitoring to determine if some aspects of the program e.g. corridors will be successful in establishing additional habitat. A longer project would have allowed for better monitoring and follow-up site visits with landholders to determine the level of habitat regeneration and suitability for bridled nailtail wallabies. Since the project has concluded (and therefore funding allocated to it is expended), there is very limited scope for FBA staff to revisit project sites and meet with landholders to discuss their current and future management expectations for the areas

Good cooperation was observed amongst the landholders involved in wild dog control, however other landholders did not participate in the program and this would have provided a greater strategic benefit to all properties and bridled nailtail wallaby conservation if they had, effectively closing the 'loop' of properties controlling wild dogs around Taunton NP.

Conclusion: A Project Implementation Plan should have been developed from conception; but despite this being lacking, the project overall was considered a success by the partners involved. This was most likely as a result of good communication and trust between partners, and dedication of on-ground staff to achieving a measurable improvement in the conservation prospects of the species. Recommendations have been put forward within FBA regarding the high costs of direct revegetation (as opposed to assisted regeneration) as a technique in the drier, more remote parts of the Fitzroy Basin. While assisted regeneration takes longer to achieve measurable outcomes, there is a lower cost and greater likelihood of success in the long term. Disadvantages of assisted regeneration may however include lower species diversity, or some undesirable native species becoming dominant.

7. Evaluation of outcomes and impact

The first evaluation of conservation impact of bridled naitail wallaby recovery was written by Evans in 1992 in relation to Taunton. His simple but clear evaluation, based on years of research in cooperation with QPWS, was that *“current management of Taunton Scientific Reserve has been successful in promoting the increase in the numbers of bridled naitail wallabies....Since numbers of bridled naitail wallabies on the reserve do not appear to be decreasing, little justification exists for altering current management practices on the reserve.”* He tempered the observation with urging adaptive management: *“The establishment of a monitoring program is essential in being able to detect a decline in the numbers of bridled naitail wallabies on the reserve, and hence effect appropriate changes to management strategies”* (Evans, 1992, p. 111).

In this chapter, we will ask four questions relating to success of the recovery program:

To what extent is the current status and trend attributable to the recovery program?
Which aspects of the recovery plan have contributed to different extents and how?
What additional impacts can be attributed to the recovery program (both intended and unintended)?

- Have the recovery actions been appropriate?
- Have recovery objectives been achieved?
- Have threats been reduced?
- Is the bridled naitail wallaby less threatened?
 - Has the total population of bridled naitail wallabies increased?
 - Is the population healthy?
 - Is the meta-population resilient?

7.1 Have actions been appropriate?

In our opinion after reviewing the whole recovery process and all the associated literature, the objectives and actions in the recovery plan of 2005 were appropriate to contribute to the recovery of the species. To counter-check this subjective opinion, we reviewed the diagram of threats (Figure 4), which we developed at the beginning of the project. We then inserted strategies which would logically be undertaken to counter the threats and assist in species recovery, matched with foundational programs that would be needed to support the strategies. The resultant conceptual diagram (Figure 16) is highly consistent with the recovery plan and with the key activities that have been undertaken over the last 40 years.

This confirms our assessment that the actions are appropriate, if not always well implemented or sufficiently resourced.

