A stocktake of recovery activities undertaken for the Orange-bellied Parrot (Neophema chrysogaster)

Prepared by BirdLife Australia for
Department of the Environment and Energy

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Cover photos: Top – Orange-bellied Parrot nestlings, Gemma Deavin. Bottom – Adult Orange-bellied Parrot, Chris Tzaros.

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2. Acknowledgements

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Photo: Chris Tzaros

3. Executive Summary

The Orange-bellied Parrot (OBP) is a Critically Endangered migratory parrot, endemic to south-eastern Australia. Significant declines in the population prompted the formation of the Orange-bellied Parrot Recovery Team (OBPRT) in 1983. Despite considerable commonwealth investment and continued recovery efforts throughout its range, on-going declines have reduced the wild population to less than 20 birds and the species is at real risk of extinction in the wild. Consequently, the OBP has been included as one of 20 priority bird species in the Australian Government's *Threatened Species Strategy Action Plan* 2015-16.

In order to better coordinate efforts and to inform future investment through the Threatened Species Prospectus, the Office of the Threatened Species Commissioner has identified the need for a stocktake of the past and ongoing OBP recovery projects and an independent review to identify gaps in the program and to explore alternative recovery models.

Project Scope

BirdLife Australia were engaged to undertake a comprehensive stocktake of OBP recovery activities to date (both past and present) including consideration of the feasibility of the OBP Threatened Species Prospectus project to be provided to a qualified independent Expert Review Panel for assessment. The project included:

- Consultation with key stakeholders involved with the OBP recovery program
- Identification of previously-implemented management actions and outcomes
- Identification of current and potential management actions for the future
- Identification of barriers to recovery efforts
- Identification of knowledge gaps
- An independent review of recovery efforts to date

Findings

The OBPRT currently consists of several sub-groups including the Strategic Action Planning Group (SAPG, responsible for making all of the decisions in relation to recovery efforts), the Captive Management Group (CMG, responsible for providing advice on and facilitating the management of the captive insurance population) and the Veterinary Technical Reference Group (VTRG, responsible for providing veterinary information, advice and support to the OBPRT and SAPG). The species is currently managed as two separate populations: a wild population (management is split into breeding and non-breeding components) and a captive insurance population including releases of captive-bred birds to supplement the wild population.

Identified threats to the OBP include habitat loss and degradation, predators and competitors, stochastic factors, disease, climate change, negative effects of management, invasive weeds, barriers to movement, hybridisation and trapping. It is not currently known to what extent each threat has on the populations.

Five Recovery Plans (generally covering five-year periods) and two Emergency Action Plans have been published since 1983. Time lags have been present between formal acceptance and publication of superseding plans due to editing, consensus issues and requiring approval from

relevant organisations across three States. There has generally been a lack of reporting on the outcomes of recovery actions listed in each recovery plan, with no instances occurring where the objectives and criteria within a recovery plan have been fully met with many actions not being attempted. Critical knowledge gaps are still evident, particularly in relation to the causes of the ongoing population decline, and potentially contribute to the failure of achieving recovery objectives. The 2006-2011 recovery plan was produced under the assumption that the wild population was stable but limited by the quality and extent of the winter habitat which was proven incorrect in 2010 through the analysis of all available data.

The OBP recovery program has experienced numerous barriers throughout its existence preventing successful delivery of the recovery plans for both the wild and captive populations. These have included:

- Inconsistent and inadequate funding and resources (no recovery plan has been fully funded)
- Small population size
- Declining genetic diversity associated with a small population
- Lack of space availability for the captive population preventing the target population size being reached
- Failure of captive releases transpiring due to operational constraints, resource limitations and/or inadequate numbers of fledglings available
- Low chick survival rates within captivity
- Dependency of wild birds on supplementary food in the breeding grounds which may be affecting foraging behaviours and survival
- Inappropriate climate conditions in captivity which may impact breeding success
- Lack of advances in technology allowing OBPs to be tracked to increase knowledge of key aspects of OBP ecology, habitat use and threats to survival
- Varied effectiveness, commitment and cohesiveness of the OBPRT at times
- Politics including challenges of integrated management, governance and delivery of recovery efforts particularly when spanning across multiple States and jurisdictions
- Lack of communication and transparency within the OBPRT, between stakeholders and with the public
- Short timeframes between the need to develop and finalise protocols, make decisions and implement recovery actions
- Decline in volunteer support
- Lack of understanding surrounding key factors responsible for population declines
- Lack of appropriate, timely data analyses and absence of a centralised, dynamic database

Available evidence implies that OBP recovery will now rely on:

- Population supplementation from an effective captive-breeding program, using strategies that have the greatest impact on wild population size and the least impact on effective captive population size
- Identification and effective treatment of the causes of low female survival, noting mortality may occur year-round (data may have previously been mis-interpreted as low female breeding participation)
- Identification and effective treatment of the causes of low juvenile survival during their first non-breeding season
- Maintenance of sufficient habitat in the breeding and non—breeding ranges to support the long-term recovery objective of a wild population that, with limited species-specific management, has a high likelihood of persistence in the wild for 100 years
- Management of threats limiting population growth in the breeding and non-breeding ranges
- A well-coordinated and collaborative recovery program allowing partners to make effective contributions across the program

After consultation with key stakeholders, existing and potential management actions for the recovery of OBPs were identified and reviewed by an independent Expert Review Panel. The Expert Review Panel reviewed all presented management actions, scoring each one out of ten based on the following criteria:

- Impact: the overall impact that the management action is likely to have on the recovery of OBPs
- Feasibility: practicability of the management action being implemented
- Value: value for money of implementing the management action
- Likelihood of success: the probability that the management action will be successful in achieving the desired outcome
- Overall rating: a summary of all of the assessment categories generated by adding the values from the previous four criteria

Scores from all reviewers were averaged and presented as a percentage with the associated standard deviation (an indication of the spread of scores from the reviewers; a high standard deviation signifies large differences in opinion between reviewers out while a low standard deviation signifies reviewers scored similarly). The ten top scoring management actions for the future recovery of the species are presented in Table 1.

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Table 1: The ten top potential and existing management actions identified by key stakeholders for OBP recovery as scored by the independent Expert Review Panel. Scores are presented as a percentage across reviewers and standard deviations are presented in brackets.

Management action	Impact (%)	Feasibility (%)	Value (%)	Likelihood of success (%)	Overall Total (%)
Maintain the current captive-breeding facilities and provide required medical, food and staff resources (as outlined in the Threatened Species Prospectus)	100 (0.0)	96.7 (0.6)	96.7 (0.6)	93.3 (1.2)	**96.7**
Continue intensive monitoring of all wild nests through direct observations and motion cameras	93.3 (1.2)	80 (2.0)	96.7 (0.6)	93.3 (1.2)	**90.8**
Secure funds for a permanent full-time Recovery Project Coordinator	90 (0.00)	90 (0.00)	100 (0.00)	80 (0.00)	**90**
Implement regular patch-burning at known and potential OBP breeding locations	96.7 (0.6)	60 (1.7)	96.7 (0.6)	90 (1.0)	**85.8**
Establish a large captive-breeding facility at 5 Mile Beach, Tasmania	85 (0.71)	95 (0.71)	70 (1.41)	85 (0.71)	**83.8**
Investigate the potential of unoccupied habitat near Melaleuca to be used as extra release sites	95 (0.71)	80 (2.83)	100 (0.00)	65 (2.12)	**83.8**
Implement and coordinate monitoring, maintain regular analyses and report results in a timely fashion	80 (0.00)	80 (1.41)	85 (0.71)	90 (0.00)	**83.8**
Increase the number of captive-bred birds released into the wild each year	93.3 (0.6)	73.3 (2.5)	90 (1.0)	80 (2.0)	**82.5**
Construct quarantine and extra captive-breeding facilities (as outlined in the Threatened Species Prospectus)	96.7 (0.6)	63.3 (4.0)	83.3 (2.9)	86.7 (2.3)	**82.5**
Develop and implement a communications plan to service the information requirements of a range of stakeholders with coordinated communications products including the public archiving of documentation	90 (1.7)	63.3 (3.8)	90 (1.7)	86.7 (1.5)	**82.5**

4. Species information

4.1 Conservation status

The Orange-bellied Parrot (OBP; *Neophema chrysogaster*) is one of Australia's most threatened bird species and is protected by Commonwealth and State legislation across its entire range. The OBP was originally listed as 'Endangered' under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and was uplisted to 'Critically Endangered' in 2006. It is listed as 'Endangered' in Schedule 3 of the Tasmanian *Threatened Species Protection Act 1995*, in Schedule 1 of the New South Wales *Threatened Species Conservation Act 1995* and Schedule 7 of the South Australian *National Parks and Wildlife Act 1972* and is listed as 'Threatened' under the *Victorian Flora and Fauna Guarantee Act 1988* (DELWP, 2016). The OBP was first listed on the International Union for Conservation of Natures *Red List* (IUCN; BirdLife International, 2015) in 1988 as 'Threatened', and was uplisted to 'Endangered' in 1994 and 'Critically Endangered' in 2002. The species is also listed as one of the 20 priority bird species in the Australian Government's Threatened Species Strategy *Action Plan 2015-16* (Australian Government, 2015).

The OBP population has experienced a steady decline in numbers from the 1920s (Brown & Wilson, 1980; Menkhorst et al., 1990; OBPRT, 1999). The number of birds counted on the mainland during the coordinated winter count weekends was relatively stable throughout the 1980s (between 70-90 birds each year with 122 OBPs counted in 1983) but declined to less than 20 birds being counted each year since 2001 and less than 10 in the last five years (Birds Australia, 2009; White et al., 2016). This corresponded with an annual 12% decline in population numbers between 2000 and 2008 (Pritchard, 2014). The extent of this decline was not detected at the time as population estimates were based on summer counts in Tasmania where the minimum number of adults present during the breeding season at Melaleuca appeared to have remained relatively stable (DELWP, 2016).

Between 1990 and 2006, annual survival, as measured from the resightings of banded birds at their breeding grounds (Melaleuca), averaged 65% for adults and 56% for juveniles and included significant but unexplained inter-annual variation (Holdsworth et al., 2011). The population size has fluctuated over recent years with juvenile survival over winter declining to 16% in the last three years. Between 1988 and 2008, the population comprised of approximately 100 birds (Holdsworth et al., 2011). In 2010, it was estimated that less than 50 individuals remained in the wild population and it was predicted that the species would be extinct in the wild in 3-5 years (OBPRT, 2010a; Martin et al., 2012). In the 2016/17 breeding season, the species consisted of a single wild population comprising 17 individuals, only four of which were female of which one was a returning captive-released bird (DPIPWE, pers. comm.). At the start of December 2017, three females and 13 males had returned to the breeding grounds. Prior to 2011, the quantity and sub-optimal condition of winter habitat was thought to be responsible for the high mortality rates and subsequent population declines, with winter survival deemed more important than reproductive efforts (Menkhorst et al., 1990; Drechsler et al., 1998). More recent analyses however suggest that low female breeding condition and participation between 2000 and 2010, which may have been caused by low food availability from the prolonged millennium drought and habitat loss on the mainland, has driven the population decline due to low recruitment levels in the wild population (Holdsworth et al., 2011; Martin et al., 2012; Holdsworth, 2015).

Management of OBPs began in 1984 through the implementation of several national recovery plans and emergency action plans in response to the wild population declining by approximately 90% over the last two decades (Brown & Wilson, 1984; Menkhorst et al., 1991; Commonwealth of Australia, 2016; Parks and Wildlife Service, 2016). The two main objectives of the plans have been to increase the wild population size and minimise further population declines.

However, the continued lack of comprehensive knowledge surrounding survival of OBPs (e.g. threats, habitat use, migration routes) is a key limiting factor affecting the recovery effort (OBPRT, 1999; DELWP, 2016). It is unlikely that all of the factors causing the decline in numbers have been identified.

4.2 Ecology

The OBP is one of six small grass parrots comprising the genus *Neophema*. This small (45-50 g) parrot is a highly-specialised coastal species (i.e. narrow niche), which annually migrates between breeding (south-western Tasmania) and non-breeding (coastal mainland Australia) ranges.

OBPs spend the majority of the day foraging for food on the ground or climbing on plants (Stephenson, 1991; Higgins, 1999). They prefer to forage in areas containing clumps of preferred food plants which are interspersed with patches of bare ground enabling access to the plants (White et al., 2016). Time spent foraging is greatest during the early morning. OBP diet consists of fruits, seeds and growing tips of herbaceous or shrubby saltmarsh vegetation, sedges, grasses and chenopods as well as introduced grasses and weeds growing in adjacent pastures or along access tracks (Higgins, 1999; Loyn et al., 1986). Diet varies within and between seasons and habitats (Brown & Wilson, 1984). During the breeding season, food availability is dependent on maintaining a mosaic of moorlands of differing age classes through controlled fire regimes with birds appearing to prefer vegetation with a time-since-last-fire of 1-8 years (Brown & Wilson, 1980). During the non-breeding season, food availability is dynamic with different plants seeding at different times and locations throughout winter. The inclusion of exotic weed species in the winter diet may reflect the lack of availability of native food plants during this period (Loyn et al., 1986). In Victoria, a shortage of seeds is likely to occur in most years during the critical mid-winter months especially as some sites become temporarily unavailable due to tidal inundation (Loyn et al., 1986; Ehmke, 2009; Ehmke & Tzaros, 2009). In South Australia, strandline plants (those growing above the shoreline and on sand dunes) are equally important in the OBP diet as pasture and saltmarsh vegetation (Gibbons, 1984; Casperson, 1995). Grazing, shell-grit extraction and construction of salt evaporation pans have greatly reduced the capacity of saltmarsh communities to provide an adequate source of food for OBPs throughout winter (Loyn, 1982; Yugovic, 1984). OBPs are now likely to require a wider range of winter feeding sites encompassing a wide range of food plant species than what was traditionally used to provide sufficient sustenance throughout winter (DELWP, 2016).

The mean lifespan of wild birds is estimated to be 2.71 years with the maximum age recorded being 10 years having successfully completed the Bass Strait migration 20 times (Holdsworth et al., 2011). In captivity, the mean life expectancy is 8-10 years, with the maximum recorded being 15 years (Holdsworth, 2006; Hockley & Hogg, 2013; CMG, 2017). In 2011, analyses of the 1990-2009 complete demographic dataset from the capture-mark-recapture data using Cormack-Jolly-Seber models indicated that maximum survival occurs in the second year and declines thereafter (only preliminary investigations had occurred prior to this; Holdsworth et al., 2011). Survival of adults is higher than that of juveniles with mortality assumed to be the highest during the first northern migration of these inexperienced individuals (Holdsworth et al., 2011). OBP survival rate represents a Type II survivorship curve (individuals experience an approximate constant probability of survival and mortality rate regardless of age) signifying a continuous probability of death (Holdsworth et al., 2011).

Despite significant research, the ecology of OBPs, including the factors influencing mortality, is still not fully understood.

4.3 Distribution

The historic breeding range of OBPs encompassed plains near the coastline along south-western Tasmania extending from Macquarie Harbour south and east to Louisa Bay and reaching up to 30 km inland (Brown & Wilson, 1980). More recently, the breeding range was restricted to a narrow (approximately 200 km) coastal strip between Louisa Bay and Birchs Inlet (Figure 1; Holdsworth, 2006). Since 2008, despite the occurrence of apparently suitable habitat across most of the historic breeding range, since 2008 OBPs breeding has only been detected at Melaleuca within the Tasmanian Wilderness World Heritage Area (in an area <4,000 ha; Weston et al., 2012; M. Holdsworth, unpubl. data).

Following the breeding season, the entire population of OBPs migrates north across the Bass Strait (consisting of an approximate 200 km ocean crossing) to spend the winter season in coastal Victoria and South Australia, with some aberrant historic records (n=3) occurring in New South Wales (Brown & Wilson, 1980; Drechsler et al., 1998; Smales et al., 2000). Migration from Tasmania follows the western coastline of Tasmania and islands throughout the Bass Strait including King Island (Figure 1; Holdsworth, 2006; Holdsworth, 2015). It is a largely uncoordinated, asynchronous event which can take several months to complete with birds stopping to forage in coastal dunes and saltmarshes including a possible stop-over of up to four weeks on King Island (Holdsworth, 2015). The main crossing of Bass Strait is thought to occur within a day during favourable southerly winds (Holdsworth, 2015). The majority of adult birds leave the breeding grounds in February two to three weeks after fledging occurs and will arrive on the mainland between March and April (Brown & Wilson, 1984; Starks et al., 1992; OBPRT, 2006a). Juveniles begin their migration in mid- to late-March (Higgins 1999; OBPRT, 2006a). The return migration trip is more rapid, with birds known to complete the journey from Victoria to the breeding grounds in two days using north-westerly gales between September and November (McCarthy, 2012; Holdsworth, 2015). In recent years, the period of arrivals has extended from early September through to January (Troy, 2017). In most years, only 40-50% of the birds that left on the northern migration return to Melaleuca to breed in the following season (Parks and Wildlife Service, 2016).

During winter, individuals are widely dispersed along the coastline (encompassing approximately 2,000 km and 90,000 ha) between south-eastern South Australia and coastal Victoria, often inhabiting remote areas (Figure 1; Starks et al., 1992; OBPRT, 2006b; Jensz & Reid, 2008; Weston et al., 2012). Birds are semi-nomadic during the non-breeding season, with the majority of observations occurring within 1 km of the coastline (less than 2% of observations have occurred further than 2 km from the coastline; BirdLife Australia, unpubl. data). Banding studies have revealed that individuals typically occupy the same mainland sites annually (Holdsworth, 2015).

In Victoria, 70% of the population has historically been distributed annually between three main sites in western Port Phillip Bay and the Bellarine Peninsula: Swan Bay (including Swan Island), Lake Connewarre and the Western Treatment Plant (WTP) in Werribee encompassing Point Wilson and the Murtcaim Wildlife Area (Brown & Wilson, 1980; McMahon et al., 1994; DELWP, 2016). These areas are still currently used by the wild population with the WTP currently being the only reliably used winter site each year. Elsewhere in Victoria small numbers of individuals have previously been regularly reported from Discovery Bay, Corner Inlet, Western Port Bay and the Bass Coast, typically early in the non-breeding season which may indicate possible arrival points from migration (McMahon et al., 1994). Less than 2% of the observed wild OBP population on the mainland has been recorded east of Port Phillip Bay (BirdLife Australia, unpubl. data).

In South Australia, large flocks of OBPs were observed on the Yorke Peninsula and near Adelaide in the 1800s (Brown & Wilson, 1980). From the 1900s, OBPs were largely distributed

between Coorong Lower Lakes and the Victorian border with fewer observations occurring over time (OBPRT, 2006b). Despite the recent absence of regular observations in South Australia, coastal habitat in this region was historically important to the population (Brown & Wilson, 1980).

The mainland distributional range of OBPs has contracted over the last few decades with individuals no longer being documented west of the Murray River in South Australia, east of Jack Smith Lake in South Gippsland, Victoria, or in New South Wales during winter (OBPRT, 1999). Range sizes have also contracted at a localised scale over the last three decades which is likely a reflection of declining population size (Hill, 1993).

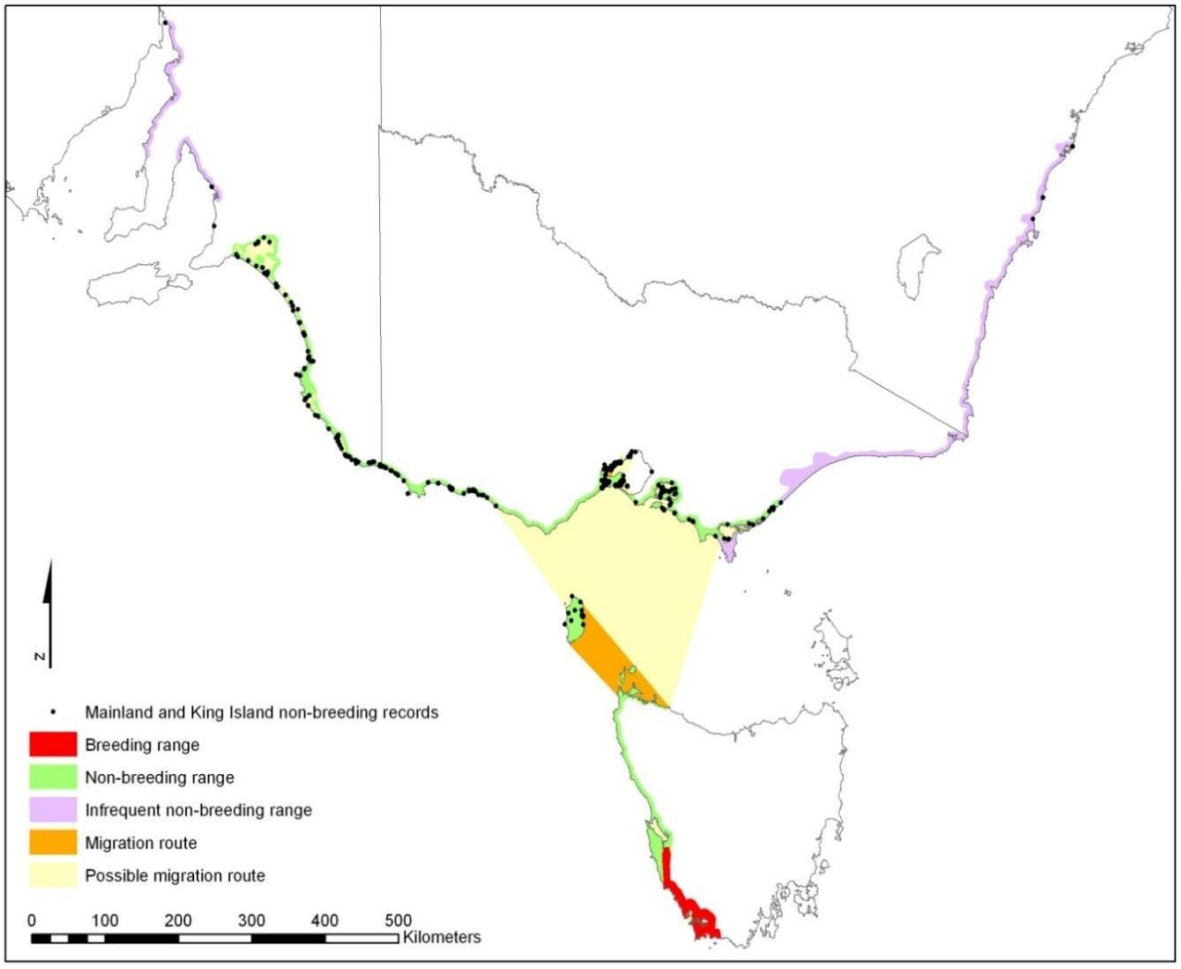

Figure 1: The migration route and spatial distribution of Orange-bellied Parrots (image sourced from OBPRT, 2006b).

4.4 Breeding

Breeding only occurs in Tasmania. Individuals begin to arrive there between late September and October, with the majority of the population present by November (Brown & Wilson, 1982). Breeding takes place between October and January (Holdsworth, 2006). Known historic breeding sites include Melaleuca, Birchs Inlet, Kelly Basin, Towterer Creek and Noyhener Beach (Figure 2; Brown & Wilson, 1980; OBPRT, 2006a). Different breeding locations may have historically represented distinct breeding populations (Baker & Holdsworth, unpubl. data). Since 2008, all known breeding has occurred at one site, Melaleuca, in the south-west Tasmanian Wilderness World Heritage Area (Weston et al., 2012; DELWP, 2016).

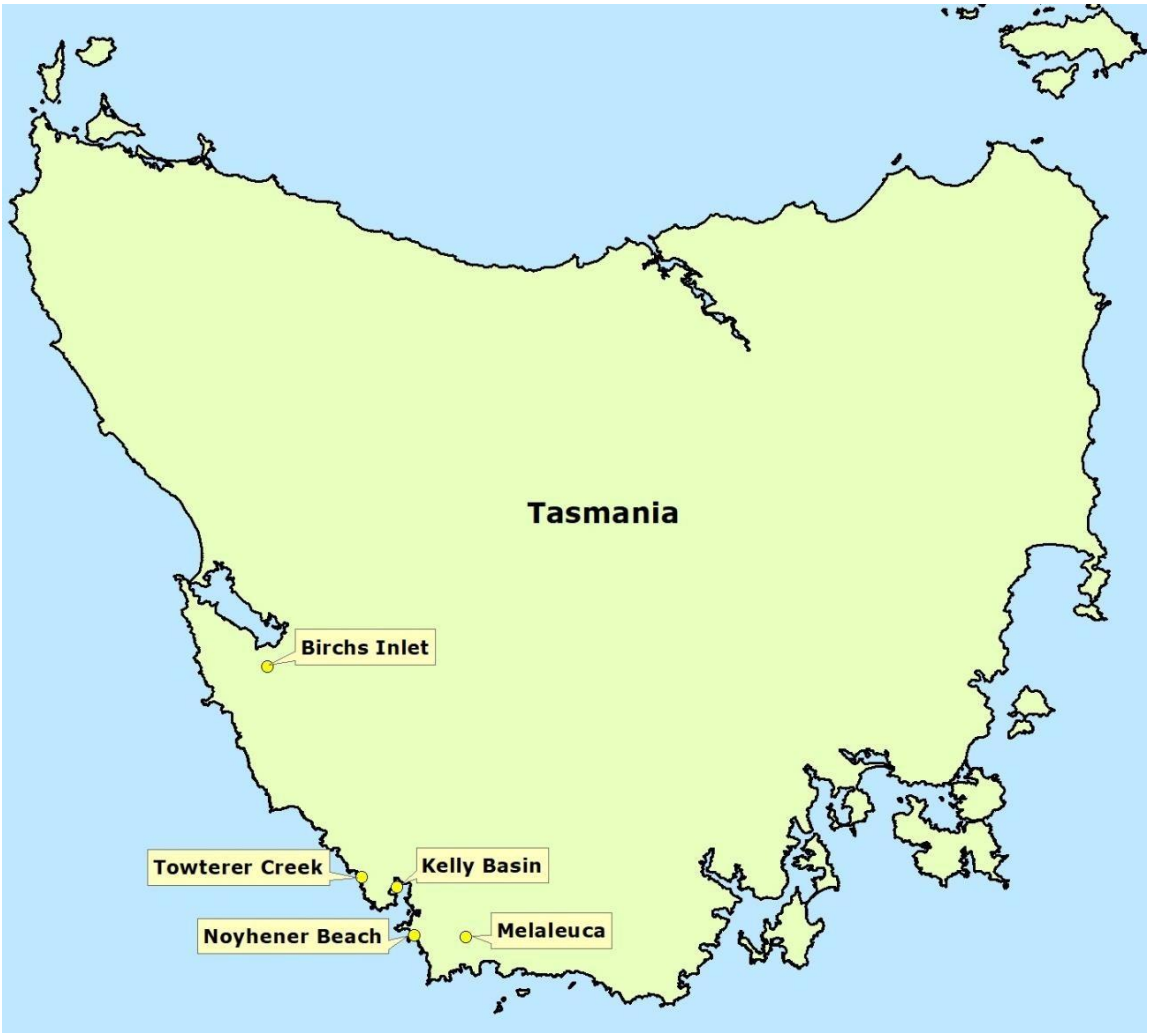

Figure 2: Known breeding locations of Orange-bellied Parrots in Tasmania (image adapted from OBPRT, 2006b).

Females generally nest in tree hollows of eucalypt trees located close to food sources with hollows being used year after year (Stephenson, 1991; Drechsler et al., 1998; Holdsworth, 2006). Due to habitat loss and competition, nesting boxes have been constructed in Melaleuca, and previously at Birchs Inlet and Towterer Creek, to supplement natural nesting sites and encourage breeding and are increasingly being used by the birds (OBPRT, 2006a).

OBPs are monogamous, with pair-bonding of older birds thought to occur within the winter months on the mainland prior to migration, as nest site selection and mating behaviours can be observed soon after arrival at the breeding grounds (Brown & Wilson, 1980; Lane et al., 1980; Stephenson, 1991). Some pairing also takes place after arrival to the breeding grounds with late arrival and first-year birds generally remaining unpaired until late November (Brown & Wilson, 1980; Stephenson, 1991).

OBPs will breed in their first year and likely remain breeding up until six years of age (realistically, 3-5 breeding years for most birds; Henry & Penrose, 2010). Pairs generally produce only one brood per season. Females lay clutches of 1-6 eggs with eggs being laid every second day (average of 4.5 eggs per female; Stephenson, 1991; Holdsworth, 1997; Drechsler et al., 1998). Females incubate eggs for three weeks with most eggs hatching by the end of December (Stephenson, 1991). Birds fledge at 4-5 weeks of age. Breeding pairs historically produced an average of 1.7 fledglings, which is a similar fledgling rate to that of more successful parrot species and should theoretically enable population growth (Brown & Wilson, 1984; Stephenson 1991).

Not all females appear to breed each year with less than 50% of females participating in breeding since 2000 (Holdsworth et al, 2011). This may be due to lack of genetic fitness which can trigger inbreeding avoidance mechanisms, body condition at the beginning of the breeding season, incompatible mates or limited availability of suitable nest hollows (O'Donoghue, 2005; Holdsworth et al., 2011; Holdsworth, 2015). Almost all of the breeding-age females in captivity participate in breeding each year (Holdsworth et al., 2011).

In captivity, breeding begins a month earlier than in the wild (i.e. in September). Breeding success, in particular egg fertility, is lower in the captive population and in recent years the sex ratio has become strongly female-biased (DELWP, 2016; Zoos and Aquarium Association, unpubl. data). Unlike wild OBPs, captive-bred birds will generally live beyond their reproductively active years (Curio, 1989; Holdsworth, 2006).

4.5 Habitat

4.5.1 Breeding habitat

Breeding activity within the breeding range requires a mosaic of rainforest, eucalypt forest and recently burnt (<8 years) sedgeland plains and buttongrass moorland (Holdsworth, 2006; DELWP, 2016). Large tracts of rainforest are avoided by the birds (Stephenson, 1991). OBPs prefer to nest in mature *Eucalyptus nitida* and roost in *Melaleuca* and *Leptospermum* tea tree species (Stephenson, 1991). Vegetation within the preferred breeding habitat is a result of complex interactions of fire, weather, soils and drainage (Stephenson, 1991). Favoured habitat in the current breeding location, Melaleuca, is entirely coastal, with most observations of birds being recorded within 200 m of the coastline and all nests occurring within 2 km of the high tide mark. It is not known how much habitat in the breeding range is required to support a viable wild population.

Upon arrival to the breeding grounds, OBPs forage primarily in moorlands 5-12 years after fire on seeds of *Restio complanatus* and *Lepyrodia tasmanica* (Stephenson, 1991). Between mid-

November and January, breeding birds forage on seeds of *Boronia parviflora, B. citriodora, Actinotus bellidioides* and *Helichrysum pumilum* with fruits being the most abundant 3-5 years after fire (Stephenson, 1991). Fire is particularly important in regulating vegetation including the height and density of moorland heath and sedge species. The current breeding range of OBPs has not been actively burnt since 2011, as it falls within the protected Tasmanian Wilderness World Heritage Area which is subject to fire restrictions (Holdsworth, 2006; OBPRT, 2006a; see section 12.7 for more details). Since 2011, the only fire within the breeding range has been a small natural bushfire in January 2016. It is important to implement an appropriate controlled fire schedule within the breeding grounds to guarantee that optimal habitat and food supply is available for breeding OBPs (Stephenson, 1991; DELWP, 2016).

4.5.2 Non-breeding habitat

OBPs require a diverse range of foraging opportunities throughout their mainland distributional range with adequate foraging habitat being required at several locations along their migration route (DELWP, 2016). The species historically occupied a diverse range of coastal and sub-coastal mainland winter habitats, including coastal dune scrubs, estuaries, islands, beaches, saltmarshes, moorlands, heathlands, shrublands, and introduced pastures and crops located within 10 km of the coast and 200 m of coastal wetlands, but further than 2 km from developed areas (Ehmke et al., 2009; Ehmke & Tzaros, 2009; DELWP, 2016). Preferred winter habitat of OBPs contains a selection of preferred forage species, habitat heterogeneity and microtopography as well as being located within 50 m of a water body (Loyn et al., 1986; Ehmke, 2009; Ehmke & Tzaros, 2009). The presence of Tussock forming sedges and rushes offer cover to birds while foraging. This is thought to be important as shelter from windy conditions and perhaps aerial predators. Dense shrubs are generally used as roosting sites and are located within a couple of kilometres of foraging sites.

There are marked differences between the winter habitats used in Victoria and South Australia (Stephenson, 1991). In Victoria, OBPs are typically found in saltmarsh while in South Australia severe storms along the coast have previously destroyed the majority of the vegetation resulting in birds being more mobile in search for food. Consequently, individuals are generally found on beaches or in dune frontages and systems, coastal lagoons (e.g. Pick Swamp) and pastures (e.g. McDonalds Road and Carpenters Rocks) in South Australia (Stephenson, 1991).