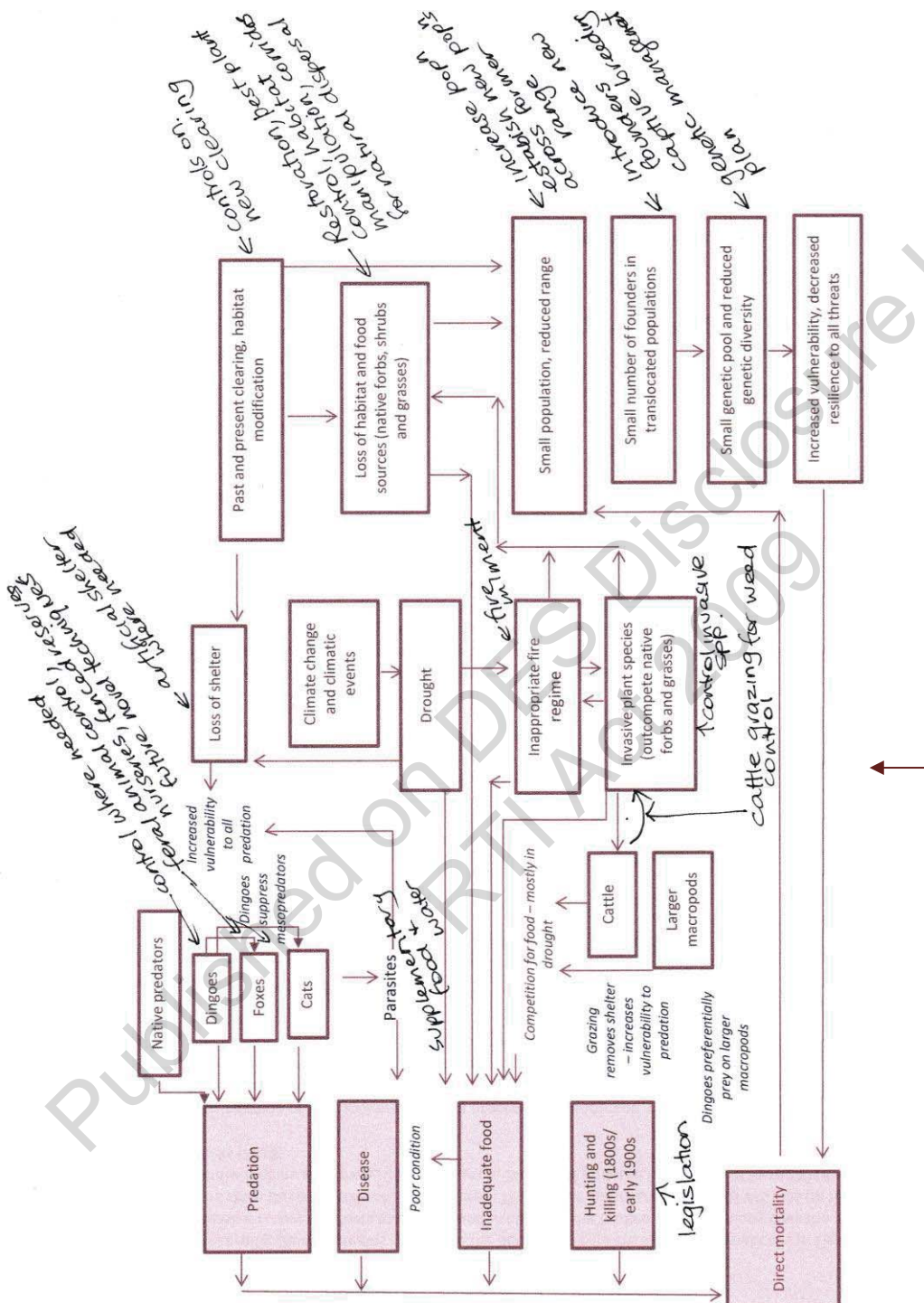


Figure 16: Threat mitigation measures

Foundational activities to support recovery actions: Recovery planning; recovery group and partnerships; research, monitoring and adaptive management; legislation; adequate resourcing; community education and support and institutional support.

7.2 Conservation impact: is the bridled naitail less threatened?

Conservation impact of projects or interventions is measured by comparing what has happened with 'counterfactuals' – that is, by monitoring what has happened without the intervention. In many cases in the real world, a 'real' counterfactual is often not possible, and so we need to model or project what is most likely to have happened without the intervention (Mascia et al., 2017, Dickson et al., 2017, Ferraro and Hanauer, 2014). In a comprehensive impact assessment, we also need to make sure that the contribution of other factors (such as a change in climate) has been ruled out, so that we can see what the actual contribution of the intervention has been (Ferraro, 2009), building on the 'theory of change' to tease out the intervening factors and the assumptions behind program design and implementation. Conservation impact assessment is complex and requires integration of a range of subjects, but is essential to improving practice (Baylis et al., 2016).

For threatened species where increasing the population is the main objective, the change in numbers of the population as compared with the projected change over the same period indicates the level of success of the intervention (Figure 17), provided that we can, with confidence, attribute that change to the recovery program.

	HOW DID THE SPECIES' ABUNDANCE CHANGE DURING THE COURSE OF THE PROJECT?				
	LARGE DECREASE (>30%)	MODERATE DECREASE (10-30%)	STABLE (<10% CHANGE)	MODERATE INCREASE (10-30%)	LARGE INCREASE (>30%)
How would the species' abundance have changed in the absence of the project?	Large decrease (>30%)	Project action had little or no impact and failed to combat a large decrease in abundance	Project action had a minor positive impact by changing a large decrease in abundance into a moderate decrease in abundance	Project action had a moderately positive impact by halting a large decrease in abundance, resulting in stable trends in abundance	Project action had a substantial positive impact by reversing a large decrease in abundance, resulting in a moderate increase in abundance
	Moderate decrease (10-30%)	Project action had a minor negative impact by changing a moderate decrease in abundance into a large decrease in abundance	Project action had little or no impact and failed to combat a large decrease in abundance	Project action had a moderately positive impact by halting a moderate decrease in abundance, resulting in a stable trend	Project action had a moderately positive impact by reversing a moderate decrease in abundance, resulting in a moderate increase in abundance
	Stable (<10% change)	Project action had a moderately negative impact by causing a large decrease in abundance	Project action had a moderately negative impact by causing a moderate decline in abundance	Project action had little or no impact and the species continued in a stable trend	Project action had a moderately positive impact by causing a large increase in abundance
	Moderate increase (10-30%)	Project action had a substantial negative impact by reversing a moderate increase in abundance, resulting in a large decrease in abundance	Project action had a moderately negative impact by reversing a moderate increase in abundance, resulting in a moderate decline in abundance	Project action had a moderately negative impact by halting a moderate increase in abundance, resulting in a stable trend	Project action had little or no impact and the species continued to undergo a moderate increase in abundance
	Large increase (>30%)	Project action had a very substantial negative impact by reversing a large increase in abundance, resulting in a large decrease in abundance	Project action had a substantial negative impact by reversing a large increase in abundance, resulting in a moderate decline in abundance	Project action had a moderately negative impact by halting a large increase in abundance, resulting in a stable trend	Project action had a moderately negative impact by reducing the observed rate of change from a large to moderate increase in abundance

Figure 17: Template for estimation of impact evaluation

Source: Dickson et al., 2017, p. 365

However, impact evaluation for the bridled naitail wallaby needs to consider more than population numbers and we will attempt to answer the following questions, with the best available information. In each case, we need to consider the actual situation with a projected counterfactual wherever possible.

- Has the population increased?

- Is the population healthy in terms of physiological health, reproductive status and genetic health?
- Has there been a *sustainable* increase in numbers, with the meta-population able to withstand environmental fluctuations? Are there sufficient populations over a wide enough area to maximise resilience to stochastic events, including disease and fire, and to climate change?

7.2.1 Has the total population of bridled naitail wallabies increased?

Assessment: Very substantial positive impact: increase in numbers is largely attributable to the recovery program.

Justification: The current estimated population of bridled naitail wallabies across all populations is currently 2450, compared to an unknown number – possibly less than 100 – in 1974.

The projected counterfactual trend of the population without any intervention would be have been to extremely low numbers and quite possible extinction in the wild.

Table 9: Assessed impact of the bridled naitail wallaby recovery program on population size

		Observed change				
		Large decrease (>30%)	Moderate decrease (10-30%)	Stable (<10% change)	Moderate increase (10-30%)	Large increase (>30%)
Projected change without intervention	Large decrease (>30%)					Very substantial positive impact
	Moderate decrease (10-30%)					
	Stable (<10% change)					
	Moderate increase (10-30%)					
	Large increase (>30%)					

Evidence: Population numbers at the three primary locations (Taunton, Avocet and Scotia) are all monitored regularly (Melzer, 2015a) and the current estimate has a high degree of confidence.

Contribution of subprograms to total population size

The primary contribution to increased total population of the bridled naitail wallaby (Table 10) has been:

- At Taunton by enabling the founder population to survive and increase; and
- At Scotia where the numbers have hugely increased.
- At Avocet where numbers are 'holding on' to a just viable population, still at lower levels than animals introduced to the area.

The two free-ranging populations at Taunton and Avocet are still small and very vulnerable to stochastic events, especially predation and potential disease. In 2018, for the first time since 1991, there are no captive breeding populations of bridled naitail wallabies.

Table 10: Estimations of population size

Location	1973 Baseline	Minimum	Maximum	2018	Notes
Taunton NP (Scientific) Surrounding area and immediate surrounds	?< 100	<100 (2007)	1400 (1980s, 1991) ¹⁴	500 - 600	
Idalia	0	0-10	1000 (2001) ¹⁵	0-10?	530 introduced. By 2015 estimate was 20, before removal of remaining wallabies.
Avocet	0			130 ¹⁶	166 introduced between 2001 and 2005.
Scotia	0	12	3700	1720 ¹⁷	12 introduced in 1988. Up to 160% increase per year in absence of predation
Captive breeding	0	12 (Pallarenda 1991); 0 (2018)	>140 total in at least four locations ¹⁸	0	33 animals were relocated from Safe Haven to Avocet, September 2018.
Total estimated	<100			2450	

7.2.2 Is the population healthy?

The reproductive health of all populations appears to be good, and a rapid breeding rate is observed in all the populations when predation is controlled or absent and conditions are good. Physiological health is generally good, with few records of serious disease or infestation.

However, there are serious concerns about the genetic 'health' of all but the wild population at Taunton (Weeks, 2018), see also Table 4. In summary, the genetic management concludes:

- Despite the small population, there is still assumed to be a high amount of genetic diversity there, which has not been affected significantly by the 'bottlenecks' of very small population size in some past periods.
- Populations at Scotia and Avocet have reasonable heterozygosity, but a reduced allelic diversity and low numbers of rare alleles.
-

The conservation implications are that while there is a large and well-protected population of healthy bridled naitail wallabies at Scotia, these animals are not regarded as having sufficient inherent genetic diversity to be used alone for seeding future populations or for significant releases into the wild. This issue will take time and good management to be rectified, but plans are in place to do so for the translocation projects to Pilliga and Mallee Cliffs (Weeks, 2018, Australian Wildlife Conservancy on behalf of NSW National Parks and Wildlife Service, 2018).

7.2.3 Is the meta-population resilient?

The meta-population of the bridled naitail wallaby is vulnerable to stochastic events and environmental fluctuations, as there are only two free-ranging populations occupying very restricted areas, and one fenced population. Losing any of these populations would be a

¹⁴ Davidson et al 1981, Evans 1992

¹⁵ J. Lowry personal communication, cited by Weeks (2018); plus 33 moved from Safe Haven

¹⁶ Op cit

¹⁷ L. Kemp cited by Weeks (2018)

¹⁸ More than 140 in 2005 ((Lundie-Jenkins and Lowry, 2005)

problem, with the Taunton population the most vital to the species' long-term survival. A positive feature is that these three populations are well separated geographically, greatly enhancing the wallaby's survival chances. Since the 1990s, clear recovery goals have specified the need to establish more populations with a wider spread across the former range of the species, and these goals have been achieved only partially to date (Section 7.3, objective 2). The situation will be improved when the Pilliga and Mallee Cliffs populations are established and stabilised, and when the genetic resilience of the Scotia population is improved.

While progress has been limited, the projected counter-factual is that the entire population of bridled nailtail wallabies would be the small remnant population in the vicinity of Taunton. If this population had survived to date, it would be extremely vulnerable to any event such as wildfire, increased predation, drought or disease. Actions to translocate the wallabies to Scotia and Avocet have thus had a very positive impact.

7.2.4 Impact evaluation conclusion

When the information in Sections 7.2.1 to 7.2.3 is considered, the overall conservation impact of the recovery plan is judged to be a **very substantial positive impact**, especially given the high level of constant threat posed to the bridled nailtail wallabies in the wild by feral predators and droughts.

7.3 Have recovery plan objectives been achieved?

We have asserted that actions undertaken in the recovery process have been appropriate (Section 7.1). Our evaluation of the extent to which the actions to date have achieved the objectives of the recovery plan is summarised in Table 11.

Table 11: Assessment of achievements of 2005 recovery objectives

Recovery team objective	Assessment and comments
To significantly improve the conservation status of the bridled nailtail wallaby by maintaining or expanding existing wild and captive populations, and establishing new wild and captive populations.	Mostly effective: an improvement in the conservation status has been achieved, but new populations have not been established since 2005, and one wild population (Idalia) has been lost
(1) Enhance or maintain existing free-range populations of bridled nailtail wallaby at Taunton and Idalia National Parks and Avocet Nature Refuge	Partly effective: one wild population (Idalia) has been lost.
(2) Establish two or more additional populations of the species (>100 individuals) in areas of suitable habitat, at a distance of >100 km from the existing free-range populations. This will demonstrate a positive rate of increase in the medium term ($\geq$ three years). At least one of the additional populations to be located in New South Wales and one on private land	Partly effective – Scotia was only a captive population in 2005 and is now well established, but genetic diversity is poor. However, no other new populations have been established since 2005. Plans are well under way to establish two new populations at Pilliga Forest and Mallee Cliffs. Population at Western Plains Zoo was lost with high mortality.
(3) A minimum of 5000ha of suitable habitat in the vicinity (100km radius) of Taunton National Park protected and managed in collaboration with landholders to promote natural and assisted dispersal and expansion of wallaby populations.	Partly effective: half this area was established as a corridor through recent project by FBA, but there is no continuation or follow-up of the project

Recovery team objective	Assessment and comments
(4) Areas of critical and potential bridled nailtail wallaby habitat identified and mapped within three years and protected under legislation within five years.	Not effective: no identification and mapping completed.
(5) Five or more additional landholders, community or industry organisations actively contributing to the implementation of recovery actions.	Effective: partnership includes more than five organisations actively contributing
(6) Maintain and enhance self-sustainable captive populations of bridled nailtail wallabies at appropriate institutions for translocations, sanctuary populations and public education.	Not effective, though there was one well-managed captive population until 2018 at Safe Haven. No populations for public education. Captive breeding programs not effectively managed or supported.
(7) Management guidelines published (within three years) based on the successful completion of key investigations completed under this and previous versions of the recovery plan.	Not effective: this has not been done
(8) Maintain a recovery group with high levels of community and agency stakeholder support and involvement that co-ordinates and reports on actions in the recovery plan in both the short and long-term.	Partly effective: no recovery group from 2005-2012; reconstituted recovery group shows good progress but may require better involvement

7.4 Have subprograms been effective?

The effectiveness of each subprogram has been discussed in Sections 3 to 6. This information is summarised in Table 12.