Prior to European settlement, western Port Phillip Bay and the Bellarine Peninsula (referred to as the central region of Victoria in terms of OBP distribution) were preferred sites for wintering OBPs and this preference still stands (Starks et al., 1992; Starks, 2000; BirdLife Australia, unpubl. data). Preferred saltmarshes within central Victoria contain several distinguishing features (McMahon et al., 1994) including:

- Widespread open saltmarsh distributed throughout the region (bare ground facilitates the consumption of seeds from the ground);
- Presence of floristically distinct upper saltmarsh vegetation including a range of perennial species which provide food during autumn and winter and annual species which provide seed from August to October including Shrubby Glasswort (*Sclerostegia arbuscula*), Beaded Glasswort (*Sarcocornia quinqueflora*), Austral Seablite (*Suaeda australis*), Thick-head Glasswort (*Sarcocornia blackiana*) and Marsh Saltbush (*Atriplex paludosa*) as well as an abundance of other important food species which are used occasionally when primary food plants aren't available. The importance of differing species varies seasonally, geographically and over time (Loyn et al., 1986; Higgins, 1999; OBPRT, 2006a);

- Structurally open and low vegetation in the vicinity of saltmarshes enabling supplementary provisioning of OBP diet during spring;
- Presence of tall shrubs within foraging sites or in close proximity for roosting and protective cover.

Winter habitat and associated food sources, chiefly coastal saltmarshes, are continuing to disappear across the mainland and are becoming harder to restore, narrowing the availability of optimal OBP habitat (Ehmke & Tzaros, 2009).

A more detailed description, as well as maps, of both breeding and non-breeding habitats can be found elsewhere (Barrow, 2008; Ehmke, 2009; Ehmke & Tzaros, 2009). Further work is required to establish if these maps currently embody all critical mainland habitat and to establish how much optimal habitat is required to support a viable wild population (DELWP, 2016).

5. Threats

Despite the long-running recovery program for OBPs, the exact mechanisms causing the decline in numbers are not clearly known, with uncertainty surrounding the effectiveness of implemented management actions. It is assumed that population declines are due to multiple interacting factors. Numerous known and potential threats have been identified across their entire distributional range (summarised in Table 2 with detailed descriptions following) with key factors thought to be habitat loss, sex-ratio bias, low female breeding participation and mortality during migration (DELWP, 2016).

To date, conservation efforts have concentrated on addressing winter habitat loss (DELWP, 2016), disease management (Peters et al., 2014) and captive breeding to supplement the wild population (Smales et al., 2000). However, these recovery efforts have not prevented further population declines likely due to knowledge gaps surrounding the causes for declines impacting the ability to deliver effective recovery actions for the species.

Table 2: Known and potential threats to the recovery of the Orange-bellied Parrot (sourced and adapted from DELWP, 2016).

Threat	Cause	Evidence for impact	Risk rating
Degradation and loss of habitat	Development and land use change	Strong	Very high
	Inappropriate hydrological regimes	Strong	Very high
	Invasive weeds	Strong	Very high
	Disturbance from human activities	Moderate	Moderate
	Inappropriate fire regimes	Moderate	Very high
	Inappropriate grazing regimes	Weak	Moderate
Loss of genetic diversity, inbreeding	Small population size	Strong	Very high
Predators and competitors		Moderate	Very high
Stochastic environmental events	Weather, fire, drought	Moderate	Very high
Disease outbreak		Moderate	High
Climate change		Moderate	Very high
Negative effects of recovery activities		Moderate	Moderate
Consumption of toxic food plants		Weak	Low
Barriers to migration and movement		Weak	Moderate
Hybridisation		Weak	Low
Trapping		Weak	Low

Evidence for impact refers to the available evidence that the threatening process is currently, or will in the future, limit recovery of the species. Risk ratings of the threats were developed on the basis of consequence and likelihood.

5.1 Habitat loss and degradation

OBPs require a combination of habitat attributes in both their breeding and non-breeding range (e.g. nest or roost sites within close proximity to foraging and drinking sites). Large-scale loss, fragmentation and degradation of habitat, especially of coastal saltmarshes, over the last 100 years due to agricultural, residential, urban and industrial development is assumed to be the most significant threat influencing the winter survival rates of OBPs through reducing food availability and secure roosting sites and causing changes to vegetation composition and structure (Loyn, 1982; Loyn et al., 1986; Menkhorst et al., 1990; Edgar & Menkhorst, 1993;

Heathcote & Maroske, 1996; Starks, 2000; Ehmke et al., 2009; Weston et al., 2012; Tolsma et al., 2014). Changes in hydrology, inappropriate grazing regimes, human disturbance and increasing invasive pressure from exotic and native plants further degrade OBP winter habitat (OBPRT, 2006a; Tolsma et al., 2014). Habitat loss and degradation continues to occur throughout the species' entire distributional range due to:

- Grazing (and trampling) of native vegetation by domestic stock (sheep, cattle, horses) and rabbits greatly reducing seed availability of saltmarsh vegetation and affecting the structure, composition and productivity of preferred OBP food plants
- Recreational activities (including off-road vehicles) along the south-eastern Australian coastline negatively impacts habitat quality and extent while increased levels of noise disturbs feeding birds which flush to cover leading to site abandonment and/or energetic stress
- Vegetation clearance for agriculture and introduction of invasive weeds (including in the upper saltmarsh) altering the productivity, structure and composition of traditional OBP habitat
- Inappropriate hydrological regimes including over-extraction of water and drainage of wetlands for agriculture impacting species compositions and productivity and survival of key OBP food plants within saltmarshes
- Saltmarsh dieback
- Common Cord-grass (*Spartina townsendii*) invasion of lower saltmarshes and mangroves
- Destruction and alteration of saltmarsh for industrial and urban development
- Early destruction and alteration of saltmarsh for sewage lagoons and saltfields
- Inappropriate fire regimes impacting the structure and productivity of sedgeland plains and moorlands in the breeding range. Limited fire within Melaleuca from 2000 to 2010 may have reduced the quantity of preferred age-class habitat and consequently female breeding participation.

The listing of subtropical and temperate coastal saltmarsh as a Vulnerable ecological community under the EPBC Act in 2013 has strengthened the protection of existing sites. While the majority of key sites used by OBPs are conserved to some degree, some regions still experience unrestricted (and inappropriate) land use practises destroying important feeding grounds on which OBPs are reliant on (OBPRT, 2006a). Within the SW Victoria site complex, 63% of the area comprising the key sites is privately owned, 20% of the area making up the key sites within the Bellarine site complex is privately owned, 0.7% of the area within the key sites in the western Port Phillip Bay site complex is privately owned, 24% of the area within the key sites in the Western Port site complex is privately owned and 20% of the area falling within key sites in the SW Gippsland site complex is privately owned. Continual site protection is required to prevent further reductions in suitable OBP habitat and food availability by inappropriate developments in the future.

5.2 Small population size

Small population sizes are more susceptible to extinction due to an increased vulnerability to demographic and genetic stochastic events. Genetic analysis of neutral markers indicates that the wild population suffered a substantial decline in genetic diversity in the early 1990s, losing approximately 25% of their genetic variation (Coleman & Weeks, unpubl. data). The declining population size has resulted in further reductions in genetic diversity in both the wild and captive populations with the effects of inbreeding depression increasing (Frankham et al., 2010). A recent review of Allee (small population) effects in Australian threatened birds, and the ecological, demographic and life-history traits which increase susceptibility to them, indicated that of all Australian threatened bird species, the OBP is adversely affected by the largest number of Allee effects (Crates et al., 2017). Continued loss of genetic diversity in both the wild and captive populations may result in further reductions in reproductive performance, reduced ability to adapt to environmental changes and a reduced lifespan (Frankham et al., 2010).

5.3 Predators and competitors

Introduced and native predators are evident in both the non-breeding (i.e. cats, foxes, rats, raptors) and breeding (i.e. Sugar Gliders (*Petaurus breviceps*), Black Currawongs (*Strepera fuliginosa*), snakes, raptors) range and are likely to have an impact on OBP survival rates, despite a lack of clear evidence. Within the breeding range, predation occurs at egg, nestling and adult levels (Holdsworth, 2006).

Inter-specific competition exists with other seed-eating bird species including the introduced House Sparrow (*Passer domesticus*), Common Starlings (*Sturnus vulgaris*), European Goldfinch (*Carduelis carduelis*) and European Greenfinch (*C. chloris*), as well as mammalian species including the House Mouse (*Mus musculus*) and European rabbit (*Oryctolagus cuniculus*) for the limited food resources at winter habitat sites, although the extent of this impact has not been assessed. At the breeding grounds, the presence of larger Green Rosellas (*Platycercus caledonicus*) at supplementary feed tables may exclude OBPs from accessing their food (DELWP, 2016).

Competition also occurs at the breeding sites where Common Starlings, Tree Martins (*Petrochelidon nigricans*), Honey Bees (*Apis mellifera*) and Sugar Gliders are known to aggressively compete with OBPs for nest hollows with instances of the competitor killing incubating OBPs or nestlings or burying eggs under new nesting material (Holdsworth, 2006; DELWP, 2016). Blue-winged Parrots (BWP; *Neophema chrysostoma*) also appear to be becoming more common within the OBP breeding range, which could further increase competition for food and nest sites (DELWP, 2016).

5.4 Stochastic factors

The wild OBP population exists as an extremely small, single population and as such is extremely vulnerable to stochastic events. The inability to adapt to rapidly changing environmental conditions as well as the entire wild population being in one location for half of the year can result in the loss of a high proportion of the remaining population, jeopardizing its continued existence in the wild. Events that could significantly impact the population include:

- Catastrophic fire in the breeding range, impacting the breeding habitat as well as adult birds and their eggs/chicks

- Catastrophic weather events including extreme temperatures, droughts (affects the quality and availability of food) or storms particularly during migration
- Catastrophic storms or fire at captive-breeding facilities which contain a significant proportion of the insurance captive population

5.5 Disease

Small, concentrated populations are extremely vulnerable to disease outbreaks which have the potential to decimate them. One disease which has affected both captive and wild OBPs is Psittacine Beak and Feather Disease (PBFD; otherwise known as Psittacine Circoviral Disease; PCD). The disease was first detected in the wild population in 1993. Only a few wild adult birds have been observed exhibiting clinical symptoms of PBFD in the last 25 years of monitoring (Peters et al., 2014). However, a significant proportion of nestlings that hatched in the wild in 2015 died due to a major outbreak of PBFD.

Several blood samples collected in 2011 from wild birds revealed previous exposure to the virus, with the non-clinical occurrence of the disease within the wild population currently unknown (DELWP, 2016). It is assumed that the wild OBP population is too small to maintain the Beak and Feather Disease Virus (BFDV) endemically (Peters et al., 2014). The recent detection of two separate lineages of BFDV in the wild OBP population (3 confirmed cases) implies that other parrot species are acting as a reservoir for infection by spill-over through contact (Peters et al., 2014). This is supported by the absence of detectable antibodies in the wild population which implies the absence of endemic BFDV in the species (Peters et al., 2014). Contact with other Psittacine parrots may occur through foraging in mixed flocks or the sharing of nest hollows, with the virions capable of persisting in the environment of nest hollows or boxes for extended periods of time (Peters et al., 2014).

It appears likely that PBFD was present in the original founders of the captive population, with an outbreak occurring in 1985 which was worsened due to the sub-optimal conditions at the original breeding facility (Hockley & Hogg, 2013; Peters et al., 2014). The disease appeared to have disappeared from both the wild and captive populations (determined via intensive serologic and PCR surveillance beginning in 2000) until 2006, when it re-appeared in the captive population (Peters et al., 2014). The majority of birds in captivity at present have been exposed to a BFDV: most captive OBPs are found to have antibodies, thus immunity, for PBFD and therefore are not infectious (Hockley & Hogg, 2013). Clinical symptoms of PBFD have developed in only four birds in recent years (CMG, unpubl. data). The presence of PBFD in captivity currently impacts quarantine procedures, resources (it is expensive and time- consuming to implement tests), management and transfers of birds and prevents the release of birds into the wild (DELWP, 2016).

There is currently little evidence however that PBFD is a significant cause of mortality in the wild or captive populations (DELWP, 2016).

5.6 Climate change

OBPs are considered to be "very highly sensitive" to climate change in both their breeding and non-breeding ranges due to low genetic variation within the population, a high level of habitat specialisation, occupying a narrow climate space and intolerance to frequent fire (Garnett & Franklin, 2014). Climate change may therefore impact the wild OBP population due to their utilisation of wetland systems and lowland coastal plains on the mainland and the location of

the Melaleuca breeding grounds with models predicting a decline in the climatic suitability of the current climate space utilised by OBPs (Garnett & Franklin, 2014; DELWP, 2016). In particular, more frequent storm surges, sea level rises and coastal erosion may threaten saltmarsh communities (Mount et al., 2010; Boon et al., 2011; Caton et al., 2011; Prahalad et al., 2011; Garnett & Franklin, 2014). Hydrological regimes of saltmarshes may be modified due to the construction of levee banks or sea walls and prevent the saltmarsh from retreating landwards (DELWP, 2016). The mainland range of OBPs will likely be significantly impacted if the extent of saltmarsh habitat is further reduced.

Species which currently have a southerly breeding range, including OBPs, are particularly vulnerable to the impacts of climate change especially if the breeding climate shifts southwards. If this was to occur, OBPs would have nowhere to go for breeding. Increased temperatures or more regular severe weather events at the current breeding grounds has the potential to negatively impact breeding success. However, increased temperatures during the breeding season may improve reproductive success for ecophysiological reasons (Porter et al., 2000). Changes in resource availability such as preferred food plants, predators, pathogens and competitors due to changing climate conditions could also reduce survival and breeding success (DELWP, 2016). Climate change may additionally alter the triggers for migration, adversely affecting the migration patterns and capacity of individuals to migrate.

5.7 Negative effects of management

As with any human intervention relating to species management and nature, there is an associated risk of unpredicted and potentially detrimental outcomes with any implement management action (DELWP, 2016). Furthermore, human motives, intentions and politics can interfere with recovery efforts and can have adverse impacts to populations. Where feasible, these risks are considered throughout the evaluation process of proposed management options. Risk management tools are employed to analyse management options and inform management-decisions when risks are complex (DELWP, 2016).

5.8 Invasive weeds

Following changes in habitat use on the mainland, searches have revealed OBPs foraging in adjacent coastal agricultural areas on exotic weed species, including those known to be highly toxic to some bird and mammalian species, including Common Heliotrope (*Heliotropium europaeum*) and Opium Poppy (*Papaver somniferum*; Starks et al., 2003; DELWP, 2016). It is currently unknown how much of a threat foraging on weed species or the potential exposure to herbicides or insecticides has on the wild OBP population.

Continued expansion of weed species throughout saltmarsh communities can further degrade remaining OBP habitat (McMahon et al., 1994; Carr et al., 2002). For example, exotic salt-tolerant annual grasses, such as Coast Barb-grass (*Parapholis incurve*) and Sea Barley-grass (*Critesion marinum*), have invaded native saltmarsh communities at key OBP winter sites, out-competing a variety of native OBP preferred food plants and altering the structure of the habitat (OBPRT, 2006a). Lake Connewarre historically obtained the largest winter counts of OBPs but numbers declined as the quality of habitat deteriorated. The *Sarcocornia* flats were rapidly invaded by Austral Salt Grass (*Distichilis distichophylla*) smothering the low saltmarsh.

5.9 Barriers to movement

As the OBP is migratory and highly mobile throughout their mainland range, there is potential to impact with barriers such as buildings, aircraft, powerlines, illuminated boats or wind turbines, causing fatalities or behavioural changes to avoid certain areas. Barriers affecting movement are likely to be the greatest throughout their migration route as the majority of the population is expected to be exposed to the barrier during a high energy-expenditure life phase (DELWP, 2016). However, there are only a few anecdotal incidences recording OBP collisions with such structures (Holdsworth, 2006).

There is some anecdotal evidence that migratory birds, including parrots, are occasionally attracted to the bright lights used by squid boats present in Bass Strait at night (OBPRT, 2006a). Similarly, other bright lights such as ships and lighthouses may have the same effect – for sample, an OBP was recorded colliding with Cape Wickham Lighthouse during the night in 1905 (Anon, 1906). If OBPs are attracted to such lights this could potentially have disastrous impacts to their migration and consequently their survival (OBPRT, 2006a). Further investigation would be required to determine if brightly lit structures are negatively influencing the survival rate of migrating OBPs.

Wind farms throughout the migratory and winter range of OBPs have the potential to impact the wild population (OBPRT, 2006a). The possibility of OBPs colliding with wind turbines during migration increases as more wind farms are proposed for development. On the mainland, wind farms adjacent to traditionally important winter sites, such as Yambuk Lake, pose a risk to OBPs moving between foraging and roosting sites (OBPRT, 2006a). Wind farm developments throughout the OBPs range have been required to perform a pre-development bird utilisation study and identify potential impacts to birds. Turbine layout has been adjusted in some instances to avoid key feeding or migratory pathways to minimise the potential of collision (OBPRT, 2006a). Further mitigating measures have also been implemented where appropriate including habitat restoration and provision of supplementary food sources away from the wind farm and weed control on site (OBPRT, 2006a). The overall impacts of wind farms to the wild OBP population is currently unknown.

5.10 Hybridisation

The breeding range of OBPs and the closely-related BWPs overlap, with BWPs becoming more common in Melaleuca. With the wild OBP population continuing to decrease, the occurrence of hybrids may increase (DELWP, 2016). There has been at least one hybrid brood recorded in the wild (DELWP, 2016). The effects of hybridisation are currently unknown, but could include reduced fitness or sterility in the first or following generations (DELWP, 2016). Hybridisation in the wild is currently regarded as a threat to the wild OBP population.

5.11 Trapping

Up until the 1960s, OBPs were regularly trapped for aviculture with some birds making it as far as Europe (Brown & Wilson, 1980; Low, 1980). Rarity of a species can increase the price of individuals on the black market, increasing the illegal wildlife trade of threatened species. Currently, OBPs are not represented in aviculture collections outside of the captive-breeding program. This absence of birds within the aviculture industry and the strict Commonwealth and state legislations has likely eliminated the illegal trapping of this species. However, there will always remain a risk and efforts must continue to minimise the potential for poaching (OBPRT, 2006a).

6. Recovery Team

In 1979, the World Wildlife Fund (WWF; Brown & Wilson, 1980) funded their first ever project to investigate the ecology, breeding sites and status of OBPs throughout their entire range, including causes for their decline. This two year project (administered by the Tasmanian National Parks and Wildlife Service) was split into three research topics: summer breeding, migration and winter distribution, using coordinated searches across Tasmania, Victoria and South Australia in July (Brown & Wilson, 1980). Outcomes from the research resulted in the formation of the Orange-bellied Parrot Recovery Team (OBPRT) in 1983 and the first recovery plan for the species in 1984 (Brown & Wilson, 1984; Stephenson, 1991). It is the longest-running government-funded threatened species program in Australia.

The OBPRT originally consisted of five members and is now a multi-disciplinary group comprised of 23 representatives from 11 organisations including Federal and State government agencies (Victoria, Tasmania, South Australia), non-government organisations, captive breeding institutes, research organisations with expertise in management of threatened species, specialists and Regional OBP Coordinators. It is much larger than most other recovery teams in Australia: the current Terms of Reference stating membership should ideally be 20 people or less. The team composition and Chair are reviewed annually and new members and Chairs are elected through consensus. There is no mandatory turnover in membership with some members sitting on the recovery team for considerable time periods. For continued success, the OBPRT strives to maintain members with leadership and management skills, threatened species recovery skills and strong connections with key delivery partners and organisations (DELWP, 2016). The Terms of Reference are currently reviewed every second year.

The role of the OBPRT is to facilitate the implementation of the current OBP Recovery Plan and to provide advice for effective on-ground conservation actions to the Federal and state governments under their respective endangered species legislations. The OBPRT is responsible for producing and implementing recovery plans and associated management actions, facilitating communication and engagement between governments, captive-breeding organisations, volunteer groups and other key stakeholders, coordinating research and conservation including analysing data, directing recovery efforts and activities of representative organisations and associated volunteers, considering new information as it arises, recommending new initiatives, reviewing progress against the objectives of recovery plans and promoting the recovery effort (Martin et al., 2012; DEWLP, 2016).

To facilitate the development of informed management actions, the OBPRT is currently comprised of three functional sub-groups (Figure 3): the Strategic Action Planning Group (SAPG; formed in 2011 it is the administrative and governance group responsible for making all of the decisions in relation to OBP recovery efforts including overseeing the coordinated implementation of recovery action priorities), the Captive Management Group (CMG; formed in 1995 to provide advice on and facilitate the coordinated management of the captive insurance population) and the Veterinary Technical Reference Group (VTRG; formed in 2015 it provides veterinary information, advice and support to the OBPRT and SAPG). The Chair of the CMG is a member of both the SAPG and VTRG, while the Chair of the VTRG is a member of the SAPG. A clinical veterinary member of the VTRG is also nominated as a member of the CMG. The formation of these sub-groups provides the opportunity to provide more detailed technical consideration for the delivery of management actions and problem-solving issues. However, the restrictions and protocols of the differing sub-groups can prohibit decision-making and implementation of recovery actions when new information becomes available. Consequently, lead-time on decisions and implementing recovery actions can be lengthy resulting in the inability of the OBPRT to be as adaptive as other recovery teams (Anon, pers. comm.).

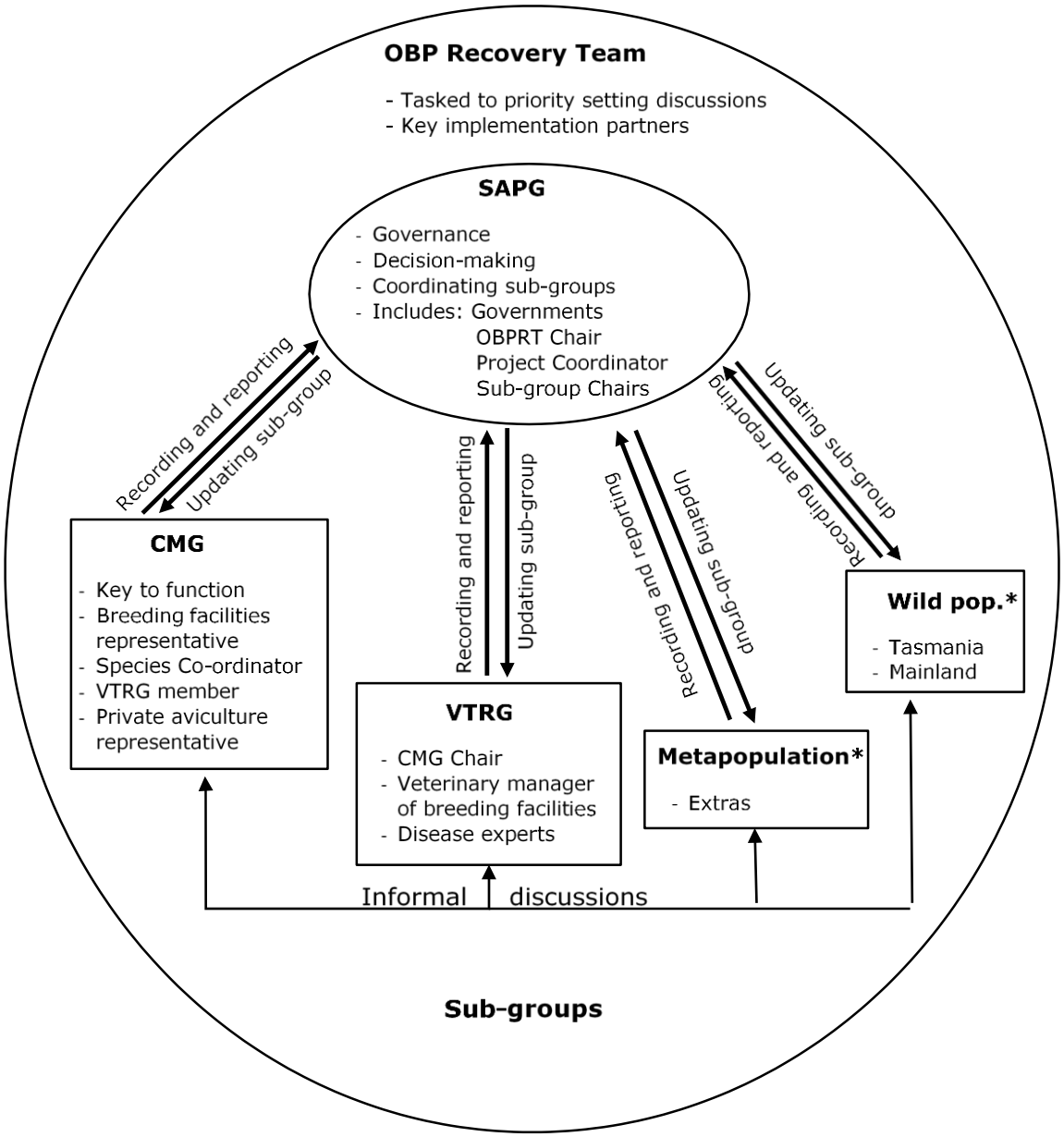

Figure 3: Diagrammatic representation of the OBP Recovery Team structure. *Sub-groups currently being discussed by the OBPRT.

The current OBPRT structure is consistent with the Commonwealth guidelines, with the guidelines being broad to allow recovery teams to structure in the way that best meets the needs of that program (DELWP, pers. comm.). During the June 2017 OBPRT meeting, two discussions (one at the recovery team level and one at the SAPG level) were initiated regarding team structure. The general consensus was that the OBPRT may benefit from one or two more functional sub-groups and support to maintain the SAPG or a Strategy and Coordination Group with overarching functions (DELWP, pers. comm.). However, new terms of reference for the groups would need to be drafted before members were comfortable with who belonged in which group and how the groups would interact (DELWP, pers. comm.). The OBPRT is currently

investigating the potential for restructuring the team including a metapopulation and wild population sub-group (Figure 3).

Development of recovery plans and coordinated delivery of subsequent management actions are achieved through the provision of a forum for collaboration between organisations and the ability to utilise diverse expertise (both from within the OBPRT and from specialists outside of it; Martin et al., 2012). Annual meetings are therefore held to review the status of the OBP population, assess progress of the objectives and management actions specified in the current recovery plan and discuss future initiatives (OBPRT, 2006a). Since 2016 in response to the critically low population numbers, the OBPRT meets twice annually to review monitoring data, evaluate outcomes of implemented management actions (with the agreement that new actions should be trialled for 2-3 years to evaluate their success) and provide advice to Governments regarding management options. Meetings are typically held over two days: the first day is a broad, open meeting allowing contributions from land owners, managers, researchers, volunteers and other stakeholders (see Appendix 2) while the second day is closed to the SAPG (OBPRT, 2006a). This meeting structure adds in a level of complexity not present in other recovery teams and increases the difficulty of the decision-making process yet removal of the open meeting would off-side important stakeholders (Anon, pers. comm.). Extra meetings and/or teleconferences are held throughout the year in response to new information about the population. It is being proposed that the SAPG meetings will replace the annual OBPRT meeting as the forum to review and decide on recovery actions. The current (larger) OBPRT meeting format will still continue, shifting the focus from deciding recovery actions to reviewing those decided on by the SAPG.

Conservation of the OBP is complex due to the distribution across three states and numerous jurisdictions and land tenures. Despite this, since the formation of the OBPRT, significant progress has been made through active research and management achieving unprecedented levels of funding, in-kind support, cooperation and commitment from all levels of government, professional groups, private enterprises and individuals (Stephenson, 1991). A key contributing factor in achieving maximum effectiveness and success of the OBPRT and sub-groups (as in other recovery teams) has been a part-time Recovery Program Coordinator dedicated to the project (Pritchard, 2014). This position was filled from 2010 to 2012 as part of the Commonwealth funding for the delivery of the 2010 Emergency Action Plan and in-kind contribution from the Victorian government. The position was then funded using EPBC controlled action offset funds held with Nature Foundation South Australia and public fund-raising from 2012 to 2015 through offset funds. Inadequate funding from 2015 has meant that this position has gone unfulfilled in recent years.

7. Recovery Plans and review summaries

Recovery plans aim to provide a structured and planned approach to managing the recovery efforts for threatened species through the identification, costing and prioritisation of actions required for the conservation and recovery of the species (Stephenson, 1991). The OBP was the first threatened species in Australia to have a recovery plan produced with five versions superseding the original (Brown & Wilson, 1984; OBPRT, 2006a). In addition to recovery plans, emergency action plans have been implemented at various stages in response to significant declines in the wild population (e.g. 2010, 2016).

All recovery plans consist of both long-term strategies and short-term actions for the recovery of the wild OBP population. The two primary objectives of all OBP recovery plans have been to increase the wild population size and minimise further population declines by:

- Increasing the knowledge about the ecology and threats to the species

- Surveying and monitoring the wild population throughout its breeding and non-breeding distributional ranges
- Managing important habitat required to support recovery of the wild population
- Establishing and maintaining a viable captive insurance population
- Developing appropriate captive-breeding and release techniques to supplement the wild population and promote population growth

More recent recovery plans have specific recovery objectives, their priority for action, performance criteria for assessment and the Agencies responsible for implementing each management action.

Recovery plans generally span a five-year period where superseding plans are anticipated to provide a continuation on from the previous plan. However, time lags are evident in the formal acceptance and publication of the superseding recovery plans due to editing, consensus issues and requiring approval by the responsible wildlife conservation agencies and Ministers in the three relevant states (OBPRT, 1999).

Over the years, there has been a lack of reporting of the outcomes from specified management actions in each recovery plan including whether specified projects or research were conducted. There has been no instance where the objectives and criteria for a recovery plan have been fully met with many actions not even being started.

7.1 Orange-bellied Parrot Recovery Plan 1984

7.1.1 Objectives

The original OBP recovery plan was produced and implemented in 1984 in an effort to conserve the OBP in response to a declining population (Brown & Wilson, 1984). The recovery plan recommended implementation of a broad range of management and research measures with the overall objectives to:

1. Safeguard the existing wild population from disturbance and predation, and their habitat from degradation and detrimental development
2. Manage known OBP habitats to ensure availability of adequate and secure food sources
3. Improve and manage other areas of potential habitat

The recovery plan included 128 management recommendations for the conservation of the wild population across its entire distributional range to fulfil the three overall objectives. These were largely centred around surveying, monitoring and habitat protection (Brown & Wilson, 1984; J. Starks, pers. comm.).

7.1.2 Review

The original OBP recovery plan was the first of its kind in Australia, therefore had no other case studies or references to model from (J. Starks, pers. comm.). Consequently, the recovery plan did not include an implementation schedule, with actions being "made up as they went" based

on available information and self-reviews of implemented actions up until that point in time and deliverables went largely unaudited (Saunders, 2002; J. Starks, pers. comm.). The main achievements of the recovery plan were:

- Establishment of the OBPRT including representatives from Federal and three state government agencies as well as nature conservation organisations
- Establishment of detailed monitoring and breeding programs
- Introduction of a supplementary feeding program and use of nest boxes in the breeding range
- Construction of a public observatory at Melaleuca to assist in the monitoring of the breeding population and to interpret the recovery program for visitors
- Collection of inputs from community groups and volunteers regarding habitat protection and monitoring activities
- Cooperative and effective recovery actions initiated by various community groups to protect the species' and its habitat. Habitat protection measures were considered very successful for the species' recovery due to an increase in OBPs using cattle-exclusion (fenced) habitat (J. Starks, pers. comm.).
- Commencement and refinement of a captive-breeding population

The initial recovery efforts were considered successful due to the regular observations of over 100 birds on the mainland and at the breeding grounds in Melaleuca in the early- to mid-90s (J. Starks, pers. comm.). The inadvertent lack of knowledge surrounding the causes for the population declines meant no adaptive management (e.g. research into the role of fires and grazing) occurred in this early period resulting in areas becoming unsuitable for OBPs (J. Starks, pers. comm.).

7.2 Orange-bellied Parrot Recovery Plan 1991-1996

7.2.1 Objectives

The second OBP recovery plan was produced in 1991 with an implementation schedule for five years (Stephenson, 1991). The long-term objective of the recovery plan was to achieve a healthy, self-sustaining wild population in sufficient secure habitat which does not require further management actions. The short-term objective was to down-list the species from Endangered to Vulnerable within 10 years where an increase of 50 birds in the wild population would help reduce the risk of extinction. The major recovery strategies outlined in this recovery plan were to commence a captive-breeding release program, monitor and re-survey all critical mainland habitats and conduct research into genetics, disease and food plants (Stephenson, 1991).

The major criteria for meeting the long- and short-term objectives were:

Criteria 1: By 1995, achieve a stable wild population containing a minimum of 250 birds

Criteria 2: By 1995, double the carrying-capacity of the winter habitat through enhancing and increasing suitable habitat including saltmarsh and other plant species used by OBPs especially in western Port Phillip Bay and on the Bellarine Peninsula

Criteria 3: Continue annual monitoring of the population

Criteria 4: Assess habitat distribution, quality and carrying-capacity of the known winter sites annually and potential sites every five years

Criteria 5: Maintain the captive-breeding program and where appropriate release individuals to supplement the wild population

Criteria 6: Continue banding individuals to provide information on the life histories of wild and captive-bred released birds

Criteria 7: Publicise the species and associated recovery efforts

Criteria 8: Integrate OBP management actions into broader habitat conservation strategies

Recovery efforts were funded by the Australian Nature Conservation Agency under the Endangered Species Program and was supported by the Tasmanian, Victorian and South Australian State conservation agencies (OBPRT, 2006a).

7.2.2 Review

The progress of the management actions outlined in the 1991-1996 OBP Recovery Plan have been thoroughly reviewed in Menkhorst et al. (1990), Edgar & Menkhorst (1993), Brown et al. (1995), Menkhorst, (1996) and Holdsworth et al. (1997).

The main achievements of the recovery plan included:

- Actions to re-establish a second breeding population at Birchs Inlet through releases of captive-bred birds (1994, 1996)
- Expansion and improvements to the captive-breeding program including the formation of the CMG in 1995 and a second captive-breeding population at Healesville Sanctuary (1994)
- Annual releases of captive-bred birds at Melaleuca since 1991 with some individuals successfully breeding in the wild
- Research conducted on OBP habitat use and ecology including the development of a remote-sensing method to identify suitable saltmarsh habitat, an analysis of the nutrient content of food seeds and a study on the regenerative ecology of food plants and feeding ecology of OBPs
- Predator and competitor control at important sites including the construction of a predator-proof fence by the Department of Defence around saltmarsh at Point Wilson
- Assessments into the effects of various land development proposals to OBPs
- Development of methods to measure genetic diversity in OBPs providing estimates of genetic heterozygosity in wild and captive populations with applications including the prevention of pairing closely related individuals in captivity
- Use of various media outlets to promote public awareness of the species including through a regular newsletter *Volunteer* (Birds Australia Threatened Bird Network) and the OBPRT newsletter *Trumped-up Corella*, brochures, posters, media articles, conference and community presentations and interpretive signs

- Production of an action statement under Victoria's *Flora and Fauna Guarantee Act 1988*
- Expansion of annual monitoring programs through an increasing volunteer network
- Establishment of Victorian (1990) and Tasmanian (1996) community support groups to assist with the coordination of recovery actions

7.3 Orange-bellied Parrot Recovery Plan 1998-2002

7.3.1 Objectives

The third OBP recovery plan outlined recovery actions for the 1998-2002 time period (OBPRT, 1999). The primary objective of this recovery plan was to improve the conservation status of OBPs so that by 2001 the species no longer met the IUCN criteria for Critically Endangered resulting in de-listing to a lower threat category. Long-term, the recovery plan aimed to down-list the species to Lower Risk-Conservation Dependent within 30 years. Three specific objectives and six recovery actions were included to fulfil the primary objective.

Specific objectives:

- Increase the carrying-capacity of critical winter habitat and ensure that OBPs persist in their present range
- Increase the number of adult birds in the wild to at least 250
- In 2001, the probability of extinction in the wild by 2011 will be less than 50%

Recovery Actions:

1. Coordinating recovery efforts
2. Managing habitat and food sources throughout the OBPs range
3. Monitoring habitat and food sources throughout the OBPs range
4. Monitoring the wild population throughout its range
5. Enhancing the captive-breeding and release programs
6. Increasing public education and information available

The criteria for meeting these six recovery actions were:

Criteria 1: All of the following criteria must be met by 2001 (relative to 1996 levels)

Criteria 2: Increasing the area, or carrying-capacity, of critical mainland habitat by 10%

Criteria 3: Actively maintaining the carrying-capacity of breeding habitat through frequent controlled burning in south-west Tasmania

Criteria 4: Increasing the probability of the average winter survival, or cohort longevity, of banded birds by 10%

Criteria 5: Increasing the maximum number of wild birds counted during the national winter counts by 100%

Criteria 6: Releasing 20-30 captive-bred birds into the wild each year

Criteria 7: Continually updating the Population Viability Analysis (PVA) to provide estimations of extinction within the wild over the next 10 years

7.3.2 Review

The 1998-2002 OBP Recovery Plan was reviewed in Saunders (2002). The main achievements considered under this recovery plan were:

- A stable wild population at Melaleuca (as determined through analysis of banded birds)
- A secure captive population considered to be equivalent to the wild population
- Consistently exceeded the target number of captive-birds designated for release
- Continued releases of captive-bred birds into the wild
- Continuation of the reintroduction program at Birchs Inlet (Tasmania)
- Improvements in the protection and management of key winter, migratory and breeding habitats
- Greater understanding of the species' breeding ecology
- Conducted assessments into the genetic variation of the population
- Habitat management trials (e.g. grazing and controlled burns) including vegetation responses to management
- Research into the potential impact to the species from various sources of disturbance (e.g. people, helicopters, fixed-winged aircraft, vehicles)
- Promotion of the importance of collision risk assessment, mitigation measures and compensatory mechanisms in managing OBP values at proposed wind energy developments
- Establishment and support for winter and summer program coordinators
- Increased public awareness of the species including as an icon species
- Establishment and support of regional groups in western Victoria and South Australia to assist with the implementation of recovery actions

Despite the above achievements, little measurable progress towards the long-term objectives was made during this period and many of the components of the recovery plan went undelivered primarily due to funding short-falls (the Natural Heritage Trust funding was reduced from $200,000 to $80,000 in 1991) and consequently the lack of knowledge of winter habitat use and key threats (Saunders, 2002). Furthermore, data that was collected went uninterpreted and unpublished (Saunders, 2002). Criteria within the recovery plan were also found to be unclear and at times unrelated to specific objectives. It was recommended that the

superseding recovery plan incorporate criteria to provide an objective measure of performance in relation to each specified objective (Saunders, 2002).

7.4 Orange-bellied Parrot Recovery Plan 2006-2011

7.4.1 Objectives

The publication of the fourth OBP recovery plan was delayed due to resource limitations on the then Project Officer's time and procedural matters (OBPRT, 2006b). Recovery actions implemented during the 2003-2005 period were based on the previous recovery plan and were largely restricted to achievable ongoing actions (OBPRT, 2006a,b).

The previous three recovery plans and the recommendations from the 2002 review directed the strategies and management actions outlined in the 2006-2011 Recovery Plan (Brown & Wilson, 1984; Stephenson, 1991; OBPRT, 1999; Saunders, 2002). The overall objective was to minimise or eliminate human-based threats to OBPs resulting in the de-listing of the species from Critically Endangered to a lower threat category. This would be achieved through:

- A sustainable improvement to the quality and quantity of optimal OBP habitat at key sites throughout the species' range to increase carrying-capacity
- Ensuring the wild and captive OBP populations continue to survive into the future
- Ensuring existing and new threats are appropriately managed to alleviate their impact to both populations

Six specific objectives were identified in the recovery plan including to:

1. Monitor the population size, productivity, survival and life history of OBPs
2. Identify all sites used by wild OBPs and increase knowledge surrounding migration
3. Increase the carrying-capacity of habitat throughout the species' range through active management including annual patch burning around known and potential breeding sites in accordance with regional fire management plans
4. Identify, measure and alleviate threats, especially in migratory and winter habitats
5. Increase the number of breeding sub-populations
6. Maintain a viable captive population

The above objectives had a range of recovery actions requiring implementation to reach fulfilment. The criteria for meeting these were:

Criteria 1: The wild breeding population increases from 150 to greater than 250 individuals

Criteria 2: An increase in the average life expectancy of wild-born birds

Criteria 3: Identification, protection and management of all key sites used by OBPs

Criteria 4: Removal or adequate control of key threats throughout the species' range

Criteria 5: Establishment of a minimum of one additional viable sub-population in the breeding range

Criteria 6: An increase in the public support for OBP conservation

Criteria 7: At least 150 individuals exist in the captive-breeding population containing the equivalent genetic diversity as the wild population

7.4.2 Review

A comprehensive review of the 2006-2011 OBP Recovery Plan was conducted to assess the deliverables against the objectives and recovery actions of the recovery plan, identify areas within the recovery program that require improvement and to assess the priorities of the plan (Table 3, Appendix 3, Pritchard, 2014). Despite considerable effort, the wild population experienced a significant decline during this period, which coincided with the exact timing of the millennium drought which is considered to have significantly impacted saltmarsh communities throughout the mainland range. Implemented recovery efforts during this time period may have slowed the decline (Pritchard, 2014). The main achievements between 2006 and 2011 were:

- The captive population increased to more than 150 birds
- A study was completed on the use of non-breeding habitat to quantify habitat preferences and spatially identify habitat on the mainland
- Some non-breeding habitat was restored
- Continued monitoring of the population during both the breeding and non-breeding seasons
- Preformed data analyses to identify breeding and population trends to identify risks and thresholds for action (2010) and prompt adaptive management responses

The recovery plan was produced under the assumption that the wild population was stable (based on observations of banded birds at Melaleuca) but limited by the quantity and quality of winter habitat due to the continued decline of OBPs observed on the mainland. Due to this assumption, the Tasmanian carrying capacity management was reduced despite lower OBP breeding success which was likely a symptom of local conditions. In 2010, both winter and summer monitoring data indicated a declining wild population, proving the above assumption to be incorrect (Pritchard, 2014). The basis of the assumption had several key implications to the design of the recovery plan including:

- The recovery plan originally aimed to increase the habitat carrying-capacity in an effort to increase the population size instead of identifying and alleviating the causes of the ongoing population decline
- Emphasis was put on winter survey effort and habitat descriptions in an effort to locate and manage the 'missing' birds on the mainland which were contributing to the lower winter counts compared to summer counts
- The focus of the captive population was primarily to supply birds for release into the wild instead of maintaining it as an insurance population through genetic management should the species go extinct in the wild

Table 3: Progress against the recovery criteria specified in the 2006-2011 OBP Recovery Plan (sourced from Pritchard, 2014).

Recovery Criteria	Status	Comment
The wild breeding population increases from approximately 150 to more than 250 birds	Not Achieved	Population has declined. Use of Tasmanian counts at Melaleuca to suggest population stability in 2006 shown to be inaccurate. Wild breeding population now estimated at less than 20 birds.
The average life expectancy of individuals in the wild population is increased	Not Achieved	One paper suggests that this parameter is not a significant limiting factor (Holdsworth et al., 2011). However, a lack of comparative data prior to the population decline, or from similar species, makes this difficult to assert with certainty.
All key sites used by OBPs are identified, protected and managed	Some Progress	All key sites have been identified, and many sites across the OBPs range are receiving active management. Some important sites in Tasmania have not received sufficient management.
Key threats through the species' range are removed or adequately controlled	Some Progress	Predator and weed management occurs throughout much of their range. Threats remain in significant unmanaged habitats. Hydrological degradation has increased in some areas.
At least one other viable sub-population in the breeding range is established	Not Achieved	Translocation trial unsuccessful but provides important information for planning future translocations.
Public support for the conservation of the OBP is increased	Unknown	Increased volunteer participation and some indications of landowner support. Baseline data is not available by which to measure changes in general public support.
The captive population contains at least 150 individuals and maintains genetic diversity equivalent to the wild population	Some Progress	Population has exceeded 150, new founders collected in 2010 and 2011 to capture more genetic variation, but a discrepancy in genetic diversity between the two populations still exists.

The review of the 2006-2011 recovery efforts indicated that the recovery program lacked coordination and ownership of responsibility and accountabilities for recovery efforts and several key lessons were identified (Table 4; Pritchard, 2014). Furthermore, due to the complexity and set-up of the document, some relationships between recovery criteria, specific objectives, recovery actions, performance criteria and tasks were not clear as was evident in previous recovery plans (Pritchard, 2014). The uncertainty between the relationships within the plan may have contributed to the incompletion of some actions (Table 4; Pritchard, 2014). The document structure was characteristic of recovery plans at the time but made the assessment of outputs of some actions challenging.

The incapacity to accomplish or implement recovery objectives is again largely due to funding short-falls and limited resources (Pritchard, 2014). This included lack of funding for positions which were responsible for implementing recovery actions and collating and analysing data required for informing decision makers. Delivery of recovery actions specified in the recovery plan cannot be achieved if there is no funding or staff. In recent years, failure to meet recovery objectives has also been attributed to, at least partly, the rate of decline in the wild population exceeding the capacity of the OBPRT to understand the causes of decline and respond appropriately. Adaptive management has been impeded due to delays (or non-investment) in data analyses and interpretation of the high-quality monitoring data (Pritchard, 2014). While the recovery plan has an extremely strong population monitoring program, decisions regarding implementation of recovery actions are not clearly based on collected data (Pritchard, 2014). It was recommended that the population monitoring data should be regularly analysed and interpreted while the recovery program required a robust, transparent reporting structure (Pritchard, 2014).

In instances where active management or monitoring was implemented, there was often no measure of the outcome (Pritchard, 2014). Absence of measurable outcomes prevents the recovery team from learning from experiences while decision makers are not provided with information crucial for developing and prioritising recovery actions (Pritchard, 2014).

Table 4: Evaluation of the delivery for each specific objective and supporting action in the 2006-2011 OBP Recovery Plan (sourced from Pritchard, 2014).

Specific objective	Outcomes, outputs and lessons
Monitor the population size, productivity, survival and life history of OBPs	Monitoring data were collected throughout the period. Analyses were limited due to limited staff time. Future monitoring and analysis should be tailored to inform thresholds for management decisions.
Identify all sites used by OBPs and better understand migration movements	Search efforts were improved, assisted by habitat modelling and mapping on the mainland. Approaches to identify migration movements were restricted by technological limitations. Future work should be targeted to fill knowledge gaps.
Increase the carrying-capacity of habitat through active management of sites throughout the species' range	Considerable habitat management in some regions may not have offset habitat losses, particularly during drought conditions. Competing land uses and interests have prevented active habitat management in some critical areas. Monitoring of habitat quality has not occurred in a coordinated manner, hindering adaptive management. Future work should prioritise monitoring, coordination and adaptive management of priority sites.
Identify, measure and ameliorate threats, particularly in migratory and winter habitats	Many of the actions associated with this objective were not considered to be high priority when allocating limited funding. However, considerable effort was made to identify threats to habitat quality. Future work should identify the threats most likely to be limiting the population, and apply adaptive experimental approaches to test those hypotheses while undertaking management.
To increase the number of breeding sub-populations/groups	Releases of captive-bred birds at Birchs Inlet failed to establish a second breeding sub-population. Contributing factors were likely the absence of wild birds at the site for behavioural and genetic interactions, low reproductive success associated with the captive population, and low annual survival. However, the results from this effort will inform future translocations. Future work will need to consider the short-term priority of establishing a further sub-population.
To maintain a viable captive population	The captive breeding population was increased to over 150 birds over the period. Genetic monitoring was not funded until 2010. Collection of new founders did not occur until 2008 (2), 2010 (2), and 2011 (21) when the need for new founders became very urgent. Future work should focus on establishing a robust insurance population.
Foster community support and involvement in the conservation and recovery of the species and its habitat	Volunteer participation increased, and new Regional Groups supported local volunteer activity. Some key communications products were prepared including an identification brochure and an updated website. Future work should continue to explain the reason and methods for conserving the species, and provide opportunities for community participation where this is likely to assist the recovery effort.
Develop and implement a Recovery Fund Plan	There was very little progress against this objective because it was not given sufficient priority. Future work should reconsider the best means to ensure support of the recovery program.

Manage, review and report on the recovery process	The OBPRT met at least annually. Funding was not available to support a Recovery Program Coordinator until a part-time Action Plan Coordinator was employed in 2010. Future work should focus on supporting the structures that allowed the swift response to the analysis of monitoring data in 2010.

7.5 Orange-bellied Parrot Emergency Action Plan 2010

In 2009, the OBPRT started collating and analysing monitoring data due to heightened concerns for the species under the leadership of the Department of Environment, Land, Water and Planning (DELWP; Martin et al., 2012; DELWP, pers. comm.). Analyses of all available monitoring data revealed an annual 12% decline in the wild population size between 2000 and 2008 indicating that OBPs would likely face extinction in the wild by 2015 primarily due to poor breeding participation by females, and therefore lack of recruitment, in the preceding years (Holdsworth et al., 2011; Pritchard, 2014). It was considered that the wild population had very limited capability to increase in size without immediate intervention (Hockley & Hogg, 2013). The OBPRT responded to this new information by immediately producing an Emergency Action Plan incorporating new priority recovery actions directed at vital conservation needs of the species. The primary purpose of the Emergency Action Plan was to shift the emphasis of recovery actions relating to captive management and releases, and the management of the wild breeding population and breeding habitat for the following 18 months (OBPRT, 2010a; Hockley & Hogg; 2013). Due to low genetic diversity, it was identified that the captive population required immediate bolstering to ensure that it would be an effective insurance population (Martin et al., 2012).

Implementation of time-critical actions began a day after the OBPRT decided to act including the collection for two new juvenile founders from the wild (Martin et al., 2012). The Emergency Action Plan was prepared within a month with Federal and state governments providing the required funding ($260,000) and resources to instigate the specified emergency actions.

The two main objectives for the following 18 months to ensure the continued survival of the species in the wild were to:

1. Create a secure captive insurance population before the species becomes extinct in the wild
2. Reverse the recent decline in breeding in south-west Tasmania

The performance measures for meeting these two objectives were:

Criteria 1: The captive population includes 25 wild-caught founders

Criteria 2: By March 2011, the captive population has increased to 230 individuals

Criteria 3: Complete the Captive Management Plan (CMP) by September 2010

Criteria 4: Complete the Re-introduction Plan by December 2011

Criteria 5: Carry out the first annual patch burning around potential and known OBP breeding sites to maintain natural foraging habitat

Criteria 6: Collate the genetic material from all captive and wild-sampled individuals

Criteria 7: Conduct supplementary feeding at a minimum of one mainland site during winter in 2010 and at Melaleuca in spring-summer 2010 to enhance the condition of birds, particularly females, to increase breeding participation

Under the Emergency Action Plan, releases of captive-bred birds were halted until the captive population reached an effective size of 400 birds containing maximum genetic diversity. New captive-breeding facilities were also sought to increase the capacity of the captive population and to spread the risk of stochastic events. The nutritional quality of supplementary food provided at Melaleuca was improved and the quantity increased to promote higher breeding participation by females. Nest boxes were also more intensively managed. Competition, predation and hygiene around feed tables were further managed in an aim to reduce associated impacts (OBPRT, 2010a).

The quick response, decision-making and implementation of emergency actions may be responsible for the observed improvement in female breeding participation, higher than average return rates of adults to Melaleuca and relatively stable numbers of OBPs sighted at Melaleuca during from 2012 to 2015 (DELWP, 2016).

7.6 Orange-bellied Parrot Recovery Plan 2016

DELWP led the development of the fifth OBP recovery plan which was anticipated to begin in 2012 and represent a five-year plan. Formal publication of this recovery plan did not occur until 2016 (DELWP, 2016). This recovery plan aims to address and incorporate the five major priorities identified by the review conducted on the 2006-2011 Recovery Plan (Table 5; Pritchard, 2014; DELWP, 2016).

The long-term objective of the current recovery plan is to achieve a wild population of OBPs that has a high likelihood of persistence in the wild over the next 100 years with limited management (DELWP, 2016). To meet this objective, the recovery strategy includes maintaining a viable wild population including supplementation with captive-bred birds and maintaining a viable captive insurance population. This involves:

- Increasing the knowledge surrounding how to address key threats to OBPs
- Direct management of the wild population to enhance population growth
- Habitat management to support population growth and persistence
- Sustainable management of the captive insurance population of at least 400 birds
- Devising a release program of captive-bred birds which facilitates recovery of the wild population

Table 5: Key recommendations from the review of the 2006-2011 OBP Recovery Plan and the responses included in the 2016 OBP Recovery Plan (table sourced from DELWP, 2016).

Recommendation	Response
Actively manage the risk of under-funding to ensure high priority actions are completed, and include a clear procedure for prioritisation	Securing sufficient resources for implementation of very high and high priority actions is a very high priority in the current recovery plan. Responsibilities and procedures for prioritisation, including the development of two-year implementation plans subject to annual reviews, is included as a very high priority action.
Clearly assign accountability of governance and coordination activities to appropriate organisations and individuals to facilitate implementation	Responsible organisations listed in this plan are those with statutory responsibilities for threatened species recovery. This approach was taken to avoid assigning responsibilities to groups (e.g. OBPRT) or individuals (e.g. OBP Recovery Program Coordinator) that are not legally responsible for recovery. Key partners for delivery (e.g. OBPRT, Wildcare Inc. Tasmania, BirdLife Australia) are listed as partner organisations for actions where relevant.
Balance effort between data collection and analysis, and revise techniques to pragmatically inform decisions to ensure effective adaptive management	The importance of timely data analysis and reporting, and the links between these analyses and decision-making are clearly articulated in relevant actions.
Establish and apply criteria for the prioritisation of actions, record and communicate decisions to ensure resources are used appropriately and changes in priority are clearly recorded	Processes for reviewing the priority of actions and tasks include two-year implementation plans to record any changes in priorities, and annual reviews to ensure priorities are still relevant.
Establish objectives tightly linked to actions and performance criteria to ensure that efforts are focused on meeting the recovery objectives	The relationship between actions, strategies, and objectives is clearly identified. The strategies aim to provide a clear link between actions and associated tasks, and the recovery plan objectives to ensure that resources are directed towards those activities most likely to achieve the objectives. Performance criteria are practically measurable and will ensure progress towards objectives is monitored during implementation.

Additionally, the 2016 OBP Recovery Plan has three primary objectives to prevent the very real risk of extinction in the wild and advance population growth over the next five years and one supporting objective (DELWP, 2016). These objectives include:

1. Achieving a stable or increasing population in the wild in the next five years
2. Increasing the capacity of the captive population to support both future releases of captive-bred birds to the wild and provision of a secure long-term insurance population
3. Protecting and enhancing habitat to maintain and support growth of the wild population
4. Ensuring the effective adaptive implementation of the recovery plan (supporting objective)

Twelve strategies have been developed in an effort to achieve the above four objectives which will be assessed against 13 criteria.

7.6.1 Primary Objective 1

While an increasing population in the wild is desirable, this may not be realistic and therefore population stability is the minimum target for the wild population over the next five years. Three strategies will be employed to achieve the primary objective of a stable or increasing population in the wild including:

Strategy 1: Increase breeding output in the wild

Strategy 2: Increase survival in the wild

Strategy 3: Preserve wild behaviours

Increasing both the breeding and survival rates in the wild population will have direct contributions to the population growth. The preservation of wild behaviours is deemed important in future releases of captive-bred birds and the long-term survival of the wild population in the wild. This objective will be measured by the following criteria:

A stable population will be achieved if:

Criteria 1: A minimum of 8 wild breeding pairs are present at Melaleuca in at least four of the five years (measured annually on December 20th)

Criteria 2: A minimum of 20 wild adult birds are known to be present and alive in the breeding range each year (measured annually on December 20th)

These targets reflect the smallest known successful breeding population size at Melaleuca which occurred between 2010 and 2012. If a minimum of 20 adults and 8 breeding pairs remain, it is expected that the population will not experience further declines.

An increasing population will be achieved if:

Criteria 3: Recruitment rates of individuals to the wild breeding population are equal to, or exceed, the mortality rates in at least four of the five years

Criteria 4: A minimum of 40 wild adult birds are known to be present and alive in the breeding range by summer 2016/2017 (measured on 20th December 2016 – this did not

occur). The target of 40 birds was estimated to be a significant and achievable increase in the wild population size based on numbers present in the population between 2010 and 2013.

7.6.2 Primary Objective 2

Presently, the captive population has two purposes: captive-breeding and release programs to supplement the wild population and as an insurance population in the event that the wild population becomes extinct. Two strategies will be employed to achieve the primary objective of increasing the capacity of the captive population to fulfil both purposes:

Strategy 4: Increase the size of the captive population as quickly as possible

Strategy 5: Manage the genetic diversity of the captive population

Quick growth of and an appropriate genetic management regime that minimises losses in genetic diversity in the captive population is essential for the long-term viability of the population and the captive-breeding release program. This objective will be measured by the following criteria:

Criteria 5: The captive population has reached a minimum of 400 birds by autumn 2017 (this target may be revised if new information reveals that an effective insurance population can be achieved at higher or lower numbers)

Criteria 6: An improvement has occurred in the breeding success rate (the proportion of breeding pairs which produce recruits into the captive-breeding population)

Criteria 7: An improvement has occurred in the equality of breeding success across pairs (the distribution of the number of recruits across pairs)

Criteria 8: The genetic contribution of new founders collected since 2008 has led to a doubling of Founder Genome Equivalents in the captive population from 2012-2017

Criteria 9: Retention of at least 97% of genetic diversity across five years (two generations) in the captive-breeding population attained from the new founders collected since 2008

The implementation of management actions for the genetic exchange between the wild and captive populations may necessitate trade-off decisions between Objectives 1 and 2. For example, the benefits to the wild population from a release of captive-bred birds needs to be weighed up against the impacts to the captive-breeding population such as a reduction in population growth. The following strategy incorporates the need to coordinate these two activities while contributing to both Objectives 1 and 2:

Strategy 6: Manage both the wild and captive populations as a metapopulation

7.6.3 Primary Objective 3

Future habitat management (including preventing further habitat degradation and loss and improving current habitat) needs to ensure that adequate habitat is available to support the current small wild population as well as the released captive-bred birds and any future

population growth. Optimal high-quality habitat refers to habitat that matches the OBPs traditional habitat preferences in structure, location, floristic composition and productivity (for descriptions of habitat preferences see Holdsworth, 2006 and Ehmke & Tzaros, 2009). Two strategies will be employed to achieve the primary objective of protecting and enhancing OBP habitat:

Strategy 7: Maintain the current extent of OBP habitat throughout the breeding and non-breeding ranges

Strategy 8: Increase the extent of optimal OBP habitat throughout the breeding and non-breeding ranges

This objective will be measured by the following criteria:

Criteria 10: There has been no loss recorded in the extent of habitat on the mainland as mapped in the relative Predictive Optimal Models (Ehmke, 2009)

Criteria 11: There has been no decline in the extent of the preferred feeding and roosting vegetation in a minimum of six optimal sites in the non-breeding range

Criteria 12: There has been an increase in the extent of the preferred feeding and roosting vegetation in a minimum of six low quality sites in the non-breeding range

Criteria 13: There has been an increase in the extent and diversity of the preferred age-classes of foraging vegetation in the breeding range compared to 2010 data

7.6.4 Supporting Objective 4

Four strategies will be employed to achieve the supporting objective of ensuring effective adaptive implementation of the recovery plan:

Strategy 9: Obtain and analyse key information required to measure and improve the implementation of recovery actions to achieve primary objectives

Strategy 10: Utilise sound procedures to manage, review and report on the progress of the recovery plan and objectives to ensure effective adaptive management

Strategy 11: Secure delivery partners and adequate funding to enable the very high and high priority actions outlined in the recovery plan to be implemented

Strategy 12: Foster and maintain relationships with key individuals, organisations and the broader community

The organisations and partner organisations responsible for delivering the various recovery actions for each objective are not fully resourced or funded preventing the full implementation and achievement of specific recovery efforts. If the second recommendation from Table 5 (clearly assign accountability of governance and coordination activities to appropriate organisations and partner organisations and individuals to facilitate implementation) is implemented, then the project partners can self-identify their skill sets and capacity to fulfil assigned activities highlighting funding and resourcing shortfalls for particular activities. It is likely that minimal progress will be made towards the long-term objectives without further funding for the recovery program with many of the components of the recovery plan going undelivered as has occurred with the previous recovery plans.

SUPERSEDED

7.7 Orange-bellied Parrot Emergency Action Plan 2016

Only 17 OBPs, four of which were females, returned to the only known breeding location in Tasmania for the 2016/17 breeding season. The Department of Primary Industries, Parks, Water and Environment (DPIPWE) OBP Tasmanian Program hosted an OBPRT workshop in Hobart in December in response to the critically low numbers of OBPs to assess their current situation and develop appropriate emergency actions to save the species from extinction in the wild. New recovery actions were devised for implementation over the next 2-3 years, subject to funding, with the OBPRT committing to biannual meetings to review current monitoring data to assess outcomes of recovery actions and provide advice to governments on current and future management options.

Three cohorts of birds were identified as needing specific recovery actions for the next 12 months:

1. Wild population: actions required to maximise adult survival and reproductive success enabling as many wild-born birds to migrate naturally in autumn 2017

2. Captive-bred released adults (November 2016): spring-released birds at Melaleuca will be caught at the end of the breeding season to transport ("assisted/aided migration trial") males to suitable winter habitat in Victoria and females to a captive institution on the mainland for "ranching/holding" (separate from the captive insurance population) before being re-released at Melaleuca in the 2017/18 breeding season.

3. Captive-bred birds that can be made available from the insurance population for wild release:

    - Release of ten or more juveniles at Melaleuca in late summer 2017 (did not occur – proposed for 2018)

    - Release of ten or more adult males at a mainland site in Victoria at the beginning of the non-breeding season (autumn release). This group could build on the assisted migration group to increase the number of birds being released into winter habitat

    - Release of captive-bred adults at Melaleuca in spring 2017 to balance the sex-ratio in the wild population and increase the potential for breeding at current and potentially new breeding sites in the region

The OBPRT also endorsed several other actions including:

- The appointment of a part-time recovery team project coordinator
- Identification of additional and/or alternative Tasmanian breeding release sites in the greater Melaleuca region and further afield
- Trialling tracking devices on captive-bred released birds on the mainland
- Trial of nest intervention actions including intensive nest monitoring and fostering
- Controlled habitat burns in the Melaleuca region during the non-breeding season
- Continuation of the mainland winter monitoring program

8. Public communication

An important component of the OBP recovery plans has been enhancing community engagement, awareness and support for the recovery of the species (Stephenson, 1991; DELWP, 2016). The current recovery plan identifies the need to develop and distribute information describing the species, its value, the progress being made towards conserving the species and outlining the opportunities for community members to be involved in the recovery efforts (DELWP, 2016).

OBPRT members publicise the recovery efforts through presenting talks to local and national organisations, attending conferences, writing articles and engaging in radio and television coverage (Stephenson, 1991). Education officers from each of the three state wildlife agencies previously publicised the species predicament in schools (Stephenson, 1991). Interpretive signs have been erected at the Melaleuca observatory and previously throughout their mainland range. Requests for volunteers and sightings of OBPs have been previously made through local newspapers (although this resulted in many false reports) and newsletters of bird groups and field naturalist clubs.

Other notable media platforms have included:

- The *Trumped-up Corella* newsletter which was launched in 1999 providing over 300 volunteers, supporters and sponsors with information regarding the OBP recovery program. Originally, the newsletter was planned to be published three times a year but due to limited resources and increasing time demands on the then Project Officer this never occurred with publication effectively ceasing for a decade. New recovery team members and technological advances digitally re-instated the publication in 2009 with publications occurring every 12 months. The last issue was published in 2013.

- An OBP project webpage created by BirdLife Australia in 2000 to communicate the recovery program with the public including involvement in the national count weekends, updates and contact details for the Regional OBP Coordinators.

- A *Save the Orange-bellied Parrot* Facebook page was established in 2011 providing an additional source of communication to the public. The Facebook page is independent of the OBPRT but is reliant on OBPRT members to provide timely, accurate information to share with the public. The page enables information that may not be interesting enough for broadcast in the mainstream media to be available online for public viewing. It has also been used as a platform for community-led fundraising efforts (DELWP, 2016).

- A Facebook page (*Orange-bellied Parrot Tasmanian Program*) was established by DPIPWE in 2016 to keep stakeholders and the public well informed about the planning, progress and outcomes of the Tasmanian recovery program.

- Publication of two brochures: one covering the identification of OBPs including distinguishing it from other *Neophema* parrots (originally funded through ICI (Australia) Pty Ltd) and one explaining the endangered status of the species and recovery efforts.

- Production of a postcard, brochure and advocacy material in 2016 to provide information on the OBP Tasmanian Program with details on how to obtain more information, become a volunteer or donate.

- Information about OBPs, their plight and information on how to help the species is published on the websites of the relevant state government agencies.

- Information about the OBP is listed on the Australian National University's (ANU) Difficult Bird Research Group's website along with their involvement in the recovery efforts and the opportunity for members of the public to donate to the project.

Despite the public engagement component of recovery plans, a lot of information regarding the recovery program is not released in the public domain.

9. Population Viability Analysis

Management of threatened species is greatly improved when recovery teams can identify the parameters that most significantly impact the population's viability (Drechsler et al., 1998). Population Viability Analysis (PVA) produces estimations of the extinction risk for a species by using a computer model to synthesise information about the species' population dynamics. Outputs of models are reliant on accurate input data based on biological information such as reproductive rates, population estimates, resightings of individuals and survival. The OBPRT utilise PVAs to guide OBP recovery efforts and refine conservation actions.

In 1990, a PVA workshop was held by the Department of Conservation and Environment (DCE; now DELWP) and the Chicago Zoological Society using VORTEX (Stephenson, 1991). The PVA simulated OBP population behaviour based on random genetic, environmental and demographic variation and catastrophic events. This preliminary simulation implied that high juvenile mortality was the most significant threat to future population growth and that the captive-breeding program was an important back-up for the wild population (Stephenson, 1991).

A PVA generated in 1993 also indicated that the greatest limitation to population increases was high juvenile winter mortality and re-instated the benefits of the captive-breeding program (McCarthy, 1995). Output from the PVA signified the most beneficial use of the captive population was to release 40-60% of the captive-bred birds annually. Winter survival was considered the most critical limiting factor to the population with the management of winter food resources and abatement of threats in the wintering range considered the most important management actions (OBPRT, 2006a). Captive breeding and the provision of nest boxes were also important in minimising the risk of extinction in the wild (McCarthy, 1995).

This PVA was further developed using a sensitivity analysis of the population model to estimate parameters for the wild population (Drechsler, 1998; Drechsler et al., 1998). A reliable estimate of extinction risk however was not able to be determined due to the uncertainty in numerous parameters of the OBP population dynamics (OBPRT, 2006a). Despite these limitations, winter survivorship was shown to be more limiting than reproduction (Drechsler, 1998; Drechsler et al., 1998). The model also indicated that the qualitative features of habitat, including the composition of vegetation, were more important than quantitative features such as habitat size (Drechsler, 1998; Drechsler et al., 1998) but both should still feed into mainland habitat management criteria. The research concluded that management should target juvenile and adult survival (Drechsler et al., 1999). Recent data analyses of capture-mark-recapture data, however, indicated that reduced winter survival was not the most important limitation to population growth as indicated by the PVAs (Holdsworth et al., 2011).