Table 12 The effectiveness of the sub-programs of the bridled nailtail wallaby program

Subprogram	Assessment
Subprogram one: Research, recovery coordination and recovery planning (section 3)	
<ul style="list-style-type: none"> Research and monitoring 	Effective: Large volume of relevant and applicable research has been completed; monitoring is undertaken but more could be publicly available.
<ul style="list-style-type: none"> Coordination and partnerships 	Partly effective: Has excellent potential and passionate participants but is inconsistent, with many issues and changing personalities.
<ul style="list-style-type: none"> Recovery plans 	Recovery plan was good but out of date
<ul style="list-style-type: none"> Community education 	Partly effective: No current community education programs from government; minor programs from NGOs, no coordinated effort.
Subprogram two: Protection of the wild population at Taunton (Section 3.3.1)	Mostly effective: threat level still high; populations greatly increased over 1974 levels; genetic diversity good
Subprogram three: Captive breeding and translocations (Section 5)	
<ul style="list-style-type: none"> Captive breeding and captive populations 	Not effective: no captive breeding populations as of August 2018
<ul style="list-style-type: none"> Translocation and management of population at Idalia NP (Section 5.2.1) 	Not effective: population no longer exists
<ul style="list-style-type: none"> Translocation and management of population at Avocet NR (Section 5.5) 	Mostly effective: threat level still high; population hanging on but genetic diversity medium to low.
<ul style="list-style-type: none"> Translocation and management of population at Scotia Reserve (Section 5.4) 	Mostly effective: Population increase has been very good; genetic diversity is low. Attempts at wild release have failed.
Subprogram four: Additional land acquisitions and community corridors in the Brigalow Belt	
<ul style="list-style-type: none"> Acquisition of further lands 	Not effective: no additional lands acquired
<ul style="list-style-type: none"> Working with landholders 	Partly effective: this work is not continuing

8. Compliance with the legislative and strategic framework

8.1 Compliance with legislation

Australian Government *Environmental Protection and Biodiversity Conservation Act 1999*: As mentioned in Section 2.2, the bridled naitail wallaby has been listed as Endangered by the Australian Government since 1980.

Under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), actions that have, or are likely to have, a significant impact on threatened species require approval from the Australian Government Minister for the Environment (the Minister). The Minister will decide whether assessment and approval is required under the EPBC Act. A significant impact is an impact which is important, notable, or of consequence, having regard to its context or intensity. Whether or not an action is likely to have a significant impact depends upon the sensitivity, value, and quality of the environment which is impacted, and upon the intensity, duration, magnitude and geographic extent of the impacts. The Australian Government entered in a Bilateral agreement with Queensland whereby the Commonwealth Environment Minister relies on the environmental impact assessment processes of Queensland in assessing actions under the EPBC Act. Of relevance to the bridled naitail wallaby, the proposed open cut mine in the Bowen Basin Walton (Walton Coal) will be assessed under the bilateral agreement. The proposed coal mine would impact on the Wallaby Lane Nature Refuge, which is adjacent to Taunton National Park and has been surveyed as a bridled naitail wallaby corridor. The Environmental Impact Statement process is currently underway.

In this context the bridled naitail wallaby program is compliant with the EPBC Act.

New South Wales *Biodiversity Conservation Act 2016*

As noted in section 2.2 bridled naitail wallabies are listed as “presumed extinct”. NSW legislation requires the development of a Biodiversity Conservation Program including strategies to achieve the objectives of the Program for each threatened species. As part of this program, NSW government has initiated a number of projects including *Reintroducing locally extinct mammals*. Bridled naitail wallabies are included on the list of potential species for re-introduction.

The bridled naitail wallaby recovery program is compliant with the Biodiversity Conservation Act 2016.

Queensland Government

Queensland *Nature Conservation Act 1994*: This species is listed as endangered in Queensland (*Nature Conservation Act 1992*) and is ranked as a critical priority under the [Back on Track species prioritisation framework](#) (Department of Environment and Resource Management, 2010).

Under the Nature Conservation Act, requirements are to conserve the (protected) wildlife and its values and, in particular to:

- a) *ensure the survival and natural development of the wildlife in the wild*
- b) *conserve the biological diversity of the wildlife to the greatest possible extent*
- c) *identify, and reduce or remove, the effects of threatening processes relating to the wildlife*
- d) *identify the wildlife’s critical habitat and conserve it to the greatest possible extent.*

The Nature Conservation Act also provides for captive breeding agreements between the State and other entities. Captive breeding agreements have been developed in the past for bridled nailtail wallabies, however there are no such agreements in place at present, and no captive breeding occurring. The bridled nailtail wallaby program is compliant with the NCA.

The Nature Conservation (Wildlife Management) Regulation 2006 outlines the management intent for endangered wildlife (Division 2 section 14). Table 13 details the management intent from the Regulation, and its application to bridled nailtail wallabies.

Table 13: Management intent for endangered wildlife under the Nature Conservation (Wildlife) Regulation 2006 (Division 2 section 14) and its application to bridled nailtail wallabies

Management intent	Has the management intent been met for bridled nailtail wallabies?
(a) to establish and maintain a database of information about the wildlife and its habitat	Effective
(b) to the extent practicable, to prepare and put into effect recovery plans or conservation plans for the wildlife and its habitat	Partly effective: Recovery plan out of date. Recovery plan has been partly implemented
(c) to seek funding to help achieve the objectives of the recovery plans or conservation plans	Partly effective: Funding has been inconsistent with changing programs
d) to take action to ensure viable populations of the wildlife in the wild are preserved or re-established	Effective: Actions have been undertaken to ensure viable populations in the wild. There is concern that translocated populations can only survive in fenced enclosures until long-term solutions can be found to feral predator problems.
(e) to cooperate with the Commonwealth and other State agencies—	
(i) for the ongoing protection and management of the wildlife and its habitat; and	Effective: Has been close working relationship with the Australian government. Strong relationship is required with NSW to ensure translocated populations are well managed.
(ii) to work towards a national conservation status for the wildlife and its habitat;	Partly effective: There is concern that the population in enclosures in NSW will result in the species being listed as Vulnerable, rather than Endangered. IUCN classification out of line with Australian and Qld.
f) to implement education programs for land-holders about—	
(i) threatening processes to the wildlife or its habitat; and (ii) the conservation of the wildlife and its habitat;	Partly effective: Educations programs with landholders and the community were funded and implemented previously. Current resourcing for these actions is limited.
(g) to regularly monitor and review the conservation status of the wildlife and its habitat;	Effective: Monitoring and review of the population numbers and health is regular
(h) to encourage scientific research and inventory programs likely to contribute to an understanding of the wildlife or its habitat including, for example, the requirements for conserving the wildlife or habitat;	Effective: Scientific research about the species have provided a solid basis for recovery. Recent work on the genetics of the species is an important step in future translocation projects

Management intent	Has the management intent been met for bridled naitail wallabies?
(i) to protect the critical habitat, or the areas of major interest, for the wildlife;	Partly effective: Core habitat of the species is protected through tenure (national park). Concern has been raised about the potential coal mine in a nature refuge adjacent to the national park.
(j) to monitor and review environmental impact procedures to ensure they— (i) accurately assess the extent of the impact, on the wildlife, of the activities to which the procedures relate; and (ii) provide for effective measures to mitigate any adverse impact of the activities on the wildlife; and (iii) if there is an adverse impact of the activities on an area in which the wildlife normally lives, provide for the enhancement of other areas where the wildlife normally lives.	Effective: Detailed pest management plans have been designed and implemented at Taunton National Park to protect the species from threats. Impacts from drought have been managed to date.

8.2 Compliance with strategic plan

Department of Environment and Science Strategic Plan 2018-2022.

The Departmental strategic plan offers little guidance in terms of objectives and strategies for protecting threatened species. Table 14 outlines the elements of the strategic plan of possible relevance to the management of threatened species, and the bridled naitail wallaby program.

The recovery work to date for the bridled naitail wallaby has been based on good science, and has been reliant on partnerships for its success. In this respect, the program is compliant with the department's strategic framework.

Table 14 Key elements of the Department of Environment and Science strategic plan 2018-2022 relevant to the bridled naitail wallaby program.

Government Objectives	DES Objectives	Our strategies	Outcome Indicators
Be a responsive government	Protection measures through robust policy, standards and insights	Set policy, underpinned by science to protect Queensland natural cultural and heritage values and systems	Not relevant to the program
	Partnerships assist betterment of natural and cultural assets	Engage with partners and communities to minimise negative interactions with wildlife and protect Queensland's ecosystems, habitats and species	Key natural values on priority national parks are maintained or improved

In summary, at the high level, the bridled naitail program is compliant with Queensland, New South Wales and Australian Government legislation. The best guidance for the management of threatened species is provided in the Qld Nature Conservation (Wildlife Management) Regulation 2006. Assessment of the effectiveness of the bridled naitail wallaby program against these requirements suggested that that program is effective in some areas, and only partially

effective in others. The recovery plan, which has no head of power and has not been up-dated for over 15 years, provides the details and strategic direction needed for the ongoing management of the species. While it is noted that the Queensland Government is not undertaking recovery planning, it is critical that a comprehensive, strategic, long-term plan and an associated implementation plan are developed. These plans need to be inclusive of the work being undertaken in NSW under the *Reintroducing locally extinct mammals* project.

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9. Conclusions and discussion

9.1 Answering the evaluation questions

In the Introduction (Section 1.2), we posed a number of evaluation questions. Our research has enabled us to answer these with a reasonable degree of confidence, though it must be stressed that the basis for this assessment has come from secondary sources, through papers, reports and interviews. A summary of the answers is presented here.

9.1.1 The problem and the history of the recovery program

What is the problem and what is the history of the recovery program?

The population of the bridled nailtail wallaby is small, and the range of free-living populations is extremely restricted, compared to its previous high population and wide distribution. The initial decline of the species was probably due to a combination of factors, including hunting and competition with pastoralism as well as the effects of introduced animals. The challenge for species recovery is compounded by the vulnerability of the species to predation, and its natural habitat being subject to severe droughts.

The history of the recovery program is summarised in Section 2.1 and the story of each subprogram is reported in Sections 3 to 6.

9.1.2 Status and trends

What is the current status and trend of the species? How has this changed over time?

The current status and trend of each of the populations is discussed in detail in Sections 2 to 5. Overall, the total population has increased substantially since the rediscovery of the species in 1974, with three populations, including one wild (at Taunton), one translocated but free-living (Avocet) and one translocated and fenced (Scotia). Numbers in each population have fluctuated widely (see Table 10), and one translocated population (Idalia) is now functionally extinct due to drought, predation and lack of adequate and timely interventions. All former captive breeding populations have either suffered predation (e.g. Western Plains Zoo) or been relocated (Safe Haven).

Although its status has improved during the recovery period, the bridled nailtail wallaby remain Endangered, in our opinion. Criteria met for Endangered classification according to the IUCN Red List (see Table 15) include criteria B2 (IUCN, 2012) because:

- There are only three subpopulations,
 - The subpopulations are widely separated, and the two free-living subpopulations are in small areas – this may qualify as ‘severely fragmented’, though the 2016 IUCN assessment did not consider this to be the case.
 - The free-living subpopulations fluctuate widely, with one becoming extinct over the last ten years. The number of individuals at Scotia have also fluctuated, having declined from a high of 3700 to a current estimate of 1700.
 - The total area of occupancy has declined with the extinction of the Idalia population.
- The species may also qualify as Endangered under Criteria C1, as there are less than 2500 mature individuals and only the single wild population has healthy genetic diversity¹⁹.

¹⁹ Note that the evaluation of the IUCN red list status included the Scotia population as it was considered to be self-sustaining. More recent genetic analysis has not supported this assertion from the viewpoint of genetic diversity.