Another PVA was generated in 2011 by an independent researcher where the baseline for analysis being the number of birds that arrived at the breeding grounds in 2011 and the mortality rate was mortality as a function of age as published in Holdsworth et al. (2011). No allowances were made for captive-released birds. Two scenarios were run including a sex ratio at fledgling of 1:1 and 2 males:1 female (D. McCarthy, pers. comm.). Extinction in the wild was predicted in seven years using the 2:1 sex ratio and nine years using the 1:1 sex ratio (D.

McCarthy, pers. comm.). However, this PVA was not considered by the OBPRT due to views surrounding the validity of the results based on conceived limitations of producing a PVA founded on such small numbers and was subsequently not published (D. McCarthy, pers. comm.).

A PVA working group was formed in 2016 to evaluate management options for the wild population by comparing historic (pre-2010) and recent (2013-2016) demographic parameters (Baker, 2016). Three models were generated using VORTEX and aimed to provide a basis for assessment for the impact of potential management actions particularly involving the use of the captive population:

Model 1: Base model using pre-2010 data

Model 2: Base model using recent (2013-2016) data

Model 3: Base model 2 plus spring release of 15 females and 5 males

Models were run for a 10 year period with 2000 simulations. Extinction was defined as when one sex remained in the population. The inverse of survival estimates from historical (Holdsworth, 2006; Holdsworth et al., 2011) and recent (S. Troy, unpubl. data) databases were used to model the estimates of mortality. The mean population growth rate (R value), mean final population size (N) and extinction probability were used to assess models. The reproductive and mortality rates were adjusted in Model 3 until a positive population growth rate (R) was achieved to determine the level of annual survival required to stabilise the wild population under the current recruitment levels and the level of recruitment (fecundity) required to stabilise the wild population under the current survival levels.

Model 1 predicted a low, positive population growth rate after ten years with a low extinction probability (0.001). Modelling of the historic data indicated that the wild population was viable until approximately 2005 (although only just).

Model 2 predicted rapid extinction of the species in the wild within a mean of 1.86 years. This model re-confirmed that without appropriate recovery actions, there is an extremely high likelihood of extinction in the wild within a few years.

Model 3 predicted a population growth of R = 0.0958 with a final population size of 61.18 and the population remaining male-biased assuming annual spring releases to correct the male-bias sex-ratio are maintained.

Models indicate that releasing approximately 20 birds annually, mainly females, could maintain the population in the wild and demonstrate a slow population growth for the coming 10 years. However, without any changes to other demographic parameters, the population is predicted to remain strongly male-biased. Increasing juvenile survival is predicted to have the maximum positive impact on population growth based on the current reproductive and survival parameters. This is followed by decreasing the mortality rate of adult females which also acts to decrease the male-bias in the wild. Models predicted that increasing fledgling success (fecundity) would have a lesser impact (Baker, 2016).

Three other scenarios were brought up at the PVA workshop which require further discussions with input from the OBPRT (Baker, 2016). These include:

- Effects of a second breeding population

- Effects of balancing the sex-ratio at the beginning of the breeding season assuming (a) 20% survival of released birds and (b) 40% survival of released birds through assisted migration or repatriation
- Evaluation of ranching options

Demographic and reproductive data were provided to the University of Tasmania in September 2017 for development of a PVA model to evaluate future population trajectories under different management actions (DPIPWE, pers. comm.).

10. Mainland (non-breeding) program

10.1 Objectives

The mainland monitoring program for OBPs during the non-breeding season aims to:

- Conduct annual winter monitoring of OBPs through the national count weekend in July and a supplementary count of key sites in May and September
- Conduct searches for colour-banded birds across their winter distributional range
- Conduct searches for potentially-suitable OBP habitat across their mainland range and monitor these for OBP presence
- Protect important OBP habitat
- Promote public awareness and community involvement in the OBP recovery program

It has been identified that no further actions are required on the mainland to improve breeding output. Winter survival has now emerged as the more significant limiting factor for the population and is the focus of current recovery actions (DELWP, pers. comm.).

10.2 Winter counts

Since 1978, an annual winter census of the OBP population has been conducted to simultaneously survey a large proportion of winter habitat to count the number of OBPs present on the mainland. The national count occurs over a weekend in late July when OBPs are likely to be present in their winter habitats and are the least mobile (Starks et al., 1992). Two supplementary counts are conducted in the last week of May and the first week of September to help determine if birds move between sites during winter (Starks et al., 1992). Since commencement of the count weekends, annual counts have never exceeded 150 birds (Starks et al., 1992).

An OBP Winter Coordinator and more recently Regional Coordinators have been responsible for organising trained volunteers to conduct the winter counts. Generally, the same sites are surveyed annually with effort largely being directed to sites corresponding with the highest chance of detecting birds based on historic records or identified as having potentially-suitable habitat as determined from habitat modelling (see section 10.9). The number of sites surveyed during the count weekend is largely dependent on the number of registered volunteers on the day and the availability of the increasingly limited resources. Depending on the size of the site

and site access, observers conduct their search either on foot, in a slow-moving vehicle or from a boat. OBPs are detected visually and aurally through their distinctive contact and alarm calls. Volunteers are recommended to perform surveys between sunrise until 11:00 am and between 3:00 pm and sunset to coincide with increased foraging activity. Between 11:00 am and 3:00 pm, individuals are more likely to be under vegetation cover socialising, preening or resting. Over 100 volunteers regularly participate in the annual winter count weekends and are a crucial component of this program. However, numbers have started to decline in recent years. Together with volunteers in Tasmania during breeding season, volunteers are estimated to provide $1,250,000 in-kind support per year (DELWP, 2016).

Sporadic surveys are also conducted at other locations during winter, such as on King Island. These surveys are further augmented by incidental sightings by members of the public who are encouraged to immediately report sightings to Regional Coordinators who assess the likelihood of the sighting and can visit the site soon after reports are made to confirm presence before potential birds depart. These additional sighting events, which often correspond to areas outside of the traditional survey sites, form a valuable record of habitat usage and help fill knowledge gaps.

Collected data is used to monitor the annual movements and site use on the mainland, conduct habitat assessments of preferred feeding and roosting habitat, review the wintering range of birds including identification of new habitats being utilised, evaluate the spatial distribution of the population and encourage public awareness and involvement.

The winter counts were funded by ICI (Australia) Pty Ltd from 1978-1982 with the DEC (now DELWP) continuing funding from 1983 with some funding from Environment Australia. Since 1984, BirdLife Australia (formerly the Royal Australasian Ornithologists Union; RAOU) has been contracted by DELWP to coordinate and conduct the official winter counts. Where possible, the Victorian and South Australian State wildlife agencies provide vehicles, boats and staff to support the count weekends (Stephenson, 1991). In 2017, the winter monitoring program went largely unfunded relying on in-kind support from the Regional Coordinators.

10.2.1 Regional Coordinators

In 1999, an OBP Winter Coordinator position was created and filled through BirdLife Australia. The main tasks of the Winter Coordinator included:

- Coordinating, managing and implementing the mainland winter monitoring program including the national count weekends (organisation of trained volunteers), searching for colour-banded birds, following up on incidental sightings, and surveying potential habitat outside of regularly used sites
- Re-visiting historically surveyed and potential survey sites prior to the first count weekend each year to determine if sites are (still) accessible to volunteers and contain potential OBP habitat
- Performing habitat measurements at used sites for inclusion in habitat modelling
- Maintaining the *Orange-bellied Parrot Winter and Resights Database*
- Providing assistance for the management of the South Australian and Victorian Working Groups
- Preparing grant applications for mainland funding and material for public awareness

In 2002, the position dissolved due to funding cuts. Consequently, coordination of the winter counts fell to volunteers (J. Starks, pers. comm.).

In 2006, Regional Coordinators were established for four main site complexes within Victoria: SW Victoria, Bellarine Peninsula, western Port Phillip Bay (Appendix 4) and Western Port and one in South Australia covering the south east and the Coorong. Further funding cuts to the mainland monitoring project in 2009 greatly reduced the capacity of Regional Coordinators to organise and conduct the three count weekends, promote public awareness and education through workshops and to perform follow-up investigations of sightings which can result in loss of crucial data including habitat use and movements (Adams & Purnell, 2016). In 2016, funding was secured through the Victorian Threatened Species Protection Initiative enabling a Regional Coordinator for SW Gippsland and SW Victoria (via the Nature Glenelg Trust) to be established to cover gaps in survey coverage. However, in 2017 only two of the five Victorian Regional Coordinators were allocated specific funding to perform mainland monitoring with the unfunded positions being filled on a volunteer or intern basis.

Continued monitoring of the winter population has previously been identified as a high priority and is listed as a very high priority in the current recovery plan (Action 7; DELWP, 2016). A comprehensive survey effort across all mainland site complexes will only be achieved again if Regional Coordinators are re-instated to their original work schedule and more resources made available (Adams & Purnell, 2016).

10.2.2 Survey effort

The winter counts were initially used as the annual index for the wild OBP population. However, from 1992 onwards, discrepancies began to emerge between the winter and summer population counts, with winter counts decreasing while summer counts (the number of individuals returning to Melaleuca) remained stable (Starks, 1997). The explanation for this disparity was that a proportion of the OBP population had shifted beyond their traditionally important winter habitat which was previously consistently used between years and had begun using non-traditional winter sites having adapted to foraging on weed species within coastal or sub-coastal agricultural habitats which are not searched during the count weekends (Starks, 1997; 1999). Furthermore, the decrease in winter counts was attributed to dispersal into smaller mainland flocks.

In response to the declining site use and numbers of OBP observed on the mainland in winter, the focus of the mainland program shifted from monitoring known sites to searching for birds in alternative habitats or areas (J. Starks, pers. comm.). Optimal habitat models indicated that key habitat in Victoria is sparsely dispersed across a large spatial area, occurring at extremely low densities with certain sites containing significantly more optimal habitat than others (Ehmke & Tzaros, 2009). For example, the western coastline areas of Victoria are predicted to have the highest number of OBP sightings due to the larger area of predicted suitable habitat (Ehmke, 2009; Ehmke & Tzaros, 2009). The central region along the Victorian coastline has the smallest potential area for OBP occurrence (Ehmke, 2009).

Searches outside of the then known sites located birds in other habitats (e.g. 18 OBPs were found using the habitat around Yambuk Lake) where they were found to be adapting to different food sources including exotic seeds (J. Starks, pers. comm.). BWPs were subsequently used as indicators to search for OBPs in new areas and began to be recorded during count weekends (J. Starks, pers. comm.). This broadening of monitoring and search efforts helped to maintain volunteer interest at the time (some volunteers had been involved for 10+ years without observing many/any birds) by contributing to new research and monitoring of other *Neophema* species (J. Starks, pers. comm.). Despite the expansion of surveys and increase in survey

frequency of known and potential winter saltmarsh sites, the majority of 'missing' OBPs failed to be located (Starks, 1997).

The *Orange-bellied Parrot Winter Census and Resights Database* (Birds Australia, 2009) has been used to review the mainland survey effort, including reporting rate and site coverage and to identify survey gaps (Adams & Purnell, 2016). Numbers of OBP-targeted surveys has decreased in nearly all of the five main Victorian site complexes over recent years, with inconsistencies evident in the number of surveys being conducted across the three national count weekends (Adams & Purnell, 2016). Spatial inequity of surveys also exists between the site complexes with the majority of surveys now only occurring in two (western Port Phillip Bay and the Bellarine Peninsula) of the five Victorian site complexes. This coverage is indicative of funding allocations for Regional Coordinators and locations of recent sightings on the mainland. Surveyed sites are also heavily biased to traditionally used sites and sites corresponding with a high predicted relative probability of occurrence value (Adams & Purnell, 2016).

Over 60% of OBP sightings since 2000 have been within optimal habitat indicating that survey effort should be concentrated in areas associated with predicted optimal habitat (Ehmke, 2009) yet 50% of all identified optimal habitat goes unsurveyed each year (Adams & Purnell, 2016). Inconsistencies and declines in survey effort is partly due to loss of funding and resources for the Regional Coordinators over recent years and their reduced ability for community engagement as well as changes in land access (Adams & Purnell, 2016). Several recommendations have been made recently regarding the survey effort and site coverage within Victoria including the need to reinstate Regional Coordinators to their original work schedule to ensure a comprehensive survey effort is implemented across the five main site complexes within Victoria (Adams & Purnell, 2016).

10.2.3 Survey limitations

The annual winter counts have been vital in providing enormous amounts of data for use in population modelling which has been critical to the OBP recovery program and management decisions. However, limited resources over the last seven years has resulted in the winter counts becoming less comprehensive and informative with results varying annually. A large proportion of the winter range remains poorly surveyed due to limited resources, site remoteness and/or accessibility. For example, accessibility to some sites that were historically surveyed has been revoked by private landowners, while other sites have been omitted from annual surveys for reasons such as drought and have not been re-instated since (Adams & Purnell, 2016). When sites are surveyed, the cryptic habits and colouration, nomadic nature and prevalence at very low densities (and therefore low detection rates) make detecting OBPs challenging. Consequently, individuals are commonly detected only when in close proximity or when they are accidently flushed.

Autumn and winter count data, thus inferred population trends, for a year can be impacted by the weather conditions over the scheduled count weekend. Survey effort is likely to be reduced in unfavourable conditions (e.g. strong winds, heavy rainfall, cold temperatures) due to site access and observer participation. Furthermore, birds are likely to go undetected during the survey and remain out of sight. This is a major limitation of surveys which are conducted on a specified date, especially when only three surveys are conducted per year.

The winter surveys are also subject to several sources of biases which can impact management decisions. Firstly, survey effort is not standardised between sites, with observers covering as much area of their corresponding site/s as possible during the time they have available. Secondly, survey effort is not consistent between years in regards to the number of sites surveyed, the particular sites surveyed and the effort spent surveying each site. These two

biases are largely an indication of the limited resources available each year. Thirdly, a reporting bias exists where negative surveys (i.e. those where OBPs were not detected) are not reported by observers and/or not entered into the database. This bias has been addressed to a certain extent in recent years but is still evident in the reporting process. Another negligible source of bias is the suppression of positive sightings by the public due to the fear of adverse impacts occurring to the environment through disturbance (do not want researchers on their private property) or to the birds themselves (i.e. the removal of founders from the wild population). Other land holders may supress records in fear of imposed restrictions or obligations tied to the management of the species. Continued public education and awareness about the recovery strategy may help overcome this bias.

Other reporting biases are also common when conducting surveys with a large number of observers including false positives (i.e. Blue-winged Parrots, Elegant Parrots (*Neophema elegans*) and Rock Parrots (*N. petrophila*)) and false negatives (OBPs are mis-identified as another species and are subsequently not reported). Identification of OBPs from other *Neophema* parrots can also be difficult to confirm by sight alone. It is therefore essential that surveyors can recognise the distinctive contact and alarm calls of the OBP to minimise reporting errors.

10.3 Mainland Orange-bellied Parrot database

During the count weekends, observers are required to complete a survey form recording information such as precise location including GPS coordinates, weather conditions, physical traits (i.e. age, sex, leg band), identification method, activity of bird, habitat type, site topography and presence of other bird species (BirdLife Australia, 2016). Mainland survey data are then entered into the *Orange-bellied Parrot Winter and Resights Database* with all records being vetted and are generally accurate to within 100 m (Birds Australia, 2009; Ehmke, 2009). Traditionally, survey forms were only completed for positive detections. In more recent years, negative surveys have also been recorded to provide a comparison between distribution patterns of previous years and between occupied verses unoccupied sites. This enables more robust analyses to be conducted as avoids skewing the collected data enabling more accurate habitat modelling and habitat use predictions to be generated.

Limited resources over the years have made it challenging to conduct comprehensive observational surveys of all known and potential winter sites, especially those outside of the recognised traditionally important locations. Due to the significant variation in survey effort and site coverage across the species wintering range, this database is not an accurate representation of the overall winter population. For example, in the 1980s, an average of 43% of the OBP population was detected in the winter counts. This has dropped to an average of 10% since 2000 despite the greater survey coverage and increased number of volunteers participating in the counts. Subsequently, only approximate estimates regarding winter population dynamics (i.e. size, distribution, survival rate, habitat use) can be ascertained from the *Orange-bellied Parrot Winter and Resights Database* and caution is required when using such estimates to infer population trends and informing management actions.

Banding information from Tasmania is only entered into this database upon request to DPIPWE after a banded bird has been sighted on the mainland. All sightings of OBPs from the mainland database are entered into the Victorian Biodiversity Atlas (VBA).

10.4 Site use and food availability (Victoria)

Habitat and food availability has been identified as being limited during mid-winter and could possibly be a main factor limiting population size (Lyon et al., 1986). In 1978, ICI (Australia) Pty Ltd funded research into the site use of OBPs at Point Wilson due to their proposal to construct a petrochemical complex on the industrial zoned land they owned (Stephenson, 1991). In 1992, the Endangered Species Program of the Australian Nature Conservation Agency funded further work into habitat requirements of OBPs in Victorian saltmarsh (McMahon et al., 1994). These research projects revealed that OBPs use both wet and dry saltmarshes and adjacent areas of exotic habitat during winter with their diet comprising a diverse range of saltmarsh plants. OBPs were detected as having a discernible preference for saltmarshes located in western Port Phillip Bay compared to the more extensive saltmarshes located elsewhere in coastal Victoria (Yugovic, 1984; Loyn et al., 1986). This may be due to the central Victorian saltmarshes being the only suitable OBP habitat supplying a stable temporal sequence of food, including mid-winter seed from native food plants, compared to eastern and western saltmarshes which generally lack the distinctive upper saltmarsh vegetation (McMahon et al., 1994).

OBPs were found to forage successionally following the sequential ripening of seeds in the various saltmarsh species and require habitat which provides a variety of appropriate food plants throughout the winter period (Yugovic, 1984; Loyn et al., 1986). The majority of traditional OBP food plants flower in summer and carry seed through to the early winter months (early March to early June) including the favoured Beaded Glasswort (*Sarcocornia quinqueflora*), Austral Seablite (*Suaeda australis*) and Southern Sea-heath (*Frankenia pauciflora*). Other plants flower in winter or spring providing OBPs with food from mid-August to November, such as Shrubby Glasswort (*Sclerostegia arbuscula*), with their diet being supplemented with Oakleaf Goosefoot (*Chenopodium glaucum*) and *Arthrocnemum arbusculum* (Yugovic, 1984; Loyn et al., 1986). Food appears to become scarce during the middle of winter after Beaded Glasswort loses its seeds until seeds from Shrubby Glasswort become available in mid-August (Loyn et al., 1986). During this time, individuals are constrained by the short- day lengths but need to be able to metabolise sufficient food to meet their energy expenditures and stay warm (Anon, pers. comm.). An important food source during June to mid-August was identified as the highly salt-tolerant Grey Glasswort (*Halosarcia halocnemoides*) which is largely confined to the low-rainfall area in western Port Phillip Bay, including at Point Wilson, and grows in the rear of saltmarshes (Yugovic, 1984; Loyn et al., 1986). The western Port Phillip Bay region corresponds with the driest climate in coastal Victoria as a consequence of the rain shadow caused by the Otway Ranges and has a high abundance and wide distribution of Grey Glasswort (Yugovic, 1984). Conversely, saltmarshes in East Gippsland and Western Port have a higher rainfall and therefore Grey Glasswort is absent resulting in the inability for these saltmarshes to provide a continual source of winter food for OBPs and may be the reason for the low numbers traditionally observed in these regions (Yugovic, 1984; Anon, pers. comm.). Subsequently, dry saltmarshes are an important winter habitat which OBPs rely heavily upon (Loyn et al., 1986).

The consumption of native saltmarsh species appears to be supplemented mainly during the mid-winter period with seeds from exotic species in adjacent pastures coinciding with the apparent critical shortage of seed available from native plant species (Yugovic, 1984; Lyon et al., 1986; Edgar & Menkhorst, 1993). Consumption of exotic vegetation, such as Cape Weed (*Arctotheca calendula*) is also greater at traditional saltmarsh sites which have contracted in size and in disturbed habitats where OBP foraging behaviour may be more opportunistic (McMahon et al., 1994).

Historically on the Bellarine Peninsula, numbers of OBPs peaked at Lake Connewarre, which is a primarily Beaded Glasswort site, in May following migration to the mainland, coinciding with

the seeding of *Sarcocornia*. As the season progresses and the *Sarcocornia* seeding dies down, areas of *Sclerostegia* begin to seed with OBPs moving to these locations including to Swan Island (numbers peaked in August) where Shrubby Glasswort and Marsh Saltbush provided important mid-winter foraging opportunities (McMahon et al., 1994). Numbers at Point Wilson increase from March to July and decrease from August to early November suggesting that OBPs moved to the dry saltmarsh at Point Wilson to feed on Grey Glasswort in response to declining food availability at other wintering locations and depart when food supplies, such as the widespread Shrubby Glasswort, increase at other sites (Yugovic, 1984; Loyn et al., 1986).

Over the years, the dry saltmarsh at Point Wilson has been modified due to agricultural, industrial (including an explosives reserve, an airfield and saltworks) and residential developments and conversion into a sewage treatment farm (the Western Treatment Plant (WTP); Yugovic, 1984; Stephenson, 1991). Conversion of the saltmarsh into sewage lagoons eliminated a large portion of the upper sections of saltmarsh, including Grey Glasswort, and what remains has become encroached with other species including weed species. The saltmarsh at Lake Connewarre has become invaded by Austral Salt Grass which has smothered the lower saltmarsh. There were some discussions about testing the use of herbicides to control the spread of the Austral Salt Grass but this never eventuated. In recent years, OBPs have been observed increasingly foraging on grassy or weedy pastures associated with coastal vegetation communities in these regions (OBPRT, 2006a). It is advised that the on-ground winter food supply, particularly of historically important saltmarsh species, is increased to ensure utilised saltmarshes have sufficient carrying capacity for the OBP population (Anon, pers. comm.).

OBPs are currently using western Port Phillip Bay very differently compared to traditionally but their continued use of this area despite modification indicates that these areas contain an important combination of favoured winter food plants (Stephenson, 1991). These dry saltmarshes therefore require appropriate management and conservation to ensure OBP persistence and survival.

Further research or recovery actions relating to OBP site use and habitat on the mainland have been previously recommended including:

- Commencement of a base-line study at Point Wilson to monitor changes in the saltmarsh community through the collection of quantitative and qualitative data on the structure and floristics of the saltmarsh vegetation and environmental variables
- Regular monitoring of important OBP foraging sites to increase knowledge of ecological requirements throughout the mainland range and to form the basis for management decisions
- Development of management strategies to conserve and/or restore Victorian saltmarshes including stock exclusion, access restrictions, control of weed species and prohibition of off-road vehicles
- Further studies investigating the flowering and seeding of saltmarsh vegetation
- Identification of the role of differing food plants in the winter diet including measuring the nutritional value
- Investigation into the declining health of upper dry saltmarshes
- Formulation of strategies to increase the availability of preferred winter food plants and provide appropriate winter food sources during mid-winter if food is limited

The majority of these recommendations have either been partially completed (with limited follow-up) or not attempted.

10.4.1 Site register

In 2000, the OBP Winter Coordinator was tasked with developing a site register for OBP locations in Victoria. Information included a site description, habitat, history of land use, all records of OBPs and BWPs, threats and current management procedures. The site details for OBPs are incorporated into the Arthur Rylah's Biodiversity Conservation database.

10.4.2 Association with Blue-winged Parrots

Traditionally, OBPs were not commonly seen foraging with BWPs with flocks remaining separate (Loyn et al., 1986). When mixed-species flocks did occur, there were often numerous OBPs within the same flock which would flock together within the larger flock, maintaining OBP foraging and migratory behaviours (J. Starks, pers. comm.).

In the mid-1990s, OBPs increasingly started to be observed mixing with other *Neophema* parrots on the mainland, including BWPs, possibly due to the decrease in OBP numbers and the declining use of traditional winter habitats (Anon, pers. comm.; J. Starks, pers. comm.). With fewer numbers of OBPs in the wild, there are now concerns when one or two OBPs join BWP flocks as individuals have a higher probability of mimicking BWP behaviours which are fundamentally ecologically different to OBPs including eating different food plants which they aren't necessarily equipped to forage on and spending less time foraging (Anon, pers. comm.; J. Starks, pers. comm.). It is also unclear what these individuals do when it comes time to migrate – do they migrate to the Tasmanian breeding grounds or do they remain with the BWPs and become lost to the OBP population? It has been hypothesised that after this association began, numbers of OBPs experienced further declines (Anon, pers. comm.). Due to the differences in the two *Neophema* species, it has been advised that BWPs should not be treated as an indicator species for OBP management actions (Anon, pers. comm.).

BWPs began turning up at traditional OBP sites in western Port Phillip Bay and the Bellarine Peninsula (e.g. Swan Island, The Spit Nature Conservation Reserve) when OBPs began to decline (J. Starks, pers. comm.). This made it harder for volunteers to observe OBPs during count weekends and increased the probability of observer error which may have impacted reporting rates at the time (i.e. mis-identifications; J. Starks, pers. comm.).

10.5 Habitat maintenance and restoration

Early research implied that management of winter sites was more important than management of breeding sites and the state of winter habitat, particularly the distribution and type of food plants, is still considered a critical factor (Loyn et al., 1986; Drechsler, 1998; Drechsler et al., 1998; Tolsma et al., 2014). The majority of Victorian saltmarshes traditionally used by OBPs during winter have now experienced high levels of deterioration or depletion. This includes significant loss of the floristically distinct vegetation in upper saltmarshes which has resulted in food shortages during winter (McMahon et al., 1994). Consequently, maintenance and restoration of optimal OBP habitat, particularly on the mainland, continues to be a very high priority in the current recovery plan as in previous ones with particular focus directed at restoring the diverse saltmarshes originally present in western Port Phillip Bay. This includes the restoration of Grey Glasswort which is an important food source during the limiting period

between June and mid-August. Site management is largely dependent on the ability to detect changes to key OBP habitat characteristics (Tolsma et al., 2014).

Habitat management strategies are however inherently difficult to implement across the species mainland range due to the number of potential sites, numerous landowners/managers and associated complex ecological, social and economic factors (Menkhorst et al., 1990). Despite this, the majority of known winter OBP habitat has received some form of protection and/or enhancement (e.g. supplementation or creation of habitat through revegetation) to increase the carrying capacity and secure a sufficient winter food supply. This has occurred through planning regulations, heritage agreements, cooperative conservation agreements between landholders or acquirement of land for incorporation into nature reserves (Stephenson, 1991; OBPRT, 2006a). For example, five areas of key winter habitat have been listed under the Ramsar Convention as wetlands of international significance citing the occurrence of OBPs as a criterion for listing: Lavinia State Reserve (King Island, Tasmania), the Coorong (South Australia), Western Port, Port Phillip Bay (western shoreline) and Bellarine Peninsula, and Corner Inlet (Victoria). Management plans have also been produced for 16 State managed reserves and parks which support important OBP habitat. Federal funding received in 2008 was directed at a habitat restoration project on the mainland. Management actions included fencing off habitat to manage grazing, re-vegetating cleared coastal landscapes through planting 30,000 OBP habitat plants and weeding (Sims, 2009).

Parks Victoria implement saltmarsh improvement works at Point Cook Coastal Park and Cheetham Wetlands including hand pulling, chipping and spraying of herbaceous weeds and have prevented saltmarsh grazing (B. McCarrick, pers. comm.). Works are carried out under tender funding thus not all sites are targeted annually (T. Stringer, pers. comm.). Additionally, Port Phillip Westernport CMA partners with Parks Victoria to manage weeds at key sites. Control of Tall Wheat Grass (*Thinopyrum ponticum*) at a site in the Lake Connewarre system by DELWP under National Landcare Program funding provided by the Corangamite CMA complements larger-scale weed control implemented on adjoining land by Parks Victoria (DELWP, pers. comm.). Parks Victoria and Port Phillip Westernport CMA manage vehicle access issues at a key OBP site in Port Phillip Bay (DELWP, pers. comm.). DELWP is currently involved in discussions with Parks Victoria and local governments to improve storm water management to at least one site with OBP values (DELWP, pers. comm.).

Within the WTP, Melbourne Water has implemented and funded numerous actions often at the request of the OBPRT (H. Graham, pers. comm.; W. Steele, pers. comm.). These include:

- Restricting or closing access to specific tracks known to be used by OBPs to both staff and birdwatchers (ongoing since 2012)
- E-mailing permit holders reminding them of appropriate behaviour in OBP areas
- Stipulating that birdwatchers should remain in their cars at the Western Lagoon during the winter months so as not to disturb any possible OBPs
- Erecting signs (ongoing since 2014)
- Restoration of 16 ha of sewage ponds into coastal saltmarsh (2010, 2016)
- Preservation of roost trees
- Modifying a drain in 2004 that was thought to be impacting saltmarsh by diverting flow of freshwater from the Spit Nature Conservation Reserve saltmarsh which resulted in the recovery of the saltmarsh

- Grazing areas (1991, 1979, 2007/08) and excluded grazing of Werribee Agricultural Group stock when that was the dogma
- Conducting research on and planted *Chenopodium glaucum* as food for OBPs (completed 1990)
- Funded assessments by BirdLife Australia of the change in saltmarsh OBP habitat at the WTP and the Spit Nature Conservation Reserve between 2005-2013. Findings concluded that there were small gains in habitat therefore no subsequent management actions were required.
- Funded assessments by Ecology Australia of the change in saltmarsh OBP habitat at the WTP between 2013-2016. Again, small gains in habitat were evident thus no subsequent management actions were required.

West Gippsland CMA and Glenelg Hopkins CMA have strategically managed the estuary openings at Powlett River and Lower Merri wetlands respectively in accordance to estuary management guidelines and best available information (DELWP, pers. comm.). Glenelg Hopkins CMA have received Coastal Stewardships for habitat works on or near estuaries including key OBP sites and have previously developed Stewardship and Tender sites which are still under contract (J. Obst, pers. comm.). They have also received Coastal Community Grants for CVA habitat protection and weed treatment at a traditionally important OBP site and conducted fencing, weed control and revegetation works at various locations along the estuary along with a Stewardship agreement delivered in the first year of the Budj Bim project (a 4 year waterway health program on the Lake Condah lava flow system including the Fitzroy River and estuary which are traditionally important OBP sites). Furthermore, estuarine wetland condition is continually monitored through the Estuary Entrance Management program including proactive artificial river mouth opening works occurring on Yambuk Lake in 2017 (another traditionally important OBP site) to alleviate long inundation periods of the saltmarsh (>2 months; J. Obst, pers. comm.). West Gippsland CMA have also undertaken a program of habitat improvement at Corner Inlet and Powlett River (DELWP, pers. comm.). Victorian sites where recent hydrological changes have occurred are being monitored to better understand vegetation responses (DELWP, pers. comm.).

Numerous agencies, community groups and non-government organisations actively participate in habitat management and restoration initiatives (Tolsma et al., 2014). The current recovery plan advises that where appropriate, at-risk OBP habitat on private land should be protected through land purchase, covenanting or voluntary land management agreements (DELWP, 2016). Support for habitat management should also be offered to private landholders with at-risk OBP habitat (DELWP, 2016). All mainland sites currently used by OBPs or are predicted to be important in the future are recommended to be afforded protection if not already managed (DELWP, 2016). No key sites have been at risk of permanent loss in recent years and no high priority sites have required consideration for purchase (DELWP, pers. comm.). Two parcels of land in south-west Victoria are due to change hands in 2018 and may face increased risk following sale. DELWP are currently seeking opportunities for this land to be purchased and added to an existing reserve. The site does not presently support OBPs, but the site was an important refuge for OBPs during the millennium drought (DELWP, pers. comm.).

Despite restoration efforts, extensive areas of suitable habitat within Victoria and South Australia remain unused by OBPs. This is likely to be partly explained by the low numbers remaining in the wild (White et al., 2016). Furthermore, while juveniles have been observed in new and recovering habitats, the high site fecundity displayed by older wild birds may restrict the likelihood that they attempt to locate or relocate to these habitats. Maintenance of suitable habitat for future recovery is still intended by the OBPRT, but despite the very high priority in

the current recovery plan, mainland habitat management is not an urgent focus of the recovery plan at this time.

10.5.1 Monitoring protocol

The absence of quantitative measures of habitat condition and changes impacting habitat suitability across time limits the capacity to implement effective management and protection of winter mainland OBP habitat. Limited longitudinal habitat monitoring of OBP sites has occurred over the last few decades, partly due to limited resources, therefore there is insufficient knowledge on habitat characteristics or management needs for winter OBP habitat across its winter range. This knowledge gap also limits the ability to dynamically identify changes which may cause habitat to become unsuitable (Tolsma et al., 2014).

In 2014, a project was undertaken with an aim of developing an easy, rigorous, cost-effective monitoring protocol to detect temporal changes in key winter OBP habitat parameters to better inform habitat management protocols to preserve optimal OBP habitat on the mainland (Tolsma et al., 2014). These included preferred OBP food plants, exotic species which outcompete preferred food plants and key structural elements of bare ground and tall shrubs. This consists of using point quadrants set at 0.5 m intervals along permanent 50 m long transects (5 per site) to measure habitat parameters and abundance of key plant species (Tolsma et al., 2014). Vertical pins are placed at regular intervals along the transects perpendicular to the ground. At each pin, intersecting vegetation and environmental characteristics are recorded.

Staff from DELWP, Parks Victoria, Corangamite CMA, Glenelg Hopkins CMA and the Department of Environment, Water and Natural Resources (DEWNR) have been trained in the use of this monitoring method with DELWP providing continued support to agencies collecting data. Habitat condition data are being collected from a range of high- and low-quality OBP habitat sites in Victoria (69 monitoring transects spanning 12 sites since 2014) and South Australia (starting in 2018; DELWP, pers. comm.). High quality sites are monitored to ensure they remain high quality and low quality sites are surveyed under a range of management regimes to see if condition can be improved and to learn from different management strategies. Surveys should ideally occur at the same time each year during winter corresponding to when OBPs would be using the sites (Tolsma et al., 2014). Sites are monitored by DELWP, Parks Victoria, Corangamite CMA, Nature Glenelg Trust and volunteers from Tafe and Conservation Volunteers Green Army undergrad students. Consistent funding for monitoring is likely to be limited thus surveys are only likely to occur on an opportunistic or irregular basis (Tolsma et al., 2014).

Data are entered into a corresponding database maintained by DEWLP where key plant species are automatically linked to a variety of functional categories representing OBP environmental preferences, food plant preferences and structural characteristics. Data collection through simple habitat assessments of key habitat attributes will enable quick determination of trends and identification of potential environmental factors responsible (Tolsma et al., 2014). DELWP attempted to analyse collected data in 2017 corresponding to 2-3 years of data for some sites. However, some identified habitat changes were clearly due to observer errors. Training refreshers in data collection will now be run annually targeting the causes for error. More data is now required to assess the outcomes of management trials before changes in management agreements can be made. Data will be reviewed again in early 2018 (DELWP, pers. comm.). The OBP Habitat Monitoring database is shared among all partners that collect and enter the data enabling land management organisations to undertake their own analyses (DELWP, pers. comm.).

DPIPWE are currently working with the relevant Tasmanian regional NRM organisation (Cradle Coast NRM) to consider including OBP monitoring as part of its Regional Land Partnership tender

bid under the National Landcare Program (DPIPWE, pers. comm.). The monitoring protocol would be similar to what is implemented in Victoria.

10.5.2 WTP habitat monitoring

As custodians of critical OBP winter habitat on the mainland, Melbourne Water performs regular audits of the extent and quality of saltmarsh vegetation via field inspections, remote-sensing and interpretation of historic and current aerial imagery (Ehmke & Herman, 2013). The first surveys were conducted in 2013 with changes in vegetation based on the saltmarsh communities present in 2005. Results revealed that there was a net gain of saltmarsh within the WTP (6.24 ha) and a net loss at The Spit Nature Conservation Reserve (0.16 ha). New saltmarsh in the Western Lagoons constituted optimal habitat for OBPs (thus falls within high probability of occurrence areas; Ehmke, 2009; Ehmke & Herman, 2013). Additionally, the relatively open structure, including presence of bare ground, high microtopographic of the diversity of new vegetation and proximity of suitable roosting vegetation as well as the floristic make-up and cover of important food plants all met the key recommendations of optimal OBP habitat as outlined in Ehmke & Tzaros (2009). The exercise was repeated in 2016 with similar net gains in saltmarsh being recorded (W. Steele, pers. comm.).

10.6 Predator control

A range of land management agencies undertake predator control at various sites across the mainland OBP range. For example, Parks Victoria implements fox control at Point Cook Coastal Park and Cheetham Wetlands (B. McCarrick, pers. comm.). Parks Victoria also implements control works for pest plant and mammalian species (fox/rabbit) in other known and potential OBP habitat in western Port Phillip Bay and on the Bellarine Peninsula. Within the WTP, Melbourne Water has implemented cat-trapping as well as 10+ years of fox control including just prior to OBP arrival at the WTP (H. Graham, pers. comm.; W. Steele, pers. comm.). Port Phillip Westernport CMA are currently working with Parks Victoria to develop a cat control program at a key site which already receives fox control in preparation for a 2018 mainland release of captive-bred OBPs (DELWP, pers. comm.). Works often aren't solely directed at OBPs and are often carried out under tender funding thus not all sites are targeted annually (DELWP, pers. comm.; T. Stringer, pers. comm.).

10.7 Grazing

Environmental studies conducted in the early 1980s emphasised the importance of saltmarsh habitat for OBPs and recommended excluding sheep from grazing in the saltmarsh for the conservation of both the OBP and saltmarsh habitat (Loyn et al., 2010). Sheep were removed from saltmarsh habitat at The Spit Nature Conservation Reserve in 1980 coinciding with regeneration of saltmarsh plants including Beaded and Grey Glassworts and an increase in the number of OBPs using the saltmarsh (approximately 50% of the wild population was observed using the area following exclusion of grazing; Carr et al., 1991; Loyn et al., 2010). However, OBP use of the dry saltmarsh declined in following years, with birds rarely being observed in the area from 1985 (Starks, 1988; Loyn et al., 2010). Saltmarsh at Point Wilson was also fenced to exclude sheep in 1986 with OBPs subsequently being observed foraging more in the saltmarsh grazed by sheep or livestock than in the ungrazed saltmarsh (Loyn et al., 1986; Starks, 1992).

It appears that OBPs prefer to walk through and forage amongst clumps of Glasswort with clumps being associated with high seed densities (Anon, pers. comm.). This is reflected in the current use of the WTP where OBPs are commonly observed using the tracks between sewage ponds, foraging on the outer saltmarsh communities (J. Starks, pers. comm.). Prior to 1980, saltmarshes in western Port Phillip Bay were kept open in the summer by grazing sheep allowing the formation of clumps. Following these observations, it was hypothesised that managing areas through intermittent or light grazing may be beneficial for seed-eating birds including OBPs by opening up the saltmarsh, encouraging re-colonisation, promoting growth of fresh shoots and increasing the production, accessibility and/or palatability of seeds (Starks, 1988; Loyn et al., 2005; J. Starks, pers. comm.). For example, grazing may induce *Sarcocornia* into a colonising mode where it produces new growth and more seeds and fertile spikes (Davy, 2003). Consequently, appropriate livestock grazing regimes may improve saltmarsh habitat for OBPs (Modon et al., 2009). Contrary research however has indicated that saltmarsh plants produce less seeds when grazed with serious damage being caused to saltmarsh plants under high grazing pressure (Lane et al., 1980; Carr et al., 1991).

Grazing trials to test the above hypothesis were rejected for many years particularly by botanists aiming to preserve the saltmarsh community despite being naturally grazed in the past. The success of the captive-breeding program and the Mainland Release Trial in 1996 (see section 13.8.4) generated an opportunity to test whether these saltmarsh habitats are suitable for OBPs without habitat management including grazing (Lyon et al., 2005). In 2004, six captive-bred birds were released at the Big Marsh (part of the WTP) to determine if the current habitat attracted OBPs (Lyon et al., 2005). Results revealed that the Big Marsh had deteriorated as suitable habitat for OBPs and was no longer favoured by wild or captive-released birds despite supplementary food also being provided in the area. Active management would be required to restore the previous value of the site (Loyn et al., 2005).

In 2007, funding from the Hydro Tasmania OBP Conservation and Management Trust and Melbourne Water enabled a sheep grazing trial to be conducted in saltmarsh habitat at Point Wilson (Loyn et al., 2010). Three hectares were fenced off and seven sheep were grazed on and off for 17 months (Loyn et al., 2010). Light grazing was found to cause several changes to the vegetation including creation of narrow pathways but no irreparable damage resulted. However, OBPs were not recorded in the grazed area, possibly due to the small size of the experimental plot. The study concluded that light grazing does not appear to be a significant factor influencing the value of saltmarsh habitat for OBPs (Loyn et al., 2010). However, results do not exclude the possibility that some level of grazing may be required to restore the value of previously important saltmarsh habitat (Loyn et al., 2010). Moderate levels of grazing have been suggested as producing the highest seed densities in saltmarsh plants but this remains untested partly due to the recognised conservation significance of the saltmarsh community (subtropical and temperate saltmarsh is now listed as a vulnerable ecological community under the EPBC Act; Anon, pers. comm.).

In 2009, a study investigating the impacts of grazing on saltmarsh habitat to the availability and energy of *Sarcocornia* seeds was implemented (Modon et al., 2009). From the sites studied, the highest seed availability and levels of energy per unit of *Sarcocornia* seed occurred in saltmarsh which had regular inundation and no grazing (Modon et al., 2009). However, the sample size was very small and soil characteristics and salinity of inundated water are likely to have been variable thus impacted seed production.

More comprehensive grazing trials within the currently used mainland sites are considered logistically impossible to implement and many sites are unsuitable for grazing due to the saltmarsh species present (DELWP, pers. comm.; J. Starks, pers. comm.). DELWP are currently working with Conservation Volunteers Australia and Green Army to establish a grazing trial at a site in 2018 (DELWP, pers. comm.). Other sites where grazing has been excluded through

voluntary management agreements are being monitored for the impacts of this management change on vegetation (DELWP, pers. comm.).

10.8 Fire regimes

Evidence suggests that OBPs prefer habitat which has been recently burnt in both the breeding and non-breeding ranges, with birds being observed with black bellies from foraging amongst the ash (OBPRT, 2006a; Forshaw & Cooper, 2016; J. Starks, pers. comm.). In the 1990s, a trial burn was conducted on one of the small islands (20 x 10 m) in Lake Connewarre to get rid of the competing grass species which were choking out the desirable OBP food plants (J. Starks, pers. comm.). In the following season, this was the only island that OBPs were observed on in the area (J. Starks, pers. comm.). As with grazing, it has been logistically impossible to implement more comprehensive testing of fire regimes throughout their mainland range (J. Starks, pers. comm.).

10.9 Habitat modelling

Until the late 1990s, up to 70% of the wild OBP population were reliably observed at a number of key mainland sites (Starks et al., 1992; Ehmke, 2009; Ehmke et al. 2009). The number of detected birds at these key sites and on the mainland in general declined rapidly in the late 1990s (Ehmke et al., 2008; Ehmke et al., 2009). However, survival models based on sightings of banded birds in the breeding grounds showed that the population was still stable (Baker et al., 2008). If these models were correct, this suggested that the majority of the wild population had shifted away from their traditionally important winter mainland sites to alternative (and unsurveyed) sites and were not being detected at the same rate as previously (Ehmke, 2009).

Given the rarity of OBPs (extremely low density), cryptic behaviours and the large area of potential mainland habitat, an effective method to direct limited survey resources was required to survey for and monitor the wild population on the mainland (Ehmke, 2009). Potential and utilised saltmarsh habitat has historically been difficult to map, especially in terms of the ability to provide fine-scale detail for formulating predictions about site use. Numerous studies defining and mapping winter habitat of OBPs have been implemented including early descriptive studies focussing on saltmarsh habitat (Carr & Kinhill Planners, 1979; Gibbons, 1984; Loyn et al., 1986; Casperson, 1995; Lee & Burgman, 1999). More recent studies have used aerial photography (McMahon e al., 1994).

10.9.1 Relative Potential Occurrence Model (rPOM)

Advances in high-quality aerial photography and mapping software enabled the mapping of biophysical variables including the complex distribution of vegetation types throughout Victoria to provide spatial models of OBP habitat distribution (McMahon e al., 1994; Ehmke, 2009; Ehmke & Herman, 2013). Assuming that the birds were still using similar foraging habitats on the mainland, key habitat variables were identified and extrapolated to generate a relative Potential Occurrence Model (rPOM) encompassing the entire mainland winter range (Ehmke, 2009). Models were based on data from the *Orange-bellied Parrot Winter Census and Resights Database* (Birds Australia, 2009) representing a comparatively accurate representation of the key mainland sites within the last 20 years. Several limitations associated with the database were addressed prior to formulating the rPOM (Ehmke, 2009). These included:

- Until 2006, absence data was largely lacking from the database with negative surveys not being entered
- Considerable spatial correlation existed in survey effort due to accessibility of different sites, previous OBP detections and distance from major population centres
- Surveys may not be independent (e.g. people will visit sites if birds have previously been detected there)

Despite the absence of true absence (negative survey) data, the database contained enough data for use in regional scale modelling using a presence/pseudo-absence or presence-only modelling approach (Ehmke, 2009). Due to the above limitations, models were generated using a unique, complex mixture of established and emerging statistical and data handling methods (Ehmke, 2009). A full description outlining the methodology utilised to generate the rPOM can be found in Ehmke (2009).

The rPOM has been used to inform the mainland survey effort and direct limited resources during the non-breeding season by predicting the potential occurrence of individuals at a broad scale throughout their mainland range and identifying non-traditional sites to survey (Ehmke, 2009; White et al., 2016). Since 2000, 63% of OBPs in the wild have been detected in optimal habitat as identified from the rPOM signifying that the models work (Ehmke, 2009; Adams & Purnell, 2016). Survey effort should continue to be directed to areas corresponding to high relative probability of occurrence values. However, it is uncertain if the maps generated from the models incorporate the entire current mainland habitat critical for OBP survival.

Prior to the development of the rPOM, it was unclear how much vegetation was available for use within the winter range of the species. Approximately 32,336 ha of saltmarsh vegetation exists within the core potential area of OBP occurrence in South Australia and Victoria but less than one fifth (19.66%) represents optimal OBP foraging habitat (Ehmke, 2009). This suggests that OBPs occupy an extremely limited realised foraging niche found within key foraging habitats which are rare both spatially and temporally (Ehkme, 2009; Ehmke & Tzaros, 2009). Therefore, it is uncertain if adequate winter foraging habitat currently occurs on the mainland to support the wild population if it was to grow in number (Ehmke, 2009).

10.9.2 Habitat extent models

A review modelling the extent of habitat and changes in optimal mainland habitat for OBPs across Victoria and South Australia has recently been completed through the Victorian Species Protection Initiative to test the assumption that loss of mainland habitat is a significant driver of decline (White et al., 2016). The project was originally funded for Victoria only but DELWP sought to partner with DEWNR to ensure work covered the entire mainland range of the species. Unlike the previous habitat models which are focussed on short time periods and coarse pixel sizes (minimum of 1 ha), this series of spatio-temporal OBP habitat models based on records from the *Orange-bellied Parrot Winter and Resights Database* and contemporaneous multi-spectral reflectance data investigates habitat data since the 1980s across a fine-scale pixel size (25 m x 25 m) representing a close approximation to the scale of OBP habitat selection (White et al., 2016).

Models were applied to OBP habitat choices and habitat layers across six time periods between 1985 and 2015 (White et al., 2016). Findings revealed that there had been a temporary reduction in habitat extent between 2000 and 2010 likely due to the millennium drought. However, habitat appeared to recover between 2010 and 2015. Results indicate that while there have been previous declines, mainland habitat extent and condition is not currently

preventing recovery with there being little change in the amount of OBP habitat since 1983 (White et al., 2016). This finding is consistent with previous data which has suggested that the majority of OBP habitat loss occurred before 1983 and the degradation and loss of saltmarsh and intertidal habitat since has not been significant (Carr & Kinhill Planners, 1979; Boon et al., 2011; White et al., 2016). The small losses in habitat and the insignificant degradation of structure and composition since 1983 have been insufficient to cause the observed decline in OBP numbers over the last few decades (White et al., 2016). This supports previous population modelling where density-independent factors including habitat quality are likely more important than density-dependant factors including habitat size (Dreschsler et al., 1998). Model outcomes reframed the view of the role of mainland habitat in OBP decline which is now thought to be more likely due to the issues faced by small population size including disease, inbreeding depression, loss of genetic diversity and poor fertility than due to mainland habitat limiting the population (White et al., 2016).

10.9.3 Habitat maps

Habitat importance maps developed from model outputs are referred to by DELWP when assessing planning proposals and as a test for DELWP-generated habitat importance mapping (DELWP, pers. comm.). Work is now underway to integrate the new habitat importance maps into internal priority-setting and decision-making frameworks. Maps have also been provided to other land management agencies to improve their practices (DELWP, pers. comm.).

10.10 Mainland supplementary feeding

Supplementary feeding during winter has occurred intermittently on the mainland for a variety of reasons.

In 1989, a feed table was put on the delta islands of Lake Connewarre to facilitate the catching of OBPs via mist-nets in the effort to locate roost sites (Starks, 1992).

A feeding trial was conducted at Yambuk Lake on a private farm in August/September 1999 to determine the relative use of natural verses supplementary food by OBPs (J. Starks, unpubl. data). OBPs originally seen foraging on Beaded Glasswort and weed species in a grazed paddock readily took to foraging on the supplied budgie seed placed on low feed tables at two locations while still foraging on natural seed. After paddocks became flooded, the OBPs remained in the area feeding nearly exclusively on the supplied seed (Starks, unpubl. data).

A component of the 2010 Emergency Action Plan included the option of providing supplementary food to OBPs on the mainland in 2010 and 2011 aiming to increase the nutritional intake of individuals over winter (Pritchard, 2011a). It was envisaged that providing food could improve over-winter survival and body condition prior to the breeding season. The option to provide supplementary food was dependent on gaining land owner permission with the amount of food provided depending on the number of individuals and competitors present at each site (Pritchard, 2011a). Supplementary food would be placed in bare patches on the ground in areas where birds are observed naturally foraging every second day. Feeding sites were rotated every 10 days to minimise disease transmission. Additionally, a feeding table was implemented on the Connewarre Delta Islands in Lake Connewarre in 2011. Birds were observed foraging naturally within 15 m of the table but were never seen at the table.

In 2014, two feeding stations were established at the WTP due to the abandonment of key feeding sites caused by water inundation and track maintenance (Davidson, 2014). A maximum

of two handfuls of OBP seed mix (seed husks removed) supplied by the Healesville Sanctuary OBP captive management staff was provided twice weekly from July to September. This quantity was deemed enough to provide adequate nutrition without encouraging the birds to become reliant on the food source and abandon foraging at other sites (Davidson, 2014). Feeding was limited to an 'as needs' basis due to associated health risks and minimisation of the risk of BFDV transmission (DELWP, pers. comm.). Leftover food, empty seed casings and weeds were removed from the feeding stations prior to fresh seeds being distributed. Remote sensor cameras were used to monitor the feeding stations and revealed four OBPs utilising and consuming the majority of the provided seed (Davidson, 2014). Feeding sites were nearly exclusively used by OBPs with three other bird species (Magpie Lark (*Grallina cyanoleuca*), Little Raven (*Corvus mellori*) and Eurasian Skylark (*Alauda arvensis*)) and two mammalian species (Red Fox (*Vulpes vulpes*) and House Mouse) using the area (Davidson, 2014). The Magpie Lark, Eurasian Skylark and House Mouse foraged on the provided seed for periods of less than 5 minutes and the OBPs never appeared to be disturbed by them (Davidson, 2014).

Supplementary feeding was offered at the WTP during the autumn release in 2017 (see section 10.12). There was little evidence of OBPs utilising the feed tables which were consequently removed after a few weeks.

The mainland recovery effort lacks the resources required to maintain and monitor permanent feeding stations like at Melaleuca. Furthermore, supplementary feeding on the mainland would experience additional challenges compared to at the breeding grounds. For example, the daily maintenance and cleaning regime would be required on a much larger-scale to mitigate disease risk which is increased in areas with high densities of individuals. In particular, BFDV can be acquired from a wider range of species on the mainland and supplementary food tables would increase the probability of disease transmission (Adams & Purnell, 2016). The concentration of individuals around feed tables can also increase the risk of inter-specific competition and predation which are minimised in Tasmania through fencing and predator/competitor control (DPIPWE, 2015b). The mainland has extra predation risks, including from cats and foxes which are absent in Tasmania and which can be enticed to areas conducive to large numbers of prey (Adams & Purnell, 2016). If food is a limiting factor for OBPs on the mainland these costs would be justifiable. However, there is currently no evidence supporting this and birds returning to Melaleuca do not appear to be malnourished (Adams & Purnell, 2016).

10.11 Radio-tracking

10.11.1 Early radio-tracking

Radio-telemetry was suggested early on in the recovery program to investigate movements and habitat use. In 1996, attachment techniques for radio-transmitters were trialled on captive Elegant Parrots at Healesville Sanctuary (Menkhorst, 1997). Superglue was used to attach transmitters to the upperside of the rachis of the two central tail feathers (Menkhorst, 1997). Transmitters remained in place for six weeks. Following the successful trial of radio-transmitters on Elegant Parrots and House Sparrows, the OBPRT endorsed radio-tracking of wild OBPs to further investigate the movements, roosting sites and habitat use across their winter range (Starks, 1992; Starks, 1995). Sirtrack single-stage transmitters (weighing 1.8 g) were attached to five wild OBPs and six released captive-bred OBPs (Starks, 1995; Saunders, 2002).

Overall, radio-tracking was largely unsuccessful due to technological issues including the large size of the transmitters (too heavy for deployment on OBPs). Battery size, thus longevity, of radio-transmitters are constrained by the small size of lightweight transmitters, impacting the signal attenuation of the tags thus the geographic range tagged individuals can be detected

over. Aerial tracking of tagged birds (receiving antennae were mounted on the wing struts of a Cessna 172) was employed along with ground radio-tracking in an effort to locate individuals but tagged birds were not always detected (Menkhorst, 1997).

Transmitters failed between 2 and 31 days after tagging due to being pulled off by the bird, falling off with tail feathers or mortality, with an instance of a tagged bird being preyed upon by a raptor (Starks, 1995; Holdsworth, 2000). These short deployment periods provided limited information about habitat use, movements and roosting sites. The mobility (and lack of resources to track birds over a wide range), inaccessibility of tagged individuals and attachment failure further limited the amount of information able to be collected from tagged birds (Holdsworth, 2000; Saunders, 2002). Undeveloped protocols (e.g. attachment methods) further hindered the use of radio-transmitters and the ability to obtain ethics for radio-tagging a critically endangered species after previous tagging had resulted in mortality (J. Starks, pers. comm.).

10.11.2 2017 radio-tracking

Very High Frequency (VHF) radio-transmitters were glued to the base of the two tail feathers using Epoxy resin (n = 5) or super glue (n = 6) and secured to the feather shaft using surgical suture of all 11 autumn-released birds at the WTP in 2017 including the assisted migration male (see section 11.3) to monitor movements, foraging behaviours, social groupings and habitat use. Transmitters were an A225 model, 40 ppm, 2-stage tag with a battery life of up to 55 days weighing 0.9 g with a read range of up to 1 km (Penrose et al., 2017).

Individuals were tracked approximately every second day after release with batteries lasting for approximately three months. The transmitters had a variable detection distance being as small as 50 m in dense vegetation. All but one of the released birds were detected at least once and had generally remained within 500 m of the release site with some individuals detected up to 2 km away. Information was recorded on the selection of food plants and habitat as well as social groupings and interactions to help ascertain the behaviours of released birds. Collected data will help inform future releases.

10.12 Mainland Release Trial Program 2017

A 4-year Mainland Release Trial Program commenced in 2017 with the aim of releasing small flocks of captive-bred OBPs in autumn into high-quality winter habitat to investigate the effectiveness of mainland releases in supplementing the wild population and to establish a network of occupied winter sites which will enable migrating juveniles to once again learn about suitable winter habitat through con-specific cueing (Penrose et al., 2017). It was hypothesised that released birds would remain in this high-quality habitat and attract naturally migrating birds, including young inexperienced birds, which could help improve winter survival rates (Penrose et al., 2017). Historically, juvenile OBPs may have located suitable winter habitat by following the coastline looking for occupied sites (con-specific cueing) by adults which depart the breeding grounds weeks before the juveniles do. Adults may also have used this method when needing to find new sites. With the extremely low population size in the past few decades, this system is likely to have collapsed. Consequently, unguided birds are more likely to make poor habitat choices with the potential of guiding juveniles to unsuitable winter habitat resulting in high mortality rates. It is hoped that releasing birds in known, high-quality winter habitat will help guide and teach the released and migrating first-year birds what good winter habitat is. This trial will also help identify the most effective methods for supplementing the wild population regarding timing of releases.

Before commencement, a translocation plan was developed outlining detailed links between the objectives of the recovery plan and trial and including clear criteria for measuring success (DELWP, pers. comm.). Methods are adaptable based on annual outcomes. Risks associated with release of captive-bred adults in winter habitat include birds not remaining in the area or death. Alternatively, released captive-bred birds could alter the behaviour of wild birds at release sites. However, due to the strong site fidelity and patterns of habitat use shown previously in wild OBPs, it is hypothesised that the released birds will copy the wild birds rather than the wild birds altering their long-standing behaviours (OBPRT, 2017). Mitigation measures included avoidance of off-site impacts to surrounding wetlands, directing site lights downwards and limiting noise/human disturbance (DELWP, pers. comm.).

The WTP was selected as the release site due to being the most reliable site used by wild OBPs in Victoria over recent years providing the best chance for the released birds to interact with, and learn from, wild birds with local knowledge about appropriate habitat and food sources. Eleven adult captive-bred males fitted with radio-transmitters from two breeding facilities were released in April to increase the number of birds present in optimal winter habitat and provide safety in numbers. Birds were selected based on their sex, age, genetic representation in the captive population and Mean Kinship (Penrose et al., 2017). The release group of birds consisted of three juveniles, a one-year old, two two-year olds, four three-year olds and a four-year old (Penrose et al., 2017). Birds were held in onsite aviaries for a week before being released.

During housing in the onsite aviaries, birds were fed a diet of dry seed (sunflower, millet, canary), apple, carrot and pear (Penrose et al., 2017). This diet was supplemented with wild food plants collected daily onsite aiming to introduce natural foods found within the release habitat into the diet prior to being released (Penrose et al., 2017). Supplementary food was provided after release but was removed after a few weeks as cameras did not detect any activity at the table.

Birds were frequently observed alone in the days after release after which they started forming loose flocks of up to eight birds in the vicinity of the release site. A wild female (who has over-wintered at the site since 2013) arrived at the site shortly after the release and was soon seen flying and feeding with some of the released birds and was later joined by a wild male. Two juveniles also arrived at the site and were observed interacting with some of the released birds. Encouragingly, released birds were observed in areas where wild OBPs typically forage and had been seen feeding on at least seven wild food plant species including known OBP food plants such as Glaucous Goosefoot and Austral Seablite. One bird was not observed since release and the remains of another two were found having been largely consumed by a predator (Penrose et al., 2017). Along with ground radio-tracking, two attempts were made to radio-track the tagged birds from the air to test the efficacy of this technique for locating the birds. Aerial tracking was unsuccessful due to signal interference in the surrounding airspace. DELWP and Aerovision Ballarat are working with experts to determine if there is a solution for this issue (DELWP, pers. comm.).

Over the next three years, the effectiveness of this trial will be assessed annually and methods will be adjusted accordingly (DELWP, pers. comm.). The OBPRT will also annually assess the results from the trial and compare this with results from other management trials so the most effective population management strategies can be identified across the entire recovery program (DELWP, pers. comm.). The program has the potential to expand in the following years to include delivering OBP mainland habitat condition monitoring at some key sites. This would enable the identification of environmental drivers of habitat change and measure the effectiveness of habitat management (DELWP, pers. comm.).

As of January 2018, at least three of these released birds have failed to migrate and have been regularly observed in the vicinity of the release site (WTP). All three birds have been observed foraging on abundant introduced weed species (Carpet Weed (*Galenia pubescens*); Wimmera Rye-grass (*Lolium rigidum*) and Buck's-horn Plantain (*Plantago coronopus*); Curled Dock (*Rumex crispus*); Giant Mustard (*Rapistrum rugosum*); Toowoomba Canary-grass (*Phalaris aquaticus*)).

At the end of the 2017/18 breeding season, the captive-bred adult male OBPs which were released at Melaleuca at the beginning of the breeding season will be re-captured and released in Victoria through assisted migration (refer to section 11.3) as part of the second year of the Mainland Release Trial Program.

The Mainland Release Trial Program is funded through a Victorian Government Biodiversity On-ground Actions grant and Zoos Victoria. DELWP developed the hypothesis, trial concept and established partnerships in less than six months (DELWP, pers. comm.). The trial is delivered by DELWP, Zoos Victoria, BirdLife Australia, Melbourne Water, Moonlit Sanctuary, Parks Victoria and DPIPWE.

10.13 Review of survey methods

In 2016, DELWP contracted BirdLife Australia to conduct a review of the current summer and winter survey methodologies and investigate alternative survey methods available to detect and monitor OBPs during winter (Adams & Purnell, 2016). The review found that no alternative survey method was superior for detecting OBPs on the mainland but two methods were identified as having the potential to act as supplementary detection methods in conjunction with the traditional observation method: a passive (acoustic monitoring) and an invasive (tagging) option. Both methods are associated with limitations but have the ability to provide a more comprehensive coverage of winter sites with the possibility of increasing winter detection rates (Adams & Purnell, 2016). Both would require more resources to trial and implement. The review also confirmed the importance of the Regional Coordinator model of population monitoring on the mainland and volunteer training and support (Adams & Purnell, 2016).

10.14 Landowner attitudes

In 2008, a study was conducted on the Bellarine Peninsula to gauge landholder attitudes to the OBP (Weston et al., 2012). Many land owners were aware of the OBP and held concerns about their conservation status. A substantial number of land owners (80.7%) indicated that they would consider changing the way they managed their land to improve habitat for the species, with 64% seeking more information on how to implement beneficial changes (Weston et al., 2012).

11. Migration

11.1 Migration strategies

At least 17 species of Australian birds spend summer in Tasmania with a proportion or the entire population migrating to the mainland in winter (McCarthy, 2017). Compared to other migratory birds, OBP migration distances are relatively short: approximately 190 km from Cape

Wickham to Lake Connewarre or 90 km from Cape Wickham to Cape Otway taking a couple of hours to complete the crossing (McCarthy, 2012). However, the migration process may be more challenging for OBPs which are highly-specialised feeders compared to other migratory species where a larger selection of food sources (i.e. insects) are available during migration. Unlike OBPs, other species may also recruit mates over winter on the mainland or a proportion of the population may remain in Tasmania over winter acting as a buffer stock (D. McCarthy, pers. comm.). These strategies employed by other species may act to buffer losses associated with migration and provide an insurance population.

During migration, birds use one of two basic strategies: fixed track or compass course. Fixed track entails the bird attempting to fly along a fixed pathway from start to finish. Compass course is where the bird will head along a compass bearing thus the actual course flown is determined by the direction and speed of the prevailing wind as well as the flying speed of the bird (McCarthy, 2012). Birds flying a compass course will always have their track affected by winds other than pure head or tail winds (McCarthy, 2017). The dominant strategy used by second year or older birds in migratory passerines is fixed track while first-year birds appear to migrate using a compass course on their maiden migration and fixed track on their return journey (Perdeck, 1958; Birkhead, 2008). It is unknown what strategy OBPs use but if they employ the strategies used by migratory passerines, first-year birds may use a compass course while older birds may fly a bearing and try and keep it with success occurring if they can fly as fast (or faster) than the wind speed regardless of wind direction (D. McCarthy, pers. comm.).

In recent years, it has been suggested that one reason for the low survival rates of OBPs over winter is birds being blown off course and drowning in the Bass Strait during migration (McCarthy, 2012). The migration speed of OBPs is unknown but has been estimated using modifications to the Pennycuick model and anatomic measurements taken from HANZAB (Pennycuick, 2008; McCarthy, 2012). The maximum migration range was calculated as 72 kph and the maximum velocity for aerobic flight was 76 kph (McCarthy, 2012). These values have been questioned as being too high with an estimate of 60 kph (based on anecdotal observations) thought to be more realistic (McCarthy, 2012). Birds would be able to hold track in gale force winds blowing from any direction if the upper estimate of flight velocity is correct but not if the lower estimate is (McCarthy, 2012). The estimated maximum airspeed of OBPs is significantly greater than those of smaller (and weaker) species migrating the Bass Strait which also cross at a wider point (e.g. Grey Fantails (*Rhipidura albiscapa*), Flame Robins (*Petroica phoenicea*); McCarthy, 2017). It appears then that aerodynamic ability is not a significant factor if OBPs fail to make the crossing (McCarthy, 2017).

According to modelled simulations, the southern migration is more hazardous than the northern migration due to the limited possibilities of making landfall should the wind shift and blow a bird off course (McCarthy, 2012). During the northern migration, OBPs have a high probability of making landfall due to the extensive south-eastern mainland coastline (i.e. many landfall options between Cape Nelson and Wilsons Promontory) even if the wind shift is quite large and occurs at the beginning of the journey and persists throughout the crossing (McCarthy, 2012). A hailing gale would be required to blow birds off course during their northern migration irrespective of migration strategy. If OBP flight velocity is above 70 kph, migration would be successful independent of weather conditions if using a fixed track strategy (McCarthy, 2012).

During the southern migration, a significant wind shift from the eastern sector may result in birds missing King Island and Tasmania where a change from the western sector is likely to result in making landfall on the north coast of Tasmania if birds are using a fixed track strategy (McCarthy, 2012). If OBPs implement a compass course strategy, even low wind velocities could cause birds to miss landfall and is more hazardous than attempting to fly a fixed track (McCarthy, 2012).

11.2 Fuel requirement

To calculate the fuel requirement of migrating OBPs, airspeed was set to 65 kph representing the mid-point of the estimated range of maximum aerobic speeds. The heat of combustion of the fuel consumed by migrating birds and the efficiency of converting fuel to energy available to flight muscles were sourced from Pennycuick (2008). These values were combined with estimates of the power required to maintain an airspeed of 65 kph resulting in a fuel consumption of 5.05 g/1000 km (McCarthy, 2017). If OBPs migrate from Cape Wickham to Lake Connewarre (190 km), individuals would require 0.81 g of extra fuel to make the crossing in still conditions. If adverse winds doubled the travelling distance, birds would require 1.51 g of extra fuel (McCarthy, 2017). Therefore, like Swift Parrots (*Lathamus discolor*), OBPs do not need to significantly 'fatten up' prior to migration.