Table 15: IUCN Criteria for Endangered as appropriate to bridled naitail wallabies

- B. Geographic range in the form B2 (area of occupancy):** Area of occupancy estimated to be less than 500 km², and estimates indicating at least two of a-c:
- a. Severely fragmented or known to exist at no more than five locations.
 - b. Continuing decline, observed, inferred or projected, in any of the following:
 - (i) extent of occurrence
 - (ii) area of occupancy
 - (iii) area, extent and/or quality of habitat
 - (iv) number of locations or subpopulations
 - (v) number of mature individuals.
 - c. Extreme fluctuations in any of the following:
 - (i) extent of occurrence
 - (ii) area of occupancy
 - (iii) number of locations or subpopulations
 - (iv) number of mature individuals.
- C. Population size estimated to number fewer than 2,500 mature individuals** and either:
- 1. An estimated continuing decline of at least 20% within five years or two generations, whichever is longer, (up to a maximum of 100 years in the future)
 - (ii) at least 95% of mature individuals in one subpopulation.
 - b. Extreme fluctuations in number of mature individuals

What are the past, current and anticipated threats to the bridled naitail wallaby and its habitat?
Threats to the bridled naitail wallaby are discussed in Sections 2.6 and are also outlined for each of the populations. The most serious threats are from predation, drought and the lack of genetic diversity, with invasive plants and disease also posing risks. Predation by foxes can rapidly decimate wallaby populations, while cats and wild dogs or dingoes can also cause very high mortality, especially during droughts when less cover is available. Other threats such as clearing of habitat have been reduced, but there are still proposals to further diminish the area of known habitat of the wallaby.

How are these threats being mitigated?

Supplementary feeding and provision of water during droughts is a necessary threat mitigation strategy at Taunton and Avocet, but no additional food is currently supplied at Scotia.

Predation by foxes, cats and wild dogs is avoided at Scotia through a well-maintained predator-proof fence, but the predation risk outside the fence is still very high and fox predation has resulted in the failure of release attempts (Hayward et al., 2012). Predators at Taunton are currently controlled through regular pest control programs. Pest control is also conducted at Avocet, where a fenced nursery area gives protection to vulnerable juveniles.

Are threats getting worse or being controlled?

While these predator control initiatives are critical, none have 'solved' the problems of cats and foxes, and dingoes are also regarded as a significant threat as long as the bridled naitail wallaby population is very small. Constant surveillance and control actions need to continue for the foreseeable future and these will continue to impose a high cost in time and resources. Some ecologists consider a goal of reintroduction programs (and presumably other conservation programs) 'must be to achieve a self-sustaining population that does not require ongoing management in the form of predator exclusion or control' and argue for 'a long-term perspective

that enables prey to develop anti-predator defences while protecting populations and avoiding their rapid decimation and extinction.’ (Moseby et al., 2015, p. 37). This is a highly desirable objective in the long term, but until this can be achieved, the level of threat to the bridled nailtail wallaby from predators must be regarded as very high.

The threat from droughts is expected to become more severe with climate change impacts, and increased temperatures exacerbate drought impacts. The effect of drought on bridled nailtail wallabies can be mitigated through supplementary feeding and provision of water, as well as increased predator control, but the threat will remain high until the population has increased substantially.

9.1.3 Impact evaluation

To what extent is the current status and trend attributable to the recovery program?

As discussed in Section 7, the recovery program is assessed to have had a **very positive impact** on the population of the bridled nailtail wallaby. There is little doubt that without the interventions since 1974, the species would now be Critically Endangered or Extinct in the Wild.

Which aspects of the recovery program have contributed to different extents and how?

The impacts of the different subprograms have been assessed in Sections 3 to 7, and their effectiveness of each is summarised in Table 12.

What additional impacts can be attributed to the recovery program (both intended and unintended)?

An important additional impact has been the provision of opportunities for many students, other researchers and volunteers to gain experience working with a threatened mammal, including through translocation programs.

9.1.4 Resources and roles

To what extent has the bridled nailtail wallaby program demonstrated efficient and economical use of resources?

Detailed information about resource inputs for the recovery program is not available, but the experience to date indicates a mixed result in terms of efficiency. Many parts of the recovery program have been conducted with meagre resources and have operated very efficiently, due largely to the ‘above and beyond’ efforts of field officers and volunteers. However, some serious inefficiencies have occurred, often due to changing priorities and staff, and poor interactions among partners. On a number of occasions such inefficiencies have meant that major investments into specific projects have had no long-term results. Inconsistent decision-making and the failure to act swiftly at critical junctures have undermined the efficiency and effectiveness of the program (see Table 11 and Table 12).

Are the roles and responsibilities of the bridled nailtail wallaby program partnerships relevant and effective in achieving improved conservation of the wallaby? How could these be improved?

As discussed in Section 3.2, partnerships are critical for the recovery program, and the re-constitution of the recovery group in recent years has been a very positive step. Overall, much better outcomes could have been achieved, both in terms of the bridled nailtail wallaby and social capital (cooperation, trust and goodwill), if positive relationships between partners had been consistent.

Is the role of DES in bridled nailtail wallaby recovery aligned with the department’s strategic priorities and obligations under the NCA and other legislation?

This alignment has been thoroughly reviewed in Section 8. In summary, DES has clear obligations under the NCA and associated regulations to conserve the bridled nailtail wallaby and its habitat. As the state with the only wild population, Queensland has an obligation to lead the recovery program in the foreseeable future in conjunction with other government and non-government partners.

9.2 Factors for success

Our assessment of the recovery process for the bridled nailtail wallaby has shown that the program's overall impact has been effective in improving the species numbers, but the program has not been an unqualified success. It appears that a much greater impact might have been achieved with a better level of institutional support and coordination, not only in terms of resourcing but of policy directions and cooperation. While a higher level of financial resourcing would have been useful, on a number of occasions relatively small investments would have saved much greater wastes of resources.

Characteristics of the successful recovery of species in Australia have been summarised by Garnett et al (2018, p. 315) as:

- *The recovery effort is strategically planned*
- *The recovery effort is implemented by an effective and representative group of stakeholders*
- *There is an enduring champion who brings long term commitment*
- *The legislative and policy settings support and commit to the recovery effort*
- *Resources are adequate and continuous*
- *The recovery effort is well-grounded in evidence, monitors progress and is adaptive as needed*
- *The story of the species, its conservation needs and its recovery progress is well told.*

In this section we consider how well the bridled nailtail wallaby recovery process to date has matched up with these success factors, and in the next section we will recommend future directions and improvements.