11.3 Assisted migration

Based on resightings data over the past few years, approximately 20% of spring-released captive-bred adults at Melaleuca survive and return to Melaleuca after departing on their first migration. This is significantly lower than the migration survival rates of wild adults and juveniles. It is hypothesised that the low survival rates of this cohort may be due to undesirable migratory and habitat selection behaviours. In response to the low survival/return rates of captive-bred released adults, the OBPRT trialled new management approaches in 2017, including assisted migration and ranching, rather than allow these birds to naturally attempt migration. This may increase the number of birds available in spring for breeding and combat the apparent high migration mortality associated with released captive-bred birds. All wild birds were left to migrate naturally.

Assisted migration was identified as having the potential to increase both the migration and winter survival rates for the species by increasing the occupancy of optimal habitat in winter (opposed to occupancy of sub-optimal habitat which may be occurring) and the potential for attracting first-year inexperienced wild birds to optimal habitat. Increasing the survival rate of both first-year and spring-released birds will increase the potential of these individuals to make a greater contribution to the growth of the wild population by participating in more than one breeding season.

All spring-released captive-bred adults were meant to be re-caught at Melaleuca at the end of the 2016/17 breeding season and flown by plane to the mainland. Males would then be released at a pre-approved winter site within their Victorian range (the WTP in western Port Phillip Bay) and females would be ranched (for further details see section 11.4). The release of males at the winter site was favoured over ranching this cohort in order to trial the potential of this management action as they are the most expendable to both the wild and captive populations due to the already low winter survival rates, the male-bias in both populations, and difficulties re-integrating back into the captive population (OBPRT, 2017). Of the spring-released captive-bred birds to survive the 2016/17 breeding season, only one male was re-caught at the end of the breeding season and underwent assisted migration to the mainland (Troy, 2017). The other captive-released birds departed Melaleuca before they could be re-caught. Once at the WTP, the male was temporarily housed in a pre-release aviary on site for four weeks to minimise the risk of it leaving the site (Troy, 2017). After release, the male remained in the area but died within the first month.

The assisted migration program is funded through a Victorian Government Biodiversity On-ground Actions grant and Zoos Victoria.

11.4 Ranching

The poor return rates (and possibly survival) of released captive-bred and first-year birds to the breeding grounds has become a significant problem. Since the 2015/16 breeding season, only four of the 20 fledglings appear to have survived (survival rate of 0.20). This is less than half of the historic values for survival rates (Holdsworth, 2006; M. Holdsworth, pers. comm.). Return rates of released birds are less than 20% compared to 56% for wild birds. The demographics of the remaining wild population means that older birds are likely to be lost soon which could halve the adult population within the next year or two (M. Holdsworth, pers. comm.).

To combat the low return rates to the breeding grounds and to reduce pressure on the captive insurance population, winter ranching of the population has been suggested for many years and more recently it has been requested to collect at least some of the double-brood juveniles for ranching (M. Holdsworth, pers. comm.). In 2017, nine females which had been released from captivity at the start of the 2016/17 breeding season were re-captured at the end of the breeding season, flown and held over winter at the Werribee Open Range Zoo in an effort to increase their chances of survival during the non-breeding season (OBPRT, 2017; Anon, pers. comm.; DPIPWE, pers. comm.). Seven of these females were part of the first release at Melaleuca at the start of the 2017/18 breeding season (Anon, pers. comm.). This trial is planned to occur again for the 2018 winter season.

Unless significantly more fledglings are produced during the 2017/18 breeding season, ranching the entire 2017/18 cohort may need to be considered to ensure that any gains made through increasing breeding success are not wasted (M. Holdsworth, pers. comm.). However, this may result in the loss of migratory knowledge in the younger generations and the lost opportunity to learn from the few remaining older wild birds. To improve survival rates and ensure breeding capacity in the wild in future years, the SAPG have approved the recapturing of approximately half of the 2017/18 wild juvenile cohort and all of the captive-bred adult female OBPs which were released at Melaleuca in spring 2017 at the end of the breeding season to undergo assisted migration and ranching on the mainland. The birds will be housed at Moonlit Sanctuary Wildlife Conservation Park and Zoos Victoria before being re-released back at Melaleuca at the start of the 2018/19 breeding season. Combining juvenile releases and ranching will balance the need to have a population that knows how to migrate with the capacity to maintain and increase the size of the wild population.

11.5 King Island

Numerous recovery actions have been implemented on King Island which is an important stopover for migrating OBPs. This has included the protection of at-risk sites on private land through land purchase, covenanting and voluntary land management agreements where feasible. For example, in the 1970s, blocks of privately owned land on King Island which form part of the important saltmarsh used by migrating OBPs were purchased by the National Parks and Wildlife Service (NPWS) as a safeguard to this vital area (DPIPWE, pers. comm.). From 1992-1995, a part-time ranger was appointed to monitor the migratory population, the condition of feeding and roosting sites, and run trap lines for feral cats.

In 2007, the Natural Heritage Trust, Department of Primary Industries and Water (DPIW, now DPIPWE) and the King Island Natural Resource Management Group (KINRMG) provided funding ($312,890) to secure foraging and roosting habitat for OBPs on King Island which is used by individuals during their northern and southern migrations (Barrow, 2008). Cradle Coast Natural Resource Committee further funded the habitat restoration project ($30,000) as well as a cat

dietary analysis ($30,000), public communication of the project outcomes and promotion of threatened species ($10,000). The specific project objectives over 2007 and 2008 included:

- Monitoring OBPs during their northern and southern migrations
- Identifying and mapping coastal plant communities used by OBPs
- Implementing habitat protection strategies including covenants, land management agreements and exclusion fencing
- Developing a multi-species fauna and flora recovery plan for King Island and carrying out actions relevant to OBPs.
- Instigating a cat control program including community education, trapping, de-sexing and population estimates

More than 50 volunteers donated over 2,000 hours to conduct coastal surveys in 2008 (DPIPWE, pers. comm.). Habitat assessments were conducted at three sites (restricted to where OBPs were observed feeding) to determine habitat requirements of migratory birds (Barrow, 2008). Eighty-three percent (70 ha) was classified as high-quality habitat, with the average patch size being 2.6 ha. Habitat was mapped using aerial photos, existing maps and ground truthing. From this, five sites were identified for habitat protection (Barrow, 2008). Stock exclusion and land regeneration were carried out with support from the NPWS and adjacent landholders at these sites (DPIPWE, pers. comm.). The project also contributed OBP sightings to the *Natural Values Atlas* database managed by DPIPWE but data for King Island was incomplete. It was found that flock sizes had decreased from 23 birds recorded in 1959 to only three in 2008 (Barrow, 2008). A long-term cat control program was initiated including fully subsidised de-sexing and media coverage (Barrow, 2008).

Lack of long-term funding has hindered habitat restoration, the continuation of management and monitoring of important OBP sites and will significantly reduce the benefits obtained from these initial actions (Barrow, 2008). The implementation of the cat control program has been limited by a lack of support from the community.

12. Tasmanian (breeding) program

The first recorded observations of breeding OBPs were made at Melaleuca in 1979, with annual monitoring of the breeding population beginning there in 1992. Additional systematic surveys were conducted in the late 1990s/early 2000s within the SW corner of Tasmania to locate other breeding populations of OBPs at previously known traditional breeding sites (J. Starks, pers. comm.). However, no birds were located outside of Melaleuca with the realisation that the early recovery efforts weren't as successful as originally thought (J. Starks, pers. comm.). This resulted in active management of some traditional breeding sites (e.g. Birchs Inlet) in an effort to re-establish breeding populations at these locations.

The Tasmanian Orange-bellied Parrot Program is delivered by the DPIPWE and is overseen by the OBP Management Group which consist of senior staff from DPIPWE's Natural and Cultural Heritage Department (Troy, 2017). The summer monitoring program aims to:

- Monitor the summer breeding population throughout the breeding range in Melaleuca (October to March)
- Monitor nesting sites

- Increase the breeding output in the wild with management protocols continually being refined as new information becomes available

Volunteers (largely provided and coordinated through Wildlife's Friends of the OBP Branch) and DPIPWE staff spend the summer monitoring OBPs at Melaleuca through inspection of nest boxes and direct observations. Volunteers conduct two daily two-hour surveys at three established feed tables in Melaleuca between 6:00-9:00 am and between 3:30-6:00 pm as well as opportunistically, recording the identity (via leg-band details) and duration of visits by OBPs (OBPRT, 2006a; DPIPWE, pers. comm.). Volunteers now conduct fieldwork in pairs in 2-4 week shifts covering approximately 180 days per year. This equates to 2,340 hours of volunteer support per year (DPIPWE, pers. comm.). The Taroona Wildlife Centre are currently developing a volunteer engagement framework to provide opportunities for volunteers to support some captive management operations (DPIPWE, pers. comm.). A public observatory was built in 1990 by the Department of Parks, Wildlife and Heritage (DPWH), with World Heritage funds provided by the Department of Arts, Sport, the Environment, Tourism and Territories (DASETT) allowing members of the public to observe and monitor OBPs further enhancing community support and awareness of the species.

DPIPWE do not undertake specific recovery projects, but rather, conducts activities consistent with priorities identified in the current OBP recovery plan, and in recent years, the Threatened Species Commissioner's emergency intervention (DPIPWE, pers. comm.). Implemented actions are informed by current knowledge and are continually refined by new information as it becomes available (DPIPWE, pers. comm.). Through these activities, DPIPWE have produced numerous protocols associated with the summer monitoring efforts including protocols for next box inspection, bird handling, collection, sampling and repatriation of deceased OBPs and unhatched OBP eggs, and disease and biosecurity management including the initiation of daily cleaning and disinfection of feed tables and the removal/refurbishment of nest boxes once occupied to reduce disease transmission (DPIPWE, 2015a). The recovery efforts and outcomes implemented by DPIPWE are reported to the OBPRT annually (DPIPWE, pers. comm.).

12.1 Colour-banding

Colour-banding of OBPs commenced at Melaleuca prior to their northwards migration in the 1986/87 breeding season as a trial for gathering survival data and investigating the potential that breeding occurred at other sites represented by unbanded first year birds on the mainland (Stephenson, 1991). Prior to 1993, banding of adults and free-flying juveniles at Melaleuca was conducted entirely by mist nesting at or near the feed tables. From 1991 to 1994, in addition to banding birds by mist-netting, nestlings were extracted from nests within a 2 km radius of Melaleuca and banded (OBPRT, 2006a; Holdsworth et al., 2011). From 1995, banding via mist-netting was stopped (Holdsworth et al., 2011). Now, all nestlings greater than 12 days old are banded and unbanded juveniles and adults are trapped at the feed table and banded (DPIPWE, pers. comm.). Colour banding of nestlings enables the recognition of individuals and age cohorts as well as facilitating the monitoring of demographic trends (OBPRT, 2006a). Currently all but one OBP in the wild population are banded; the proportion of banded birds has increased as the population size has decreased (DPIPWE, pers. comm.).

The banding protocol for OBP consists of one leg being banded with an Australian Bird and Bat Banding Scheme (ABBBS) metal band and a colour band representing the year of banding and a coloured plastic band on the other leg providing an identifier for individual birds (OBPRT, 2006a). Coloured plastic bands were replaced by coloured anodised aluminium lettered bands in 2000 to improve detectability (OBPRT, 2006a). All captive-bred released birds are also colour-banded in the same manner.

Volunteers monitor the number and identity of individuals visiting the supplementary feed tables via leg bands. Resightings of banded birds at Melaleuca provides vital information regarding recruitment, migration patterns, habitat use, age cohorts and site fidelity and enables estimation of population trends (Menkhorst, 1992; OBPRT, 2006b).

12.2 Tasmanian OBP database

Data associated with the breeding season is managed by DPIPWE in a banding database containing information about the banding history of individuals (includes entries from 1986 onwards) and a resighting database of banded individuals primarily from the supplementary feed tables (includes entries from 1988 onwards; DPIPWE, pers. comm.). Where it is known, the pedigree of individuals is also recorded. Resight data is also used to generate capture histories for individuals (Holdsworth et al., 2011). Data associated with banded individuals sighted on the mainland are provided for inclusion in the mainland *Orange-bellied Parrot Winter and Resights Database* upon request (i.e. when a banded bird is sighted on the mainland).

Monitoring data within the databases provides information on population size, survival, female breeding participation, departure and arrival patterns and determination of maternity and likely paternity at nest boxes (DPIPWE, pers. comm.). This data is input into mark-recapture models to estimate the breeding productivity and effective population. Population estimates are then used in PVA models to generate population predictions and evaluate the recovery of the species. The annual survival rate is also estimated by the resights data which is used to assess individual and population survival as well as forming the basis of population modelling to establish current population trends and generate population predictions.

Since 2014, DPIPWE has expended significant resources on the ongoing entry, collation, validation, curation, summary and analysis of the Tasmanian monitoring data to inform decision-making (DPIPWE, pers. comm.). A volunteer was recruited in 2017 to help vet the data, with the database still containing incomplete or inconsistent data. Information from the database is included in annual reports for the wild population and contributes to captive management reports produced by the ZAA species coordinator. Data in these annual reports are used to determine the location, number and demographic composition of releases to the wild, transfers between captive-breeding facilities, whether transfers of wild birds into captivity is required and where management efforts should be focussed in the next 12-24 months (DPIPWE, pers. comm.).

12.3 Breeding population statistics

DPIPWE staff calculate annual demographic metrics including translocation success, within season survival, annual survival, nest box occupancy, female breeding participation, number of breeding pairs, clutch size, fertility rates, hatching rates, fledgling rates and breeding success (DPIPWE, pers. comm.). The summer monitoring data is now used to formulate the annual population index for the species (originally estimated from winter counts) due to the consistently higher numbers being recorded at Melaleuca compared to on the mainland during the non-breeding season.

The size of the breeding population, however, has not been consistently counted over time with no indication of whether counts occurred at the beginning or the end of the breeding season and if it included juveniles (Parks and Wildlife Service, 2016). In the last few years, census dates have been implemented and definitions have been generated relating to the population

at the beginning of the breeding season and the population at the end of the season including juveniles (Parks and Wildlife Service, 2016). All other calculated demographic parameters are also now consistently measured.

Between 2010 and 2015, the number of breeding pairs has varied between 7-18 pairs. Data analysis from 2010 onwards has revealed that not all females participate in breeding each year, with less than 50% breeding in some years (DELWP, 2016). Breeding participation has been measured in two ways:

- Number of females that participate in breeding as a proportion of the number of females that return for breeding
- Number of females that participate in breeding as a proportion of the number of females that return for breeding and survive to participate

Breeding participation is more accurately reflected by the second measurement (Troy, 2017).

A total of 13 females, including three of the four wild birds that returned to Melaleuca, attempted breeding in the 2016/17 breeding season resulting in 17 nesting attempts (Stojanovic et al., 2017). The majority of observed pairings were between wild males and released captive-bred females (13 pairs) with two pairings between wild males and females and one pairing between released captive-bred birds (Stojanovic et al., 2017). Breeding success is considerably higher in the wild population compared to the captive population.

Released captive-bred females commonly produce only 1-2 eggs in the wild, producing comparable clutch sizes to wild birds in the 2016/17 breeding season (Stojanovic et al., 2017). The corresponding hatching success is considerably lower than the historical average of 80% (Holdsworth, 2006; Troy, 2017). The majority of unhatched eggs over the last four breeding seasons appear to be infertile (Troy & Gales, 2016; Stojanovic et al., 2017).

Fledgling success (the number of fledglings as a proportion of the number of eggs that hatched) has declined from 87% (historical average) (Holdsworth, 2006; Troy, 2017). While captive-bred birds provided a substantial contribution to the number of fledglings produced in the 2016/17 breeding season, this cohort experienced sub-optimal breeding productivity due to producing significantly fewer fledglings per nesting attempt than wild females due to significant hatching failures related to infertility (Stojanovic et al., 2017).

The causes of low and variable breeding success and number of fledglings between years are unknown (DPIPWE, pers. comm.). Infertility of released captive-birds represents a waste of conservation resources (Stojanovic et al., 2017). The factors leading to low breeding success and infertility are unknown but could be due to nutrition, cumulative or individual genetics, behaviour, pathology or anthropogenic factors (Stojanovic et al., 2017). It is now crucial to improve fertility to maximise the potential of releasing females into the wild and for the remaining wild males to successfully mate (eight nests involving a wild male and a released captive-bred female failed due to egg infertility; Stojanovic et al., 2017). Since 2015, management actions to try to improve breeding success has included adjusted nest box design, nest box substrate and transition from a seed-based diet to a pellet-based diet (DPIPWE, pers. comm.). Monitoring the effect of these management actions on breeding success has been confounded by disease outbreaks (DPIPWE, pers. comm.). Thorough evaluation of the factors contributing to the decline in breeding success has not been conducted (Holdsworth et al., 2011).

12.4 Disease management

One of the most common direct threats to survival of OBPs is health (DPIPWE, pers. comm.). DPIPWE vets respond to observations of sick and injured birds via photo monitoring, observation, trapping and direct examination, and treatment. Response depends on the severity of symptoms as well as individual birds and their health history (DPIPWE, pers. comm.). Of particular importance is the management of likely impacts of BPFD on the wild population (DPIPWE, pers. comm.). At Melaleuca, the impacts of BFDV have been managed through:

- Disease screening of captive OBPs prior to release (implemented in 2013)
- Surveillance disease screening of all nestlings each year (implemented in 2014)
- Disease screening of birds in ill health
- Implementation of feed table cleaning protocols to ensure that tables are cleaned daily with disinfectant effective against circovirus
- Provision of supplementary seed in feeders rather than on mats where it can mix with faeces increasing the likelihood of disease transmission
- Development of protocols to minimise risk of disease transmission by staff handling birds
- Replacement of nest boxes used by parrots each year to minimise risk of disease transmission between cohorts
- Installation of a third feed table at Melaleuca to reduce the density of OBPs feeding at the same feed table

Actions 2 to 7 above were put in place following the PBFD outbreak in the wild population during the 2014/15 breeding season (DPIPWE, pers. comm.). Since the implementation of these management actions, the incidence of BFDV in the captive and wild populations is quite low, with only two PCR positive results for BFDV in the last 18 months (as of Nov 2017). This suggests that these measures have limited the potential disease transmission opportunities at Melaleuca (DPIPWE, pers. comm.).

Blood and feather samples are taken from individuals at the time of colour-banding. This occurred intermittently prior to 2013, and since then has become part of routine protocol (DPIPWE, pers. comm.). These samples are used for BFDV screening and genetic sex determination. One extra sample is archived at the Australian Museum (DPIPWE, pers. comm.). DPIPWE staff are currently assisting Sydney University and Australian Museum staff in obtaining historical blood and feather samples and compiling their metadata for future uses (DPIPWE, pers. comm.).

DPIPWE prepared the *DPIPWE Biosecurity and Disease Management Protocols for Captive and Wild Orange-bellied Parrots in Tasmania* in 2013 which was reviewed in 2015 (DPIPWE, 2015a; DPIPWE, pers. comm.). The protocols will be reviewed again in 2018. This document outlines biosecurity measures and management of diseases such as BFDV including quarantine of morbid birds and post-mortem of deceased birds (DPIPWE, pers. comm.). Regular post-mortem of deceased birds is now providing information on the incidence of other infectious diseases and pathogens of concern in the wild population (DPIPWE, pers. comm.).

12.5 Supplementary feeding

Supplementary food during the breeding season has been provided at Melaleuca at both breeding and non-breeding locations since 1988 (and also at Birchs Inlet during releases (see section 12.10.2); OBPRT, 2006a). The purpose of supplying supplementary food has changed over the years from a successful monitoring method aiding the observation of colour-banded individuals through the strategic-placement of observational feeding tables to providing a targeted dietary supplement for breeding birds in an attempt to improve female breeding participation which has increased to greater than 80% from 2013/14 to 2016/17 (calculated as the number of female OBPs that participated in breeding as a proportion of the number of females that return for breeding and survive to participate; Troy, 2017). Supplementary feeding and associated protocols are reviewed by the OBPRT and DPIPWE vets annually (DPIPWE, pers. comm.). In the 2015/16 breeding season, biosecurity measures were improved from advice provided by the VTRG including the cleaning protocols of feeding tables (Troy et al., 2016). The delivery of supplied food was also modified to minimise disease transmission between birds utilising the feed tables (Troy et al., 2016). During the 2016/17 breeding season, the sprouted seed was contaminated with the bacteria *Pseudomonas aeruginosa* which resulted in mortalities and evaluation of the feeding protocols.

The amount and type of food provided is recorded daily (DPIPWE, pers. comm.). Between the 2013/14 and 2016/17 breeding seasons, 100-170 kg of food was provided between September and April (DPIPWE, pers. comm.).

Research conducted in 2016/17 revealed that only 28% of surveyed sites at Melaleuca supported medium/high abundance of preferred OBP food plants indicative of a decline in breeding habitat quality and a reduction in the availability of natural food (refer to section 12.15.1 for further information; Stojanovic et al., 2017). Time spent by individuals foraging away from the feed tables is not monitored as would require radio-telemetry and intensive behavioural observation of individual birds (DPIPWE, pers. comm.).

The overall impact of supplementary feeding at Melaleuca on OBPs is largely unknown. All of the returning birds now frequent the feed tables (numbers have increased over time) with the majority using them regularly throughout the breeding season. Many of the captive-released birds also utilise the feed tables as their primary source of food. The provision of supplementary food is potentially associated with several negative impacts associated with shifts in dietary search patterns and food types (thus nutrition; J. Starks, pers. comm.). It has previously been noted that supplementary feeding may be training OBPs to eat the wrong food during winter especially in the early years where large budgie mix seeds were supplied and is thought to be a contributor to the changing behaviours and mainland habitat use (J. Starks, pers. comm.). Nest boxes are within close distance to feed tables hence breeding birds do not have to travel far to food (where they can essentially gorge themselves; J. Starks, pers. comm.). The first thing fledglings do is visit the unlimited amount of budgie mix prior to migration (J. Starks, pers. comm.). During migration, food sources may become scarce, with the potential for naïve juveniles to select big seeds of exotic species similar to those provided at the feed tables instead of the small seeds from traditional saltmarsh species (J. Starks, pers. comm.). This may explain the observed move away from traditional saltmarsh plants including small herbaceous buttongrass seeds in the winter range to seeds from weed species (J. Starks, pers. comm.). After banding began, a higher proportion of unbanded OBPs were observed feeding on traditional saltmarsh species compared with the high number of banded birds (which were present at Melaleuca) which were observed eating seeds from weed species (J. Starks, pers. comm.). Unbanded individuals are likely to have used breeding areas away from Melaleuca and therefore had not been exposed to supplementary food.

Nutritional information of the provided supplementary food and weed species and their effects on OBPs is largely unknown. Supplementary food may have numerous negative consequences including calcium deficiencies in parents, metabolic bone disease in chicks, vitamin A deficiencies and obesity in breeding birds as well as contributing to differences in productivity between wild and captive-released breeding OBPs (Anon, pers. comm.). Plants that OBPs are now foraging on in the wild may not be giving them adequate nutritional gains to survive the winter and the return migration trip to Melaleuca (J. Starks, pers. comm.). Furthermore, seeds from new habitats may be subject to pesticides/herbicides (as well as predators) which can have cumulative efforts (J. Starks, pers. comm.). For example, grains have been known to be contaminated with Heliotrope which BWPs are known to feed on. BWPs were subsequently shot and dissected to determine if they had been poisoned by the pyrrolizidine alkaloids causing lesions on the liver which was confirmed (J. Starks, pers. comm.). It has been suggested that the use of supplementary food could also impact chick weights which are affected by the availability of native food and the supplementary feeding protocols (Anon, pers. comm.).

The provision of supplementary food is an important factor to the success of transitioning captive-bred Psittacine species after release where longer time spent feeding at feed tables promotes site fidelity, increased social interactions and quicker integration of released birds into already established flocks (White et al., 2012). Released OBPs frequent the supplementary food tables more often than wild birds, with use increasing over the first two months post-release (Magrath & Penrose, 2013; Gulli & Magrath, 2015). This increase in use may be due to provisioning chicks or could be an indication of low fitness where birds experience higher energy demands due to living in the wild and flying longer distances compared to in captivity combined with a lack of local knowledge of appropriate feeding sites and food (Gulli & Magrath, 2015). These findings suggest that a larger area is required to develop flight skills and improve physical fitness while birds are still in captivity as well as familiarising birds with wild foods prior to release to help encourage adjustment to wild food sources (Gulli & Magrath, 2015).

The same study investigated the vigilance behaviour of wild and captive-bred OBPs at the feed tables in Melaleuca (Gulli & Magrath, 2015). Results indicated that after initial release, captive-bred birds showed increased vigilance at feed tables with this behaviour significantly decreasing over the following two months as they settled into their new environment (Gulli & Magrath, 2015). The level of vigilance was lower than that displayed by wild birds (Gulli & Magrath, 2015). If this low level of vigilance at feed tables is an indicator for overall vigilance, it may be a contributing factor to the low success rate of releases as birds would be more susceptible to predation during migration and on the mainland (Gulli & Magrath, 2015). These findings suggest that some form of vigilance training prior to release may be required such as through predator awareness as has been successfully implemented for Helmeted Honeyeaters (*Lichenostomus melanops*) at Healesville Sanctuary and predator avoidance training to increase the success of future releases (Gulli & Magrath, 2015).

12.6 Fire regimes

Fire ecology is well understood in south-west Tasmania with fire shaping the vegetation communities (Marsden-Smedley & Kirkpatrick, 2000). Prior to 1830, aboriginal burning regimes included small-scale, frequent low-intensity fires across the moorlands. Following European settlement, fire regimes have been greatly altered resulting in larger, less-frequent, higher-intensity fires (Marsden-Smedley, 1988). Moorlands now dominate the landscape and have become predominately old-growth, suppressing abundance of preferred OBP food plants (Marsden-Smedley & Kirkpatrick, 2000; DELWP, 2016). Evidence suggests that OBPs heavily use areas that have been recently burnt as evident from soot on feathers, with preferred food plants being in the best condition eight years after fire (Brown & Wilson, 1980; OBPRT, 2006a;

Forshaw & Cooper, 2016). The extent of preferred age class foraging habitat is updated annually via the provision of ecological burning information provided by the Tasmanian Parks and Wildlife service (DPIPWE, pers. comm.).

Fire management has been identified as the most important consideration to the wild population within their breeding range since the second OBP recovery plan (Stephenson, 1991; OBPRT, 2006a). This has also been reflected in fire management plans and previous Tasmanian Wilderness World Heritage Area management plans. As such, schedules and protocols for ecological burning in south-west Tasmania already exist including planned burns of buttongrass plains to enhance OBP feeding habitat in the Melaleuca vicinity (Marsden-Smedley, 1993; OBPRT, 2006a; DPIPWE, pers. comm.). Furthermore, asset protection burns near Melaleuca will incidentally protect some nesting sites (DPIPWE, pers. comm.). However, regular burning within Melaleuca has not occurred which is largely due to lack of resourcing and priority issues for the Tasmanian Wilderness World Heritage Area (Table 6; Figure 4). Consequently, planned burns (including those prescribed within the OBP fire management plan to enhance breeding habitat) have not occurred as scheduled (Marsden-Smedley & Kirkpatrick, 2000) with the last OBP prescribed burn occurring in 2011 (Table 6). Over time, increasing fuel loads, limited budgets, negative impacts to other natural values and more rigorous agency requirements have made implementing planned burns even more difficult (Parks and Wildlife Service, 2016; OBPRT, 2017). The OBPRT have previously tried to arrange more regular patch-burning at Melaleuca to diversify the potential seed sources but this has proven difficult due to the location with the Tasmanian Wilderness World Heritage Area who govern the times, places and conditions that controlled fires occur under (N. Murray, pers. comm.). Funding from the Australian Government in 2017 enabled pre- and post-fire vegetation surveys in the Melaleuca Valley to be performed to help identify changes in habitat at priority sites (DPIPWE, pers. comm.).

Table 6: Fire history for Melaleuca from 1975 to present (provided by DPIPWE).

Fire Name	Fire Area (Ha)	Ignition Date	Ignition Cause/Type	Comments
Mt Fulton	325.03	1/06/1975	Planned Burn	Ignition month only known
Claytons	49.32	6/10/1976	Planned Burn	
Horseshoe Inlet	951.63	8/10/1976	Planned Burn	
Ketcham Bay	27.827	1/01/1985	Deliberate/Bushfire	Ignition year only known
Fulton Cove	141.36	1/01/1986	Undetermined/Bushfire	Ignition year only known
Pandora Hill	391.99	16/03/1987	Accidental/Bushfire	Escaped HRB Dummy Origin
Melaleuca Moorings	2.08	1/01/1989	Planned Burn	Ignition year only known
Bathurst Narrows	1.36	24/01/1996	Natural/Bushfire	
Moinee Ridge, Cox Bight	214.28	24/01/1996	Natural/Bushfire	
Melaleuca north Moth Creek	6.25	1/01/1997	Planned Burn	Ignition year only known
Melaleuca	4735.49	26/09/2000	Accidental/Bushfire	Escaped OBP ecological burn
Melaleuca Pandora Hill	72.97	26/09/2000	Planned Burn	Escaped OBP ecological burn
Melaleuca	121.09	1/01/2003	Natural/Bushfire	
Melaleuca Creek	12.53	16/05/2006	Planned Burn	Successfully completed
North Moth Creek, Melaleuca	5.868	16/05/2006	Planned Burn	
Melaleuca Lagoon SCA1ECO	464.42	7/04/2011	Planned Burn	OBP ecological burn
Melaleuca Mine West SCA2ECO	3.99	7/04/2011	Planned Burn	OBP ecological burn
Melaleuca Range, Mt Council	0.05	13/01/2016	Natural/Bushfire	

SUPERSEDED

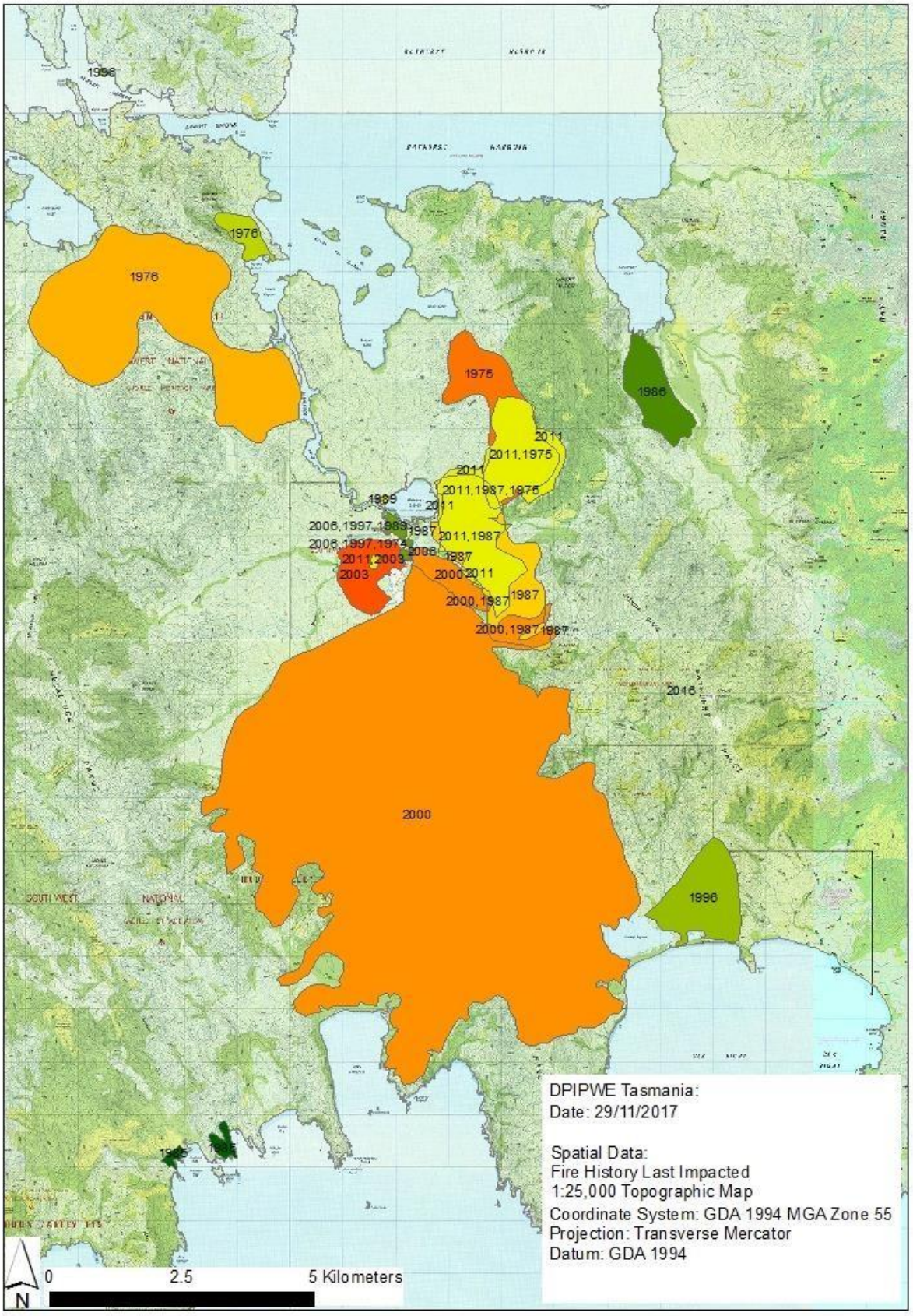

Figure 4: Fire history for Melaleuca from 1975 to 2017 (provided by DPIPWE).

12.7 Nest boxes

The provision and maintenance of nest boxes at known breeding locations by DPIPWE aims to help manage OBP breeding in the wild (DPIPWE, pers. comm.). Custom-made nest boxes have been installed at Melaleuca since the 1991/92 breeding season to provide more selection for females, particularly if females were not participating in breeding due to space limitations, encourage breeding pairs of OBPs to nest in accessible sites and to alleviate competition for natural tree hollows (OBPRT, 2006a; J. Starks, pers. comm.). Nest boxes are considered an integral component of the breeding program with band resighting data indicating that the majority of breeding activity of both wild and captive-released OBPs now occurs in nest boxes (OBPRT, 2006a; DPIPWE, pers. comm.). Monitoring of nest boxes occurs in September, January, February and March each year (DPIPWE, pers. comm.).

During the 2016/17 breeding season, 74 nest boxes were deployed at Melaleuca with the majority of nesting attempts occurring within them. Nest boxes have also been previously installed at Towterer Creek (11) and Birchs Inlet (including 13 between 2000-2010) to encourage local wild and released birds to nest in them (OBPRT, 2006a). One next box was used at Towterer Creek in 2003 with breeding success unknown. A maximum of nine nest boxes were used by released birds each year at Birchs Inlet resulting in 46 juveniles (OBPRT, 2006a). These nest boxes are no longer used by OBPs and are not maintained (DPIPWE, pers. comm.).

The design of nest boxes has been optimised through Federal funding including an interchangeable inner sleeve to minimise the spread of PBFD and aid disease management by improving the ease of cleaning (implemented in 2014; Parks and Wildlife Service, 2016; DPIPWE, pers. comm.). The design has also been modified to exclude large predators and competitors from entry (Parks and Wildlife Service, 2016). Nestling growth and survival may be affected if nest boxes are subject to physiologically stressful extremes due to climate conditions influencing temperature and evaporation (Larson et al., 2015). Data loggers have recently been installed in nest boxes to collect information on the inside humidity and temperature to help monitor the condition of nestlings and provide extra data for the analysis of nesting attempts which can then be used to help improve nest box design. Since the 2014/15 breeding season, motion-sensor cameras have been installed outside selected nest boxes to monitor use by both OBPs, predators and competitors (Parks and Wildlife Service, 2016; DPIPWE, pers. comm.). In 2015/16, 10 nest boxes on poles were successfully trialled (Troy et al., 2016).

12.8 Predator/competitor control

One of the main ongoing recovery actions of the OBP recovery plans is the management of predators and competitors at the breeding grounds to help improve breeding success. The activity and impact of predators and competitors, and control where required, at breeding sites has occurred opportunistically since 1999 and systematically since 2013 including the use of remote cameras on select nest boxes and feed tables since 2014 (Parks and Wildlife Service, 2016; DPIPWE, pers. comm.). However, data has yet to be formally analysed (Parks and Wildlife Service, 2016).

A management strategy for the OBP competitors and predators was developed by DPIPWE in 2015 (*Guidelines for the Management of Orange-bellied Parrot Predators and Competitors*; DPIPWE, 2015b). This document sought to assess the potential impacts of OBP predators and competitors on OBP nest and food sites. It outlines transparent and approved protocols for the management of introduced and native competitors and predators at nest boxes and feed tables.

12.8.1 Predators

The impact of native predators at the breeding grounds is managed by culling at key times of the year or following persistent interest in or interactions with OBPs (DPIPWE, pers. comm.). Black Currawongs (*Strepera fuliginosa*), Sugar Gliders (*Petaurus breviceps*) and Tiger Snakes (*Notechis scutatus*) have been identified as nest box predators. Sugar Gliders have caused nest failures and deaths of at least six female OBPs at Birchs Inlet from 1999 to 2005 (Holdsworth, 2015). Their absence at Melaleuca may be a contributing factor as to why this is the only remaining breeding location for the species (Holdsworth, 2015). Furthermore, a raptor, most likely a Brown Goshawk (*Accipiter fasciatus*), was observed capturing an OBP near one of the feed tables in recent years (Troy, 2017).

Integrated introduced predator control programs at sites used by OBPs for nesting, feeding and roosting are implemented at Melaleuca where feasible. European Starlings (*Sturnus vulgaris*) are the only introduced predator commonly observed at Melaleuca, with shooters being deployed to control the population (DPIPWE, pers. comm.).

12.8.2 Competitors

The impact of native OBP competitors is largely managed by trapping and relocating individuals from Melaleuca to Hobart (DPIPWE, pers. comm.). Considerable effort has been made to ensure adequate numbers of nest boxes are available to breeding OBPs each season, adapting the design to exclude competitors from entry, manually removing nests of competitors from nest boxes and killing nest competitors (Parks and Wildlife Service, 2016). The most common competitor for OBP nest boxes are Tree Martins (*Petrochelidon nigricans*), with occupation varying from 25-68% since the 1992/93 breeding season and increases as the number of nest boxes increases (Troy & Gales, 2015). They now occupy at least half of all nest sites in Melaleuca each breeding season (Parks and Wildlife Service, 2016). Tree Martins are known to build nests over top of active OBP nests (even nests which contain nestlings of up to three weeks of age) and prevent adult access by blocking the entrance with mud (Troy, 2017). Tree Martins will re-commence nest building on the same day that their nests have been removed from nest boxes. The potential impact and optimal management of Tree Martins is currently being investigated through an Honours project from ANU in collaboration with DPIPWE (pers. comm.).

Nest boxes are occasionally occupied by other species including Green Rosellas (*Platycercus caledonicus*), Australian Owlet-nightjars (*Aegotheles cristatus*), Common Ringtail Possums (*Pseudocheirus peregrinus*), Eastern Pygmy Possums (*Cercartetus nanus*), and Chocolate Wattled Bats (*Chalinolobus morio*). Honeybees or ants may also be present within nest boxes (Troy & Gales, 2015). The introduced European Starling irregularly use nest boxes since at least the 1995/96 breeding season. They were considered a significant competitor for nest sites in the early 2000s after which control methods were implemented at Melaleuca and Birchs Inlet. Nest boxes are typically occupied by competitors for more than one breeding season. Green Rosellas also harass OBPs at the feed tables and prevent them from accessing the supplied food (Troy, 2017).

12.9 Releases of captive-bred birds

The presence of PBFD in the captive population delayed releases of captive-bred individuals until 1991 when the disease was positively detected in the wild population (Brown et al., 1995). A total of 555 captive-bred OBPs have been released between 1991 and 2017 at Melaleuca and

Birchs Inlet in an effort to increase the numbers in the wild and to establish a second breeding population (DPIPWE, pers. comm.). This has included:

1991-1993: Melaleuca adult spring release – 37 birds

1994-2009: Birchs Inlet adult spring release – 402 birds

1996-1997: Taroona accidental release (escapee) – 1 bird

2013-2017: Melaleuca adult spring release – 110 birds

2017: Melaleuca nestling release (January) – 5 birds

12.9.1 Melaleuca

Eleven adult birds were initially released at Melaleuca in October (spring release) however none of these individuals were observed on the mainland during the non-breeding season nor were they observed back at Melaleuca in the following breeding season. In October 1992, 14 OBPs were released with two of the birds being observed in Victoria during winter and another two birds being detected at Melaleuca in 1993 (Brown et al., 1995). One bird returned to Melaleuca for three consecutive breeding seasons providing validation that released captive-bred birds can successfully migrate and survive during the winter (Brown et al., 1995).

Releases were halted after 1993 as the OBP population at Melaleuca was reported as stable and therefore the release effort and use of captive birds were directed at establishing a second population at Birchs Inlet (DPIPWE, pers. comm.). After the rapid decline in the wild population was detected in 2010, releases re-commenced at Melaleuca in 2013 with an additional aim of correcting sex-ratio biases present in the returning wild population which may have been reducing breeding success due to increased male competition for females as well as providing more opportunities for breeding and subsequent production of juveniles capable of migration (Gulli & Magrath, 2015). A spring release of 23 adults (15 females, 8 males) occurred in 2016 in an effort to balance the male-biased sex-ratio and increase the breeding potential for the season. Released birds increased the potential number of pairings in the wild from four to 19. Sixteen breeding attempts were made with captive-released birds producing nestlings. An additional five nestlings were released in January 2017 to trial releases of this age cohort (for more information see section 12.12; DPIPWE, pers. comm.). The return rates of captive-bred birds however have been extremely low.

Analysis of OBP translocations at Melaleuca and reporting of the outcomes have been provided annually to the OBPRT since 2014 (DPIPWE, pers. comm.).

12.9.2 Birchs Inlet

OBPs were last confirmed breeding at Birchs Inlet in 1985 (OBPRT, 1999). Following the successful releases of captive-bred birds at Melaleuca, a release program was established for Birchs Inlet operating between 1994 and 2009 in an effort to re-establish a breeding population at this historic breeding site (OBPRT, 2006a). A total of 402 adults were released in spring during this time period including an initial release of 15 birds in 1994. Release cohorts included a balanced sex-ratio comprised of individuals from multiple captive-breeding facilities (Parks and Wildlife Service, 2016).

Released individuals survived well during the breeding season with some birds observed to have paired and successfully bred in their first breeding season. Overall, 71 fledglings were produced throughout the release program at Birchs Inlet. Some birds also successfully completed a return migration including one of the 1994 release birds being observed at Point Lillias (Victoria) in 1995 and another in 1997 back at Birchs Inlet (Starks, 1997; OBPRT, 2006a). Reproductive success and return migrations, however, were overall extremely low and the re-establishment of a breeding population here was unsuccessful (Smales et al., 2000; OBPRT, 2006a; Pritchard, 2014). For example, in one season only one pair bred producing only one fledgling (OBPRT, 2006a). The causes for this may be due to the small number of birds being released, known breeding limitations of released captive-bred birds, predation from sugar gliders, low fertility, poor annual survival and/or the absence of wild birds to teach wild behaviours or to pair with to rectify genetic deficiencies present in captive-bred birds (OBPRT, 2006a). In 1999, a pair of captive-bred birds were held back in the holding aviary to act as call birds in an effort to entice released birds to remain in the area, but this did not help in the establishment of a breeding population.

The last confirmed breeding at Birchs Inlet by released captive-bred birds or their progeny was in 2008. Monitoring of Birchs Inlet consequently ceased in December 2010 (DPIPWE, pers. comm.). Analysis and reporting of translocations at Birchs Inlet between 2000 and 2008 has not been completed (DPIPWE, pers. comm.).

12.9.3 Survival rates

A study in 2013 revealed that twice as many birds from the second round of releases during a single breeding season survived which could be related to continued access to the holding aviary after release which is unavailable to birds from the first release cohort (Magrath & Penrose, 2013). Nearly twice the number of first-year birds survived compared to older birds indicating the need to investigate the use of more first-year birds in future releases (Magrath & Penrose, 2013). Assortative pairing (i.e. wild-wild and captive-bred-captive-bred) was evident and may be due to (i) the release of captive-bred birds after the majority of the wild birds had arrived at Melaleuca and had started pairing, (ii) housing together of some of the captive-bred birds for months prior to release thus were familiar to each other, and/or (iii) birds prefer to pair with birds of a similar origin (Magrath & Penrose, 2013). This study provided several recommendations for future releases including:

- Further development and implementation of pre-release conditioning techniques
- Investigating the selection of younger birds for release
- Releasing birds earlier in the season (e.g. early November)
- Constructing a second release aviary enabling the continued access by the first release cohort
- Increasing the holding period prior to release
- Increasing the effort to determine the identity of breeding birds (e.g. camera traps or volunteers)
- Considering the use of micro-chips to provide more comprehensive data on the use of the supplementary food tables
- Collection of DNA samples to perform parentage analyses and investigate the possibility that released captive-bred males are cuckolded

By 2015, release groups were held in different release aviaries for four to six days with releases occurring in early November in favourable weather conditions (Gulli & Magrath, 2015; Troy & Gales, 2016). Adult releases at Melaleuca in spring are planned to continue to increase numbers in the wild breeding population and correct for any evident sex-ratio biases. The potential for releasing larger cohorts is currently being reviewed by the OBPRT to maximise breeding potential. The OBPRT have also identified the possibility of releasing birds at additional sites within the greater Melaleuca area guided by habitat and monitoring of wild foraging behaviour in the future and is currently under consideration (OBPRT, 2017).

12.9.4 Behaviours of released birds

Released captive-bred adult birds tend to migrate later than their wild counterparts being more similar to wild-born juveniles. While juveniles of released captive-bred adults appear to return to Melaleuca at similar rates to that of juveniles from wild-born parents, survival/return rates of the released captive-bred adults are extremely low with a large proportion never being resighted again after departure from the breeding grounds (OBPRT, 2006a). These birds, along with their offspring, may fail to successfully migrate and/or locate suitable winter habitat decreasing their likelihood of survival during the non-breeding season (OBPRT, 2017). In recent years, no released captive-bred bird has successfully made the return migration trip to Melaleuca more than once and migration rates are not improving (Troy, 2017). There has been no documented evidence of released captive-bred birds displacing wild birds during the breeding season (OBPRT, 2017).

12.10 Acoustic recording

Field trials of prototype audio recording equipment were conducted in 2004 in Melaleuca on OBPs to assess the applicability of the technology as a potential detection method across their entire distribution (Wilson & Holdsworth, 2005). OBP vocalisations, including the flight call, were able to be identified in the field recordings and could be distinguished from other sounds in the environment including other birds, frogs, wind and anthropogenic noise (Wilson & Holdsworth, 2005; OBPRT, 2006). However, the quiet calls (thus low signal strength) limited the ability of recording devices to detect and record their calls, even when the recording device was in close proximity to the birds (M. Holdsworth, pers. comm.). This was attributed to the quiet nature of OBPs (only tend to emit an alarm call when flushed), their somewhat unpredictable calling nature (affecting where and when recorders should be set) and their rarity within the environment (M. Holdsworth, pers. comm.; M. Webb, pers. comm.).

12.11 Nest Intervention project 2016/17

In response to the low return rates of OBPs in spring 2016, researchers from the ANU Difficult Bird Research Group launched a crowdfunding campaign (*Operation Orange-bellied Parrot*) to raise funds for resources required for trialling new emergency interventions to increase the number of fledglings produced in the wild. The campaign attracted over 1,600 supporters and raised more than $140,000 in two weeks (Cook, 2016).

DPIPWE collaborated with ANU to improve breeding output through the translocation of eggs and nestlings from captivity to the wild (DPIPWE, pers. comm.). A plan was devised to intensively monitor breeding OBPs at Melaleuca over the 2016/17 breeding season and implement intervention measures when required to ensure all nests had fertile eggs and all

nestlings fledged (known as the Nest Intervention Project; Stojanovic, 2017). Risks identified with the implementation of more invasive nest monitoring and recovery efforts included disturbance to wild nests with the potential to cause abandonment, transmission of disease between nests and death of nestlings being crop-fed or hand-reared. However, it was considered valuable to collect more comprehensive data regarding causes of nestling deaths and growth curves than what has previously been collected. The project was comprised of three components:

1. Rescue including the removal of ailing nestlings from wild nests and temporary hand-rearing/treatment before replacement back into the natal nest

2. Intervention including the cross-fostering of eggs and/or nestlings from captivity to wild nests which are under capacity due to egg infertility, poor hatch rates or small brood sizes and will be primarily restricted to one-way direction of movement (Taroona to Melaleuca)

3. Increased nest monitoring including determining if nesting OBPs can tolerate regular nest monitoring, intervention and rescue measures

Searches for nests were made at the beginning of the breeding season at Melaleuca at 10-day intervals (Stojanovic et al., 2017). All known nests were subsequently checked approximately every third day. Nests were monitored to confirm that males were adequately visiting nests to provision females during incubation and that both parents were adequately provisioning nestlings. Monitoring occurred through a combination of observations of nest boxes from the ground and observations of nest contents via tree climbing. Internal and external (within 1 m of nest boxes) motion-activated cameras were also used to monitor nest boxes until nests were deserted (Stojanovic et al., 2017). Candling via a small flashlight or dissection of unhatched eggs were used to determine egg fertility (Stojanovic et al., 2017). Additionally, volunteers monitoring the feed tables were provided with the leg band combinations of nesting birds to help identify if incubating females were away from nests (sign of nest desertion) or if adults which should be provisioning mates or chicks have disappeared (sign of nest desertion, inadequate parental care or parent death). The outcomes of this pilot trial revealed that no nests were deserted as a result of intensive and repeated nest monitoring (nests were checked 10-15 times before fledgling including candling of eggs and handling of chicks) and the risk of disturbance was concluded as low (Stojanovic et al., 2017).

Cross-fostering techniques which have been successfully used in the captive population were trialled for the first time in the wild as a tool for improving the contribution of infertile released captive-bred birds (Stojanovic et al., 2017). Fostering has successfully been used as a management tool in recovery programs of other parrot species improving breeding productivity (Beissinger et al., 2008). Furthermore, it is assumed that cross-fostered fledglings would have a higher survival rate during migration (mean of 0.56 for wild juveniles) than captive-released adults (mean of 0.16). Fostering attempts were constrained to only nestlings (no eggs) thus foster chicks could only be sourced from three captive pairs based at the Taroona Wildlife Centre and host nests could only be selected from nests of released captive-bred birds (Stojanovic et al., 2017). Nests of released captive-bred birds (n = 4) were selected if egg laying was synchronised with the nests of captive birds at the Taroona Wildlife Centre (Stojanovic et al., 2017).

A clutch of the youngest possible chicks (n = 5) aged between 0.5 and 4 days old were flown from the Taroona Wildlife Centre to Melaleuca in January 2017 and placed in foster nest boxes. The oldest foster chicks (n = 4 chicks) were assigned to nests with wild-born hatchlings (n = 3 nests), while the youngest foster chick was put in a nest with four infertile eggs within 5 days of their expected hatching date (Stojanovic et al., 2017). Nests were initially checked 6 and 24 hours after foster chicks were inserted, then reduced to the same frequency as the other nests

(Stojanovic et al., 2017). The chick in nest 1 died on the same afternoon as insertion, possibly from aggression from the parents. In nest 2, both host and foster chicks appeared healthy for a week before dying from *Pseudomonas aeruginosa* caused from sprouting seed prepared at the Taroona Wildlife Centre which had become resistant to the disinfectant being used to sterilise the seeds (Stojanovic et al., 2017). In nest 3, the two chicks were observed cold and lying away from the female and each other. Subsequent checks showed continual negligence by the female thus the chicks were removed, warmed, and transferred to nest 2 but died overnight (Stojanovic et al., 2017). The youngest chick was immediately accepted by the female and subsequently fledged. She was later detected on the mainland in Victoria at the WTP along with two wild adults but did not return to Melaleuca for the 2017/18 breeding season. The outbreak of the *Pseudomonas aeruginosa* infection cut short the cross-fostering trial which was set to move nestlings into two more wild nests.

The Nest Intervention Project was trialled as a pilot study, where results will be used to evaluate the potential of intervention measures as a management tool for recovery of the species at the nest scale and to further develop and finalise associated protocols (Troy, 2017). The acceptance of two of the four foster nestlings which survived past the first day and the subsequent fledgling of one of these chicks indicates the potential of this technique for use as a management tool to improve productivity of infertile birds (Stojanovic et al., 2017). However, it has been suggested that a 20% overall survivorship is generally not considered acceptable in other threatened species release efforts (Anon, pers. comm.). In the 2017/18 breeding season, the focus of the Nest Intervention Project has changed from translocation of nestlings to eggs with outcomes pending (DPIPWE, pers. comm.).

Other planned intervention strategies included in the trial were crop feeding of ailing nestlings at the nest and hand-rearing ('rescuing') of deserted or morbid nestlings with the aim to return healthy nestlings to wild nests before fledgling. Crop feeding and hand-rearing is restricted to experienced and authorised persons (DPIPWE staff) and occurs over the minimal possible time period in accordance with protocols (including general biosecurity, supplementary feeding and hand-rearing) endorsed by the VTRG and CMG (due to time limitations, protocols were in draft form for the 2016/17 breeding season and the Chair and Deputy Chair of the VTRG could only provide limited input into the protocols due to the short timeframe between the proposal and the recommendation to go ahead; VTRG, 2017a). One nestling was hand reared during the 2016/17 breeding season, but later died from a bacterial infection. To date, eight eggs have been rescued during the 2017/18 breeding season, but none have survived (DPIPWE, pers. comm.).

12.12 Plumage condition

Feather condition was examined in the 2016/17 breeding season by the ANU's Difficult Bird Research Group who found that condition differed between wild and released captive-bred birds with the latter having considerably poorer feather condition (Stojanovic et al., 2017). Feathers of released captive-bred birds tended to be dull, excessively weathered and dishevelled (Stojanovic et al., 2017). Excessive loss of barbs at the ends of contour, flight and tail feathers were evident in some individuals coinciding with a loss of refractory ultrastructure proximal to the barb loss (Stojanovic et al., 2017). Poor feather condition in captive birds may be attributable to abnormal behaviours, feather mutilation due to skin hypersensitivities or poor nutrition during feather growth (Stojanovic et al., 2017). In the wild, loss of feather condition is likely associated with high energetic costs due to migration and cold weather (Stojanovic et al., 2017).

12.13 Breeding habitat

The current recovery plan includes the integration of habitat protection requirements and habitat maps into decision-making processes through improved statutory planning tools, agency decision-making frameworks and databases, regional plans, reserve management plans and electronic land management systems. Habitat protection requirements and maps of predicted habitat are incorporated into DPIPWE decision-making frameworks (DPIPWE, pers. comm.). Information on the distribution and habitat requirements of OBPs are recorded in two locations that are used by decision-makers/land managers to check for threatened species records: the Tasmanian *Natural Values Atlas* and the Threatened Species Link, which provides management and conservation advice on Tasmania's threatened species (DPIPWE, pers. comm.). Information included in the Threatened Species Link is used to inform landholders in at-risk locations of the habitat requirements of OBPs, opportunities for supported management of habitat and relevant legislation protecting habitat loss (DPIPWE, pers. comm.).

12.13.1 Breeding habitat condition

During the 2016/17 breeding season, ANU researchers surveyed historic breeding locations which have not been surveyed for the presence of OBPs in the last 5-10 years (Noyhener Beach, Towterer Beach, Bond Bay and Settlement Point) to determine habitat quality and occurrence of OBPs (Stojanovic et al., 2017). In 2013, a large wild fire burned both Settlement Point and Bond Bay while Towterer Beach and Melaleuca were affected by smaller fires in 2011. There have been no fires at Noyhener Beach in the last decade. Findings revealed that traditionally important breeding locations are more likely to support preferred OBP food plants if they have been recently burned (proportion of sites with medium/high densities of preferred OBP food was 5% for unburned and 48% for burned areas; Stojanovic et al., 2017). Only 28% of the surveyed sites at Melaleuca supported medium/high abundance of preferred OBP food plants despite recent small fires. This indicates that habitat quality within the breeding area has declined considerably with only low levels of natural food currently being available for OBPs to forage on (Stojanovic et al., 2017). Sites with no or low abundance of preferred OBP food plants largely consisted of unburned scrub (greater than 15 years since fire) or skeletal soils on steep rocky hillsides (Stojanovic et al., 2017).

The study concluded that recently burned historical breeding sites support a significantly higher abundance of preferred OBP food plants than unburned sites but burning didn't always correspond to uniform, abundant or widespread regeneration of these plants (Stojanovic et al., 2017). The current limitation of naturally-occurring OBP food plants at Melaleuca may also be contributing to the dependence on the provided supplementary food (Stojanovic et al., 2017). Implementation of a fire regime to favour the growth of preferred OBP food plants requires urgent action and is likely only possible through large-scale burning of appropriate locations (Stojanovic et al., 2017).

12.13.2 Disturbance

The primary human activities that could cause disturbance within the breeding range include helicopters, fixed-wing aircraft, tourists and DPIPWE staff (DPIPWE, pers. comm.). DPIPWE contracted Ecology Australia to assess the threat of disturbance by helicopters and fixed-wing aircraft in 2000 and 2001. The outcomes from this study were the development of 'fly neighbourly' guidelines for helicopters and the development of guidelines for flight paths for fixed-wing aircraft (DPIPWE, pers. comm.). The 'fly neighbourly' guidelines were reviewed in 2016 when the extent of nest boxes at Melaleuca changed. Changes to the guidelines have

been submitted to the Civil Aviation Safety Authority (CASA) for approval in 2018 (DPIPWE, pers. comm.).

12.14 Development proposals

DPIPWE staff assess, provide expert advice on and manage the risks from development proposals that may represent a barrier to OBP migration or movements. Projects range from mining, fuel reduction/planned burns and wind farm proposals as well as helicopter activity in the area (DPIPWE, pers. comm.).

13. Captive-breeding program

13.1 Objectives

The original focus of the recovery effort for OBPs gradually shifted from surveying, monitoring and habitat protection to captive-breeding due to the initial successes experienced and the availability of funding due to the benefits other threatened Australian species had experienced through captive-breeding. The OBP captive-breeding program was initiated in 1986 with the captive population being managed as both an insurance population and one to supplement the wild population through releases. The captive population also provides the opportunity to study the species to obtain biological data (Smales et al., 2000). The long-term goals of the program include to:

- Act as a safeguard (insurance) against catastrophic stochastic events in the wild population including maintaining a high level of genetic variability representative of the wild population
- Supplement the wild population through releases of captive-bred individuals
- Provide opportunities for public engagement, education and research
- Conserve the natural behavioural repertoire of the species

The captive population is managed as a single population under a Zoos and Aquarium Association (ZAA) Captive Management Plan (CMP) through the Australasian Species Management Program (ASMP; Hockley & Hogg, 2013). The captive-breeding program consists of three cohorts of birds:

- Breeding: birds are held for breeding following strict breeding protocols
- Display: birds are not involved in breeding but could be made available for breeding in the future
- Surplus: birds have reached non-breeding age or are diseased

The captive-breeding program aims to fulfil the long-term goals by:

- Maintaining a captive-breeding population of 400 birds across a minimum of two locations (i.e. minimum two sub-populations)
- Conserving 90% or more of the expected genetic diversity (heterozygosity) found in the wild population over 100 years (based on a generation time of 3 years and an effective

population size of 0.4 of the census population size; see Frankham et al., 2010). A reduced generation time since 2010 due to intensively managing the gene pool via young founders and their progeny means that 95% cannot be achieved (N. Murray, pers. comm.).

- Providing 20-30 individuals for release each year
- Maintaining some birds for display and research

13.2 Captive Management Group

The CMG was established in 1995 to supervise the operation and management of the OBP captive-breeding program as well as the release of captive-bred birds through the implementation of the CMP (OBPRT, 2006a). The CMG has eight members including representatives from all of the breeding facilities (Taroona Wildlife Centre (Taroona), Healesville Sanctuary, Moonlit Sanctuary Wildlife Conservation Park, Adelaide Zoo, Priam Parrot Breeding Centre), a specialist bird veterinarian, the Species Coordinator and a representative from private aviculture (Anon, pers. comm.). The Chair has a two year term. The ZAA also provides advice and management to the captive-breeding program. Meetings are held at least annually and the CMG reports to the OBPRT providing recommendations surrounding husbandry and population management decisions. There are no archives attached to the CMG (i.e. of historical documents; Anon, pers. comm.).

The CMG is responsible for producing the CMP which is implemented at all captive facilities and provides guidelines for increasing the population size, maximising and managing genetic diversity, veterinary management including disease monitoring and control, husbandry procedures including consolidation of existing diets, supply of birds for release and collection and collation of monitoring data. The CMG also endeavours to address the list of specific research questions regarding breeding success, disease, behaviours and diet over the next few years as outlined in the CMP (Hockley & Hogg, 2013). However, it is likely that some of these questions will not be investigated due to lack of resources or changes in recovery priorities (Hockley & Hogg, 2013). The CMP is updated as new information becomes available and is due for review in 2018. The CMG has also produced an annual timeline for management of captive OBPs and created consistent quarantine protocols for implementation across all captive facilities. Two documents have also been generated for the expansion of the CMG to include non-ZAA members (see section 13.3). The CMG is currently working on finalising a husbandry manual by the end of 2017.

The CMG operates with no funding or budget, with the Chair's institution providing administrative support (estimated as $18,000 per annum including administration and time; Anon, pers. comm.). All costs associated with the involvement in the captive-breeding program are covered by the individual facilities including animal husbandry, capital cost of facilities, veterinary care including disease testing, staff, transport costs, data management, reporting and attending meetings. Funding has previously been provided from an external source for a year of PBFD testing.

13.3 Captive-breeding facilities

OBPs were first documented as having been successfully bred in captivity in 1973 in South Australia (Shephard, 1994). Prior to initiating a captive-breeding program for OBPs, husbandry techniques were trialled on Blue-winged and Rock Parrots in a specially-built aviary complex at Green Point (north of Hobart, Tasmania). Both species were successfully maintained and bred

in captivity with captive-bred birds being released into the wild (Brown, 1988; Brown et al., 1995). Ten founder juveniles were then collected from the wild in 1985 to establish a captive OBP population in Tasmania to support a Breed-for-Release program (OBPRT, 2006a). Juveniles were selected over adults as they are generally able to adapt better to captivity and their removal from the wild population would not reduce the stock of experienced breeding birds (Stephenson, 1991).

Breeding occurred in the first year after collection with two nests producing four fledglings confirming that OBPs will breed in their first year (Stephenson, 1991). However, seven birds died within the first few months from PBFD (Smales et al., 2000). The survival rate of juveniles continued to be very low in the first five years of the captive-breeding program due to the prevalence of PBFD which was likely present in the founders and was exacerbated by the cold, damp conditions within the Green Point aviary during winter (Menkhorst et al., 1990; Stephenson, 1991; Brown et al., 1995; Peters et al., 2014). Additionally, the site experienced several minor break-ins during the initial years (OBPRT, 2006a). The facility relocated to Taroona (south of Hobart; known as the Taroona Wildlife Centre) in 1989 and was more secure and less-exposed to weather conditions. Consequently, survival rates and breeding productivity improved (Brown et al., 1995).

A second captive-breeding population was established at Healesville Sanctuary using founder stock sourced from the Taroona Wildlife Centre in 1994 (OBPRT, 2006a). This second population acted as an insurance population in the event of a stochastic event (e.g. disease, fire) destroying the entire captive population at the Taroona Wildlife Centre. The use of Healesville Sanctuary also provided access to valuable professional advice and support systems for captive management through Zoos Victoria. In 1998, the housing arrangement for the OBPs was modified so that breeding birds were housed as pairs instead of in breeding groups where parentage was not always known (OBPRT, 2009). The switch to housing breeding pairs appeared to have maximised productivity during the breeding season and enabled more control over the management of genetic material. New materials were also used in the aviaries which were designed to decrease the number of traumatic injuries that were occurring through contact with the wire mesh and reduce the possibility of zinc poisoning which may have been occurring from the previously utilised galvanised wire mesh. Breeding capacity was further increased in 2007 with the construction of 20 breeding aviaries (Anon, pers. comm.).

More spaces, thus new facilities, were required in response to the 2010 Conservation Breeding Strategy after the rapid decline was detected in the wild population. An Expression of Interest was distributed around ZAA organisations resulting in several new facilities expressing interest in participating in the captive-breeding program. However, the majority indicated that they would require funding to construct the relevant infrastructure and have been unable to commit to the program (Hogg & Everaardt, 2017). The CMG is in ongoing discussions with potential institutions to secure participation thus extra holding spaces (Anon, pers. comm.).

Since the mid-1990s, the captive population has contained at least 100 OBPs with the two largest populations occurring at the Taroona Wildlife Centre and Healesville Sanctuary. In 2017, the captive population consisted of 340 birds spread across 11 ZAA institutions including:

- Taroona Wildlife Centre (Tasmania; holds just under half of the OBP captive population)
- Healesville Sanctuary (Victoria; display and breeding)
- Moonlit Sanctuary Wildlife Conservation Park (Victoria; display and breeding)
- Priam Parrot Breeding Centre (New South Wales)
- Adelaide Zoo (South Australia)

- Melbourne Zoo (Victoria; display only)
- Werribee Zoo (Victoria; display only)
- Halls Gap Zoo (Victoria; display only to natural attrition of current stock)
- Taronga Zoo (New South Wales; display only)
- Currumbin Wildlife Sanctuary (Queensland; display only)
- Cleland Wildlife Park (South Australia; display only as from 2017)

A further institution in New South Wales has expressed interest in holding a small number of birds but has yet to be confirmed.

Captive facilities are currently restricted to ZAA member institutions which must meet a collection of membership criteria ensuring there is a high level of confidence in the facility being able to provide high standards in animal welfare, husbandry, biosecurity and administration and enables captive birds to be managed as a single population (DELWP, 2016). Member institutions must adhere to the ASMP provided by the ZAA as well as operate within the CMG protocols and under OBPRT guidance. Provision of OBPs to facilities is determined by the relevant State legislation requirements and through consideration by the ASMP upon the advice of the OBPRT (OBPRT, 2009). All birds remain the property of the ASMP (i.e. the State). Adherence to strict biosecurity protocols enables the movement of individuals between facilities and release into the wild under CMG coordination.

Consistency between the captive-breeding facilities is highly desirable, particularly in relation to pre-release screening and general biosecurity, to mitigate risks associated with movements and releases (DPIPWE, 2015a). However, this is challenging due to varying funding and resource availability between breeding facilities. Birds are often housed and handled differently at each facility with the husbandry manual being used only as a guideline (Anon, pers. comm.). The breeding facilities are generally off-limits to the public and are often dedicated to OBPs. Housing aviaries are typically partly sheltered with the remaining component being open to the elements. Some facilities have air-conditioning and misting systems installed enabling the cooling of the entire facility when required during the breeding season (Anon, pers. comm.). The CMG chair is contacted by representative from the individual facilities if issues arise rather than the breeding facility making independent decisions (Anon, pers. comm.).