9.2.1 Strategic planning

Recovery planning for the species began in the 1970s, and formal recovery plans were in place from the early 1990s until 2009. These plans have been important for the survival of the bridled nailtail wallabies in the wild in Queensland. As outlined in Section 3.3, the recovery plans have provided good guidance, and the most recent plan (2005-2009) is a strong, well written and comprehensive document.

The Australian government no longer requires recovery plans for threatened species. Recovery planning is a legislative requirement in Queensland, but there is currently little support for the process. It is difficult to see how the recovery of the bridled nailtail wallaby can progress without a planned and documented approach, especially where many partners are involved.

Improved and detailed policies and direction for captive breeding and translocation would be valuable as part of the recovery plan development. This is especially evident as some issues relating captive breeding and translocation have not been well managed over recent years, and sound transparent management will be critical in the establishment of all new populations, including those about to be established in NSW. The recently completed genetic management plan provides key guidance and a solid scientific basis for proceeding. Translocation plans for

NSW protected areas also provide good guidance, but there is no plan for reintroductions or captive breeding in Queensland and this is an obvious gap. The inclusion of a risk management approach has been lacking in the management of bridled naitail wallabies to date. Modern recovery planning should be grounded in the principles of adaptive management, to enable agile responses to crises and opportunities. The 'open standards' approach to planning and evaluation, which has been adopted by many conservation organisations, provides a useful approach (Conservation Measures Partnership, 2013).

9.2.2 Partnerships, stakeholders and champions

The involvement of partners and key stakeholders has been highly variable over the time since the bridled naitail wallaby was rediscovered. Early champions were critical in rapidly securing the conservation of Taunton, an action that was vital to the species' survival. The involvement of partners has resulted in activities such as the establishment of bridled naitail populations at Idalia, Avocet, Scotia, Western Plains Zoo and the Gregory Mine. The fact that some of these locations failed was in many instances because the partnerships were not maintained, or the objectives of the partners were not well aligned. As discussed in Section 3.2, partnerships with the Fitzroy Basin Association, Australian Wildlife Conservancy and Wild Mob and with landholder Hugo Spooner have been critical. However, poor relationships have resulted in the withdrawal of AACE from the recovery program, and considerable concerns raised by the owner of Avocet Nature Refuge. For the recovery of the species to be successful, efforts need to be made to ensure that partnerships with conservancies, FBA and other interested partners are strong and inclusive.

Changes in staff at central office, *"the revolving door of managers"*, is perceived by some stakeholders to be highly detrimental to the partnerships, though some staff at local level are recognised for their ongoing commitment and dedication. The feelings of many participants in this program were succinctly expressed by one partner: *"We need to listen to people 'on-ground' much more. Recovery has been overtaken by bureaucracy in capital cities"* (interview, name withheld, August 2018).

Queensland has the only population of wild-living bridled naitail wallabies and the only current population with a high level of genetic diversity. While expertise and knowledge about bridled naitail wallabies are spread across a number of individuals and organisations, the staff within the Department of Environment and Science (QPWS and the TSP) are best placed to continue coordination of the program and on-ground activities at Taunton and Avocet. As expertise is gained in NSW, there may be an opportunity for some of the program coordination responsibility to be shared, but at this stage, DES is best placed to continue with this role.

9.2.3 Legislative and policy settings

Legislation provides the basis for the listing of the bridled naitail wallaby as an Endangered species. The Australian, Queensland and NSW governments all have different legislative requirements for the management of threatened species. Queensland's Nature Conservation (Wildlife Management) Regulation 2006 has the most prescriptive requirements for the management of the species (Section 8.1).

The Australian Government move away from requiring recovery plans, and the prioritisation of 20 mammal species, may result in greater difficulties in gaining support and funding for bridled naitail wallabies. The previous Australian Government funding and support, based on the need for recovery plans and their implementation, was critical in establishing the recovery objectives and implementing actions.

Any policy that the Queensland Government would not support recovery planning would be in contradiction to the NC Regulation which requires the following for all listed Endangered species *“to the extent practicable, to prepare and put into effect recovery plans or conservation plans for the wildlife and its habitat”*.

9.2.4 Resources are adequate and continuous

It is apparent that continuity of funding has been a key issue in the recovery of the bridled nailtail wallaby. Following the high level of support for the Australian government in the 1990s, there is now little public funding allocated to management or research. Over time, the reliance on partners including individuals, small business and community groups has grown and the sustainability of this model is not clear. The conservancies have assumed a greater role in the recovery program, and it has been postulated that the comparatively steady and reliable resourcing of their efforts fits them best to undertake some tasks, such as translocations (Kanowski et al., 2018). However, it would also seem important to ‘spread the risk’s through several partners being funded to undertake recovery work.

Factors that have been raised by stakeholders relating to dispersal of funding include the lack of delegation to local staff, to the extent that experienced staff need to seek high-level approval for even very minor purchases. This lack of trust appears unwarranted and wasteful. Continuity and certainty are key issues, as gaps in funding for activities such as predator control can be disastrous.

Human resources for the recovery program in the field within the Queensland Government are barely adequate, but the more serious problem has been the lack of ability to backfill and cover for people when on leave, and lack of delegation of decision-making. It appears if measures had been in place for adequate backfilling of park management and threatened species staff at Idalia National Park, the crises leading to the local extirpation of bridled nailtail wallabies would have been avoided.

9.2.5 Good science, monitoring and adaptive management

Scientific research about the species has provided a solid basis for recovery, providing applicable and useful results for management. Recent work on the genetics of the species is an important input for future translocation projects. Annual monitoring using compatible techniques is a key element tracking the success or otherwise of the recovery of the bridled nailtail wallaby. Adaptive management to enable quick and appropriate actions is necessary, from a strategic planning perspective and an on-ground management perspective. For example, earlier action at Idalia may have prevented the loss of species there and a more rapid response would have prevented mass mortality from foxes at the Western Plains Zoo. Transparency, accountability and clear documentation about recovery actions is necessary for both government and donor-funded organisations, and is critical for learning from mistakes as well as from successes.

9.2.6 Good story telling

The story about the finding and recovery of the bridled nailtail wallaby is worth telling. Communication and education about species, its habitat and threats has declined over the past 15 years as budgets have become tighter, and actions have been prioritised. As one stakeholder commented, *“the posters about bridled nailtail wallabies are over 20 years old”*. Improved communication and education about the recovery program have the potential to secure additional funding, as well as encouraging local landholders to participate in feral animal control and the development of corridors and revegetation of key habitat.

10. Recommendations and future directions

Under the Nature Conservation (Wildlife Management) Regulation 2006 the Queensland Government is required to **maintain wild populations** of bridled naitail wallabies, if at all possible. The following recommendations for the Department of Environment and Science are made on this basis.

1. Continue to support survival of the species in the wild, as per the requirements of the Nature Conservation (Wildlife Management) Regulation 2006. Allocate on-going and reliable **funding** for key actions in threat management to support, at a minimum, the populations at Taunton and Avocet. Continue as a matter of priority to protect wild populations of bridled naitail wallabies, especially through controlling cats and foxes, and where necessary dingoes and wild dogs. Respond rapidly to emerging threats.
2. Ensure sufficient **capable and qualified staff** are allocated to the conservation of the bridled naitail wallaby, that there is good cooperation among staff from different areas of operation, and that positions are always backfilled. Empower local staff to make decisions and have financial responsibility as appropriate to their level of competence. Provide local contingency funds to cover urgent on-ground needs as they arise in line with recovery objectives.
3. Re-invigorate a strong, diverse and balanced **recovery group**, using the Australian Government guidelines (Commonwealth of Australia, 2017). The group must meet regularly and have a clear understanding of the objectives and actions for the recovery of the species. Consider appointing an independent chair of the recovery group, elected by members (as specified in the guidelines), rather than relying on the Queensland Government staff to undertake this role. Ensure this group is able to make decisions and is able to effect outcomes in a timely manner when issues arise, including through out of session discussions. An important role of this group is to update the recovery plan as outlined below. Members should be supported to attend meetings, depending on their institutional resources. Another important role of the group is the open sharing of information, including problems and solutions: cross-visits by land managers to other sites could be supported. An annual report of the species' status at all sites should be prepared and this should be publicly available on websites of all the organisations concerned.
4. Urgently update the **recovery plan** to outline objectives, key actions and strategies over the next 10-20 years. Ensure that information about the proposed populations in NSW is included, and that the recovery plan incorporates principles and actions for adaptive management. Identify key risks that may impede achieving the outcomes and undertaking the actions. Develop risk management strategies to deal with such issues in the plan.
5. Develop **strong partnerships**, in particular with people and organisations with a long-term commitment to involvement and protection of the species. Ensure these partners understand their responsibilities and agree on the outcomes to be achieved. Develop memorandums of understanding or similar documents with partners. Treat all partners with respect and consider that some who make very valuable contributions may have limited time and financial resources. Ensure contributors are acknowledged frequently for their efforts. Support the work of non-government organisations and conservancies

to protect the species and actively seek opportunities for cooperation and sharing of information.

6. Develop a very clear strategy for any **captive breeding**, including the purpose and time frame of the captive breeding, the genetics and source of founders for the captive breeding, the number of individuals required, and the locations to which the progeny will be sent. A risk management strategy should be developed for captive breeding addressing issues such as failure to breed, successful breeding leading to excess progeny, and disease.
7. **Secure facilities** suitable for captive breeding to enable successful reintroduction of the species to suitable locations as outlined below and in the genetic management plan. A modern and appropriate captive breeding agreement must be made available to partners willing and able to undertake captive breeding according to the requirements for the translocation of bridled naitail wallabies. The agreements need to have flexibility to cope with changed circumstances, and support needs to be provided where necessary in a short timeframe. Consider actions in the case of organisations withdrawing from captive breeding at short notice.
8. Secure **additional translocation sites** within Queensland, where possible using existing protected areas (managed by QPWS or conservancies) where there are suitable facilities and pest control programs. Engage with Bush Heritage Australia to determine the appropriateness of Goonderoo as a translocation site. Review information about other protected areas within the bridled naitail range that have suitable habitat and already have strong predator control. Consider properties that have different climatic conditions to that of Taunton, to take the best advantage of variable seasons. Consider additional acquisitions where appropriate, and work with local landholders to secure corridors for safe dispersal of animals. Follow the most up-to-date advice for translocation, and ensure that releases occur in good conditions and with extensive predator control.
9. Boost **public education** and communication about bridled naitail wallabies, to raise awareness and encourage support for the species. This may include supporting some animals to be displays in captivity (ambassador species), and this may include those from poorer genetic stock, that have been deemed to be unsuitable for future wild release. Continue to cooperate with programs involving volunteers, including those working through other agencies.
10. In recognition of the need for additional **funding**, develop a prospectus for how philanthropic organisations, industry and the public can contribute to recovery of the species through programs prioritised by the recovery group. Develop a range of projects for university students to undertake that support the recovery objectives.
11. Retain the **listing** of the species as Endangered until additional wild populations are established and fully stabilised through a range of seasons.
12. Continue to support research and to apply new information and innovative ideas in bridled naitail wallaby management and recovery, especially relating to threat mitigation techniques. Fully engage with research relating to feral predators and about the ecology of dingo populations, and incorporate this into approaches for new and existing populations of bridled naitail wallabies. Also research methods to encourage or

facilitate animals to disperse to areas of suitable habitat (for example at Taunton and Avocet/ Goonderoo, where this does not appear to occur as much as expected)

13. Implement the **genetic management plan**, including the establishment of populations in Pilliga and Mallee Cliffs that are from genetic stock with higher allelic diversity. Consider removal of some animals from the wild at Taunton during conditions where populations appear to be exceeding the local carrying capacity. Continue to monitor genetic make-up of populations, and immediately obtain necessary information for the optimal management of the animals recently removed from Safe Haven.
14. Document all learning relating to captive breeding, translocation and management of wild populations in a succinct set of **guidelines** for future managers.

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