13.3.1 Expenses

The costs associated with the captive-breeding program was supported by cooperative funding from the Federal, Tasmanian, Victorian and South Australian governments for the first nine years prior to facing funding limitations (Stephenson, 1991). The average annual cost of housing an OBP is currently $2,000 (Hockley & Hogg, 2013). Each new space created to house an OBP will cost an estimated average of $3,750 (Hockley & Hogg, 2013). It is estimated the cost associated with expanding the captive population to the target of 400 will include a one-off payment of $562,500 to create the required additional spaces and an annual operating cost for the entire population of $800,000 (Hockley & Hogg, 2013).

Participating captive facilities are generally required to cover the large financial costs associated with the OBP captive-breeding program. An example of the associated capital expenses covered by Moonlit Sanctuary Wildlife Conservation Park includes:

- Construction of a breeding facility comprising five aviaries (2014). This was a "proof of concept" facility to try and make captive-breeding more economically feasible by designing a facility that would have low running costs, minimise injury to birds, fully exclude vermin and minimise the potential for disease transmission. The facility cost $14,000 to construct ($5,000 was covered by a grant from the Avicultural Society of Australia).

- Construction of a quarantine facility (2015) to meet quarantine requirements introduced in response to the PBFD outbreak. The facility cost $20,000 but is also used for general quarantine requirements of the institution.

- Construction of a new breeding facility comprising 20 breeding aviaries, two flocking aviaries, a kitchen for food preparation, keeper work areas and a double-quarantine arrangement (2016). Designed from experiences from the 2014 aviary complex and is considered a state of the art facility for the species which cost $120,000 ($94,000 was covered by a grant from Zoos Victoria).

The estimated annual cost for the husbandry of OBPs at Moonlit Sanctuary Wildlife Conservation Park is $64,000. Administrative and meeting costs are an additional $5,000 per annum. Costs associated with a staff member being the current CMG Chair is approximately $18,000 (M. Johnson, pers. comm.).

The total cost of running the OBP captive population across the Zoos Victoria facilities in 2016/17 was approximately $330,000. Additionally, $40,000 was spent on research (primarily on the Mainland Release Trial, see section 10.12) and $140,000 on infrastructure and grants. Another $300,000 has been allocated in 2017/18 for further expansion of facilities at participating institutions (Anon, pers. comm.). A staff member has also been sent to Melaleuca during the last five breeding seasons to assist with field activities and research (Anon, pers. comm.).

13.3.2 Transfers between breeding facilities

In 2015, the CMG requested that pairings of breeding birds take into account the potential to breed over numerous years in an effort to reduce the number of transfers between captive-breeding facilities (ZAA, 2015). Minimising the frequency of movements would help reduce the risk of disease transmission between facilities and exposure to stresses associated with transfers.

In order to maintain existing disease-free status of breeding groups, the VTRG formulated several recommendations for OBP transfers (ZAA, 2016) including:

- Prior to movement all birds should be assessed as healthy with no symptoms of clinical disease

- Before transfer of birds for breeding purposes, birds should be tested at least once for BFDV using PCR, and preferably via HI for antibodies, with testing occurring at the CSU diagnostic lab

- Testing should occur within six weeks prior to birds being transferred between captive-breeding facilities with results known before the transfer occurs

- Transfers should be restricted to PCR negative birds

- If both the sending and receiving facilities are in agreement, testing may occur at the time of transfer where the result will not influence the individual's participation in the new breeding group (i.e. when BFDV is known to be present in both facilities)
- Receiving facilities should quarantine transferred birds upon arrival thus should have the capacity to hold birds in isolation
- Receiving facilities can re-test birds after arrival and should have the capability of holding birds in isolation throughout the testing period and on an ongoing basis if a positive result is returned. Birds that test positive upon arrival may not be able to be returned to the sending facility.

13.3.3 Diet

In the wild, OBPs constantly forage on small seeds to meet their energy requirements. Early in the captive-breeding program, little research had been conducted into dietary requirements of OBPs thus captive birds were provided with seeds much larger than they would naturally forage on in the wild causing overweight birds with reduced reproductive outputs (Anon, pers. comm.). Investigations into the nutritional requirements of OBPs are still incomplete with the potential to have implications to the composure of the captive diet. For example, a study in 2009 found that the calorific value of *Sarcocornia* seed in potential winter saltmarshes was much greater than that of the seed mix provided to captive birds during the winter season (Modon et al., 2009).

Each breeding facility has formulated its own OBP diet which the CMG have recently collated and included as guidelines in the OBP Husbandry Manual (Anon, pers. comm.). For example, the OBP diet at one captive-breeding facility has been derived from dietary research based on observations of wild parrots and sampling of their natural food sources. Nutritional requirements of captive birds are further refined based on individual body condition, fertility, egg condition and density, daily food intake and weather (Anon, pers. comm.).

The draft husbandry manual (CMG, 2017) states that the captive diet can include:

- Sprouted seed (of any seed species but tend to be a legume-based mix. Pigeon mixes are considered ideal for sprouting): can be used as a highly nutritious and constantly available food source containing numerous essential vitamins. Can prevent chick death by preventing crop impaction from hard seed. Can be feed year-round as the sprouting process lowers the proteins and fats compared to dry seeds. Soaked seed should make up 50-100% of breeding birds diet if diets are seed-based.
- Grey striped sunflower
- Extruded pellets
- Small mixed dry hard seed (e.g. budgie mix)
- Canary seed
- Nuts including almonds and peanuts
- Mixed fruit and vegetables such as carrots, kiwifruit, pears, apples, corn, peas, spinach, kale, silver beet and broccoli (with a preference for dark green leafy vegetables). Daily quantities of fruit and corn are recommended to be less than 5 g per bird to prevent obesity.

Absolutely no avocado, onions or rhubarb are to be provided to birds. Fresh food to be provided daily and removed within 24 hours.

- Apple cider vinegar
- Shell grit, cuttlefish or calcium blocks provided on an ad lib basis throughout the year

The non-breeding season diet should comprise of a sprouted seed and/or a non-oily, low fat and protein dry seed mix and/or a pelleted diet mix supplemented with fresh vegetables and fruit (CMG, 2017). Sunflower seeds are not required as part of the non-breeding season diet and if excluded during this time can act as a trigger for breeding activity at the beginning of the breeding season (CMG, 2017).

Diet formulation should be based around diversity, frequency and volume. Diversity relates to providing as many different nutritional components as possible to expose the digestive system to a wide range of food sources enabling individual bodies to consume what it requires. Frequency relates to the concept of altering the diet in response to changing seasons as well as spreading food groups over several days. Twice daily feeding is recommended to encourage activity including foraging behaviours. Volume relates to varying the quantity of each food group available to ensure individuals consume as much variety as possible. Ad lib feeding is not recommended as the make-up of food items (e.g. fats, proteins, calcium) will influence the individual's preference in what it eats. There should be at least 10% of dry food remaining during the breeding season (CMG, 2017).

Healesville Sanctuary recommend supplementing every 1 kg of sprouted or dry seed with 18 g calcium carbonate, 27 ml Calcivet, 5.5 g Soluvet and 7.5 ml cod liver oil (CMG, 2017).

13.3.4 Sources of mortality

Major causes of mortality within the captive population include:

- Renal failure
- Intestinal worm impaction
- Aspergillosis
- Stress during courtship
- Trauma induced from flying into aviary hardware
- Accidents during handling
- Instances of predators getting into captive facilities (e.g. rat predation of 14 OBPs at the Taroona Wildlife Centre in 2015)
- PBFD: this was an annual cause of juvenile mortality during the first five years of the captive-breeding program. In recent years, 4/11 nestlings tested positive in 2011/12, 19/26 nestlings tested positive in 2014/15 and 0/24 birds tested positive in 2015/16.
- Herpes virus detected in the nesting material from nests where 43 nestlings died at the Taroona Wildlife Centre corresponding to three times the average annual mortality rate (OBPRT, 2006a). This outbreak highlighted the requirement to improve the quality of aviaries, quarantine facilities and the overall management of the captive population and led

to the development of a disease action plan including the implementation of disease management protocols to detect and reduce the risk of transfer or spread of disease.

- Adenovirus detected at Adelaide Zoo in 2016 with the population being managed as a closed population ever since (however the lesions caused by the adenovirus were not identified as the primary cause of death in the three deceased birds and healthy birds at two captive-breeding facilities have tested positive). It is uncertain whether this virus is present in the wild population and the significance that this virus may have to the species (VTRG, 2017a).
- *Pseudomonas aeruginosa* infection from the provision of sprouting seed within the captive diet cutting short the cross-fostering trial program in the 2016/17 breeding season. Consequently, the VTRG is currently developing a list of recommended protocols for sprouting seed (VTRG, 2017a).
- Mycobacteriosis

The spread of disease throughout the captive population has been a continued source of mortality (Philips & Holdsworth, 2006). Any diseases evident in the captive population jeopardises the ability of the captive population to act as an insurance against extinction in the wild and limits the ability to supplement the wild population as releases are suspended until the captive population is given disease clearance.

PBFD is regarded as a significant threat to both the wild and captive OBP populations. The CMP identifies the need to improve the knowledge and management of PBFD through:

- Identification and comparison of the virus strains present within the captive and wild populations
- Identification of potential sources of PBFD origin within the captive population
- Conduction of regular testing of disease positive birds to evaluate impacts to health and consistency of test results
- Determining if nest materials can be tested to identify PBFD positive birds
- Determining the impacts of PBFD to reproduction and survival in captivity

Since the commencement of the VTRG (see section 14), the CMG has been advised about illnesses or welfare concerns in both the wild and captive populations and kept updated with specific veterinary information throughout incidences. In some instances, a VTRG member has been requested to further investigate mortality events including inspection of captive-breeding facilities, review of pathology reports and discussion with key personnel (VTRG, 2017a).

13.3.5 Research

Captive facilities are often involved in research projects directed at better understanding OBP ecology and threats. For example, over the past five years Zoos Victoria has been involved in numerous research projects including:

- Analysis of the reproductive behaviour and performance of the captive population (Penrose, 2016)
- Vigilance behaviour of released verses wild birds at Melaleuca

- Use of supplementary food by released verses wild birds at Melaleuca
- Diet trials in captivity to assess the use of pellet food. This resulted in a shift in the captive diet at Healesville Sanctuary and the Taroona Wildlife Centre
- Investigation of the ecology and significance of BFDV (partner organisation on a current ARC Linkage grant)
- Development of a vaccine for PBFV (partner organisation with Charles Sturt University on an unsuccessful ARC Linkage grant which has since been funded by the Commonwealth)

Findings from these projects have been circulated to the OBPRT but have not been published as of yet (Anon, pers. comm.).

13.3.6 Private aviculturists

In 1998, a private aviculturist, who had been involved in the OBP recovery effort, was provided with three pairs of OBPs which produced two fledglings in the first breeding season. Subsequently, the aviculturist held four pairs of OBPs in his private aviaries for another eight breeding seasons producing 47 fledglings. The majority of these fledglings were used in the releases at Birchs Inlet (Morley & Menkhorst, 2013).

It was documented that the decision to release birds to a private aviculturist was a hard one for the OBPRT with serious concerns over the security of the birds including theft for the international aviculture trade as well as the expectation among the avicultural community for a wider release of OBPs to private facilities. A security system was installed at the aviculturist's home and the identity and location of the aviculturist was not divulged to the Australian Avicultural Society (Morley & Menkhorst, 2013).

Private aviculturists continue to enquire about the possibility of housing and breeding OBPs but no further instances have occurred.

13.4 Founders

Since the original collection of 12 founders in 1985 an additional 46 founders have been sourced from the wild population on 10 separate occasions (Hogg & Everaardt, 2017). In 2007, the OBPRT recommended the collection of a further two male founders per year for four years commencing in 2008 but this was revised in 2010 following the considerable decline in the wild population (less than 50 were estimated to be remaining in the wild; OBPRT, 2009). In 2010, the captive population began to be managed as an insurance population requiring more intensive genetic management (OBPRT, 2010a). Consequently, the collection of more founders was identified as one of the highest priorities in the Conservation Breeding Strategy 2010 and the 2010 Emergency Action Plan to increase the genetic diversity in the captive population so that it remained similar to the wild population as well as retaining the ability to produce fit birds for release once threats had been identified and managed (Pritchard, 2011b).

A target of an additional 25 unrelated founders from the wild was recommended to supplement the original founders (OBPRT, 2009). Given the size of the wild population in 2010, this number was unfeasible. The strategy therefore aimed to collect whatever genetic variation was available to maximise the probability of accomplishing a robust insurance population (OBPRT, 2009). Project Officers aimed to retrieve three juveniles per brood equating to the collection of

1.75 unrelated founders under the assumption that the parents were unrelated (OBPRT, 2009). Additional value was placed on collecting related fledglings as the more related individuals collected, the greater number of pairings could be made between new and existing genes in the first few breeding seasons assisting in the rapid spread of new genetic material through the captive population (OBPRT, 2009). Furthermore, mortality and breeding failure can limit the contribution of founders to the captive population hence collecting related individuals increases the probability that their shared genes will become represented in the captive population (OBPRT, 2009). The genetic quality within the captive population improved considerably after the inclusion of the new founders in 2010/11 and the population is now able to biologically reach the target of 400 birds as specified in the current recovery plan (Hockley & Hogg; 2013; Hogg & Everaardt, 2017).

Collected founders have largely been juveniles (although in some instances ages are somewhat unknown) sourced from Melaleuca with the exception of two adult females in 1996 who were caught in Victoria in the hope that they originated from a different breeding sub-population than Melaleuca (Smales et al, 2000). Juveniles are associated with less risk than transporting nestlings or eggs, have a smaller risk of inappropriate imprinting and have a higher success rate of transitioning to captivity compared to adults (Pritchard, 2011b). Furthermore, juveniles have a lower average survival rate to first breeding season in the wild (58%) compared to annual survival rates of adults (65%; Holdsworth et al., 2011). Therefore, removing juveniles is associated with a lower impact to the wild population due to the lower probability of contributing to the wild breeding population compared to breeding adults (Pritchard, 2011b; Anon, pers. comm.).

DNA profiling revealed that up until 1993, the captive population at the Taroona Wildlife Centre was founded by three females and one male collected in 1987 (Smales et al., 2000). Prior to 2010, only 6-9 founders had been reproductively successful in captivity (although this could be as high as 12; Hogg, 2013). This has resulted in a considerable over-representation of some individuals in the captive population with the majority of individuals being related to a small number of founding individuals (OBPRT, 2009; Hogg, 2013; Hockley & Hogg, 2013). A proposal to limit breeding of the newly collected (2010/11) founders with each other was rejected on the basis that the new founders were being derived from a declining wild population with a reduced gene pool and increased inbreeding potential (N. Murray, pers. comm.). Additionally, OBP founders have not bred well with one another historically (Hogg, 2013). Furthermore, restricting breeding to within the new founders could result in the loss of genetic information if one of the new founders within a pairing was infertile (N. Murray, pers. comm.).

Instead, a new approach to genetic management was implemented aiming to equalise all founder contributions and growing the captive population quickly to enable maintenance of the genetic variation present within the founders (OBPRT, 2010a; N. Murray, pers. comm.). As such, the newly acquired founders were interbred with individuals already present in the captive population to rapidly incorporate the new genetic diversity into the existing captive population increasing the allelic diversity and heterozygosity (OBPRT, 2009; Hogg, 2013). New founders which successfully bred in their first year were then paired with each other to further obtain maximum genetic benefit from their addition (Hogg, 2013). However, the ability to quickly spread genes from the new founders throughout the captive population has been limited by the large size of the existing captive population and the small number of new founders (OBPRT, 2009). The approach to interbreed the new founders with the existing captive population was reinforced by a molecular genetic analysis which revealed the presence of allelic variation within the existing captive population which was not present in the new founders and vice versa (Coleman et al., 2011). Individuals can now be bred equally following a Mean Kinship strategy (breeding the least related individuals within the population with each other) due to the equalisation of the genetic representation of the original and the newly-collected founders (Hogg & Everaardt, 2017).

Before the collection of new founders in 2010, which essentially halved the wild population, the risks associated with collection and non-collection was assessed. This included the possibility that the wild population would go extinct before required founders could be collected or the wild population would go extinct quicker due to the collection of founders (OBPRT, 2009). However, only limited genetic work had been conducted at the time of collection and a comprehensive assessment of the genetics of the wild and captive populations was not conducted (C. Hogg, pers. comm.). Due to the release of captive-bred birds into the wild, there is now the potential that some wild birds are directly related to birds within the captive population (Hockley & Hogg, 2013). Further collection of founders from the wild may therefore not improve the genetic diversity within the captive population without additional molecular genetics work being carried out on the wild population (Hockley & Hogg, 2013).

13.5 Breeding success

To address the declining breeding success in captivity the CMP outlines the need to determine causes of hatching failure by:

- Continuing to distinguish between undeveloped and infertile eggs
- Examining the relationship between egg fertility and copulation behaviours
- Examining the relationship between egg development and incubation attendance of parents
- Examining the sperm quality and count in relation to egg fertility
- Investigating the possible relationship between egg development and diet
- Determining the environmental and genetic effects on egg fertility

It also states that other methods to increase the reproductive output of the captive population should be identified including by:

- Determining if keeping the sexes separate outside of the breeding season increases the likelihood of pairs breeding successfully
- Analysing historical data to determine if pre-breeding movements between breeding facilities and the timing of pairing influences reproductive performance (e.g. acclimatisation period required for translocated birds to settle into new environments and associated stimuli, photoperiod stimuli (differing latitude/longitudes), routines and diets associated with different captive-breeding facilities)
- Investigating the reproductive performance of females housed in trios (1 male, 2 females) compared to in pairs
- Analysing historical breeding records to further inform pairing recommendations
- Comparing new founders with captive-bred individuals to establish the impacts of selection in captivity on reproductive behaviours such as courtship, copulation, incubation and chick provisioning as well as on other traits such as clutch size, egg fertility and fledgling success
- Analysing the captive diet (i.e. diversity, frequency and volume of proteins, vitamins, fats and minerals) in relation to egg quality, fertility and hatching success

- Identifying causes of chick and post-fledgling mortality as well as mortality of breeding birds

13.6 Genetic management

Methods have been developed to measure the genetic diversity in both the wild and captive OBP populations in an effort to minimise the impact of inbreeding depression (OBPRT, 2006a). Development of a probe that could identify genetic markers in DNA from blood began in 1992 with the entire captive population being screened for allelic variation in 1996. Funding for genetic monitoring was gained in 2010 resulting in all captive individuals now being genotyped (Coleman et al., 2011). However, in recent years, blood samples have not yet been genotyped (DPIPWE, pers. comm.).

Genetic diversity is lost in small populations and through population bottlenecks (i.e. due to recurring disease outbreaks within a small population) exacerbating phenotypic and genetic abnormalities (Hale & Briskie, 2007; Hawley et al., 2006). Genetic analysis of samples collected between 1992 and 2011 has revealed that there has been a 25% reduction in the genetic diversity of the wild population which largely occurred between 1992 and 1995 (Coleman et al., 2011). However, the genetic diversity (Allelic richness and Heterozygosity) within the wild and captive OBP populations remain broadly similar at the time of the most recent comparison (2011, Miller et al., 2013). The level of relatedness between birds is higher in the wild population which may be due to the number of birds collected for the captive-breeding program in 2010 and 2011 (Coleman et al., 2011).

Pedigree analyses (conducted annually) are used to manage genetic diversity (assessed annually) to maximise genetic heterozygosity in the captive population through pair selection, avoidance of mating closely-related individuals (inbreeding) and to inform decisions regarding individuals for release. Genetic diversity is also managed under the assumption that all founders are unrelated which may not be true due to the small source population (Hogg & Everaardt, 2017). Furthermore, pedigree-related analyses are limited as a considerable amount of the early pedigree of the captive population is unknown. For example, prior to 1998 birds at Healesville Sanctuary were housed in small flocks with one male being assigned paternity to all chicks within the group despite the possibility of multiple males siring young (OBPRT, 2009). The percentage of certain pedigree has, however, increased over the last five years (Hogg & Everaardt, 2017).

In 2017, genetic management of the captive population had succeeded in incorporating the last remaining unrepresented founder from 2010/11 (Hogg & Everaardt, 2017). Consequently, the inbreeding coefficient and Mean Kinship (relatedness) has decreased over the last five years due to the equalisation of founder representation through breeding recommendations and release of birds which already have their genetics represented within the captive population (dependent on if they met other selection criteria) and retention of birds with novel genes (Hogg & Everaardt, 2017). However, the captive population still exhibits an over-representation of the genetic diversity from the old captive population and there is now a surplus of birds in captivity that are not recommended for breeding due to the over-representation of their genes (Hogg & Everaardt, 2017). Ongoing genetic management of the captive population continues to reduce the imbalance in the contributions of founders, but the genetic diversity will begin to slowly decline without the acquirement of new individuals (Hogg et al., 2015).

13.6.1 Selection of breeding pairs

During the non-breeding season, OBPs are typically housed together dependent upon the numbers that captive facilities hold and the size of the aviaries. During the breeding season, breeding-age birds at the Taroona Wildlife Centre and Healesville Sanctuary were traditionally maintained as mixed-sex groups consisting of between three and seven individuals as social competition was thought to be important for successful breeding (Smales et al., 2000). In 1996, birds began to be housed in breeding pairs enabling greater control over breeding contributions of individuals and subsequent management of genetic diversity (Smales et al., 2000). Fertility rates improved after implementation of this single pair breeding system (CMG, 2017). In some cases, breeding trios (a female and two males) are housed together. Although in some instances breeding facilities have not experienced significant success with this arrangement with males favouring only one of the females (Anon, pers. comm.).

Breeding pairs (as determined by the Species Coordinator prior to the commencement of the breeding season) should be placed together at least one month before the breeding season begins (i.e. September) along with a nest box (CMG, 2017). Birds not recommended for breeding, including display only birds, remain housed as flocks during the breeding season (ZAA, 2016). Breeding pairs are selected based on minimising the loss of genetic diversity from the population and reducing inbreeding (Hockley & Hogg, 2013). Criteria used to select optimal breeding pairs include:

- Low Mean Kinship values relative to the population average (with the aim to reduce the over-representation of some founders)
- Like Mean Kinship values between potential pairs (all birds available for breeding receive a breeding recommendation until the target population is reached including birds that fall below the average population Mean Kinship)
- Where possible, known breeders with a lower than average Mean Kinship are paired with unknown breeders with low Mean Kinship
- Avoiding inbreeding levels ≥ 0.125

Founders collected in 2010/11 which bred during the 2011/12 breeding season have been paired with other founders to increase their representation within the captive-breeding population (Hockley & Hogg, 2013). New founders which did not breed have since been paired with known breeders within the existing captive population (Hockley & Hogg, 2013).

13.6.2 Target captive population size

To be genetically viable, the captive population requires an estimated 418 birds (Murray, 2010; DELWP, 2016). This number is based on the formula: $\Delta H = 1-(1 - 1/2N_e)$ where $\Delta H = 0.05$ (change of heterozygosity), $t = 17$ (number of generations during the 50 years assuming a 3 year generation time). The target number of birds (N) was then calculated assuming $N_e/N = 0.4$ for a well-managed population as per Frankham et al. (2010). The estimate of 418 birds will require amendment (increased) the longer it takes to reach the target number (Murray, 2010). It is suggested that up to 500 individuals are actually required in order to maintain the target of 400 individuals within the captive population and to provide individuals for release annually into the wild (Anon, pers. comm.).

13.6.3 Microsatellite analysis

Under the Conservation Breeding Strategy 2010, a microsatellite DNA analysis of all DNA, tissue and blood samples collected since 1990 was conducted (OBPRT, 2010b). The complete mitochondrial genome sequence for the species has been identified (18,034 bp; Miller et al., 2013). No mitochondrial diversity exists in either the current or historical samples from wild OBPs (Coleman et al., 2011). This could signify that the species has a recent origin or has suffered a past bottleneck (Coleman et al., 2011). The majority of the 14 polymorphic loci exhibited low to moderate genetic variation (range: 2-8 alleles, mean: 2.79 alleles per locus), with no evidence of significant deviation from Hardy-Weinberg equilibrium (Miller et al., 2013).

The OBP genome has not been mapped thus it is difficult to know the exact areas (e.g. functional or otherwise) current analyses is looking at regarding genome wide diversity. Further mitochondrial and detailed genomic analyses is currently being conducted including work on the immune genes to determine if the very low variability in these genes is recent or has existed for a while as well as developing different measures of genetic diversity and targeted analysis of particular genes that could be contributing to reduced fitness expected to be completed by 2019 (C. Hogg, pers. comm.). Funding shortfalls however have delayed genomic work with many of the OBPRT questions remaining unanswered (C. Hogg, pers. comm.).

13.6.4 Studbook

Records of all captive-bred birds, including founders, are recorded within the ZAA's OBP studbook. Annual transfers of birds and breeding recommendations are formulated by the Species Coordinator and the ZAA species management staff based on the species management software PMx and individual-specific information (e.g. behavioural traits, health status, location) in an effort to achieve the highest genetic diversity possible through minimising the Mean Kinship (relatedness) for each pairing.

The current studbook is based on an algorithm that does not take into account individual outcomes and is the same studbook program designed for Tamarin and Tasmanian Devils (Anon, pers. comm.). This means that the program is blindly moving forward with the hope that the current studbook application is preserving genetic diversity within the captive OBP population. The program relies solely on theoretical genetic management. However, benefits of including other disciplines, such as biology, could result in a more effective management of reproductive outcomes and infertility to maximise reproductive output (Anon, pers. comm.).

A significant flaw in PMx is the continual recommendation to pair individuals which are not currently represented in the population. While this sounds ideal, it does not factor in the underlying causes for why some individuals don't breed successfully or where two individuals are incompatible and won't form pair-bonds. An individual pairing analysis may be more useful in that it would allow the review of individual genetic compatibility thereby resources and time are not wasted in an effort to pair individuals with minimal chances of producing viable offspring (Anon, pers. comm.). Alternatively, enabling some degree of natural pair selection (rather than solely based on the algorithm designed for mammalian species) will allow for social and reproductive pairing compatibility (Anon, pers. comm.). For example, Red-tailed Amazons (*Amazona brasifimpis*) which had previously been housed as breeding pairs producing infertile eggs subsequently formed pair-bonds and fertile eggs when housed in a mixed-sex aviary being allowed to select their own mates (Waugh & Romero, 2000). Pairs that were previously housed together did not re-form once free-choice of mates was offered (Waugh & Romero, 2000).

13.7 Quarantine

Internationally, quarantine is considered a key requirement for best practice in animal husbandry and management. Quarantine is a principle concern for the captive-breeding program, especially due to the prevalence of BFDV and is fundamental should a metapopulation management model be implemented (see section 17.4.1). Without the establishment of appropriate quarantine measures, the captive population is at risk of contracting pathogens. Exposure can occur through individuals entering the captive population and releases of birds into the wild, winter population management including assisted migration and ranching, and access to the natural environment where pathogens are naturally prevalent (Anon, pers. comm.). Furthermore, the risk of spreading disease increases as the number of breeding facilities participating in the OBP recovery program increases, particularly if pathogens are not screened for (Anon, pers. comm.). The VTRG have developed strict quarantine protocols which apply to any movements of OBPs including transfers between captive facilities, release of captive-bred individuals into the wild and capture of individuals from the wild for inclusion into the captive population.

One issue surrounding the implementation of stringent quarantine protocols is the time delay required to process birds which have tested positive for disease. During this time, a decision must be made regarding the treatment and outcome for the infected individual. There is still a lot to learn about viruses, bacteria and pathogens, requiring time, observation, testing and treatment before individuals can be permitted to move outside of quarantine (Anon, pers. comm.). Restricted movement and containment can therefore delay the progress of breeding or translocation programs until a course of action is agreed upon. This has previously resulted in some individuals which have been genetically valuable not being able to be released into the wild or transferred between facilities for breeding purposes due to the risk of spreading disease (Anon, pers. comm.). Furthermore, management of quarantined birds requires additional resources, time and money.

The captive breeding program has experienced some disastrous results in association with quarantine procedures during transfers between breeding facilities resulting in the spread of diseases and deaths (W. Entsch, pers. comm.). It has been suggested that in some instances movements have been influenced by zoos which are more focused on displaying the birds at the expense of quarantine procedures and against avicultural advice from experts (W. Entsch, pers. comm.).

It has been proposed that the current quarantine procedures and requirements for the program need to be revised, including the use of OBP-specific quarantine facilities and the retention of experienced aviculturists for inclusion in decision-making processes (W. Entsch, pers. comm.).

13.8 Releases of captive-bred OBPs

The release of captive-bred birds to supplement the wild population is perceived as an integral action for the recovery of the wild OBP population. Prior to release of captive-bred birds, individuals are screened for diseases and placed in quarantine under strict biosecurity controls. Once cleared, a 'soft' release method is employed entailing housing birds in a release aviary at the release site for up to a month (for a full description of the methods see Brown et al., 1995). This enables wild birds to interact with the captive birds prior to release and allows the captive birds to acclimatise to the new environmental conditions. All released birds are colour-banded.

Since 1991, 555 captive-bred birds have been released into the wild (DPIPWE, pers. comm.). Released individuals are capable of successfully migrating between Tasmania and the mainland, surviving over winter on the mainland and breeding with wild-born or other captive-released

birds to produce fledglings (DELWP, 2016). Despite this, the return rates of released captive-bred birds at breeding sites is low (42-85% survival rate since 2013) signifying that released birds are either incapable of making the southward migration back to Tasmania in spring or are not surviving in their winter range – it is unknown which occurs (DELWP, 2016; Parks and Wildlife Service, 2016). Consequently, the wild population continues to decline despite decades of captive releases, with releases appearing to have no discernible impacts to the size of the wild population. Chicks from released captive-bred birds however seem to return to Melaleuca at similar rates as chicks from wild-born parents indicating that birds may be more successful at completing migration when reared in wild nests.

13.8.1 Release protocols

Selection criteria for birds to be made available for release include the:

- Removal of post-reproductive and display only birds
- Removal of birds with breeding recommendations within the captive population
- Removal of birds older than 4 years
- Exclusion of birds based on recommendations from the holding captive-breeding facility due to testing positive for PBFD, excessive feather loss, are known feather pluckers, weigh less than 40 g or have other known health issues

Released birds are then selected from the potential pool based on demographic (i.e. sex/age) and genetic (i.e. relatedness, genetic representation within the captive population) parameters (Troy et al., 2016). Based on the Translocation Strategy (see section 13.9), birds will be selected for release into the wild based upon the following priority list:

- Are known breeders
- Preferably 2 years of age
- Preferably not F1 generation
- Have no/limited impact on existing reproductive planning including maintenance of genetic diversity for the captive insurance population
- No full-siblings of the opposite sex are released to avoid the potential problem of full-sibling mating which has occurred in captive-release programs of other species. All attempts are also made to prevent release of half-siblings of the opposite sex.

Additionally, birds considered surplus to the captive-breeding program are released in accordance with the Translocation Strategy (Hockley & Hogg, 2013). DPIPWE prepares Translocation Plans for releases, including monitoring indicators to evaluate the outcomes of each release. Candidate release groups for November releases at Melaleuca are usually finalised in July.

Prior to translocation to Melaleuca, the VTRG recommends the implementation of strict quarantine procedures including individuals being housed separately from the remaining captive population and meeting strict disease and condition criteria comprising two rounds of BFDV testing where the testing clock is re-set as necessary (Troy, 2017; VTRG, 2017b). Individual OBPs within a release cohort which test PCR positive are removed and the remaining birds are required to re-start the BFDV testing regime (VTRG, 2017b). However, there have

been issues around releases due to VTRG protocols associated with testing of birds prior to release (up to three separate testing occasions; Magrath & Penrose, 2013). Testing is time-consuming and can result in birds not being available for the release. Currently, the VTRG are evaluating the existing protocols implemented following recent disease outbreaks in captivity to determine if these can be relaxed in relation to captive releases (i.e. timing and frequency of testing and duration of quarantine required to appropriately reflect the disease risk).

Prior to release at Melaleuca, captive-bred birds are held in a holding aviary for 4-6 days to undergo a period of fitness and flight training to recover from stresses associated with translocation, become familiar with the new environment at the release site, and have the opportunity to encounter and interact with wild birds through the wire mesh (Magrath & Penrose, 2013). A feeding platform is positioned both outside and inside the aviary to encourage interactions between wild and captive birds. Releases typically occur in stages (2-3 releases), where the holding aviary is left open after the last release of birds enabling continued use of the aviary and food table within (Magrath & Penrose, 2013).

Presently, releases are generally overseen and monitored by volunteers, some of which have minimal to no training or experience in sighting OBPs (Anon, pers. comm.). The majority will also not have seen the technical management protocols associated with captive OBPs (Anon, pers. comm.). As the reintroduction process is the most stressful and high-risk period for the birds, it is advisable to incorporate experienced individuals, such as the most experienced keepers from the CMG captive-breeding facilities, into the management of releases although this would be dependent on funding (Anon, pers. comm.). To help overcome this, the CMG is currently working on trying to educate volunteers associated with releases with the best husbandry protocols for the birds which have come from differing captive-breeding facilities. This includes improving the weaning process from supplementary food such as through changing the release diet so that it is less enticing for the birds, encouraging them to forage on wild food sources (Anon, pers. comm.).

13.8.2 Melaleuca, Tasmania

See section 12.10.1 for details regarding the release of captive-bred birds at Melaleuca.

13.8.3 Birchs Inlet, Tasmania

See section 12.10.2 for details regarding the release of captive-bred birds at Birchs Inlet.

13.8.4 Point Wilson Armaments Complex (Department of Defence), Victoria

Mainland releases have been recommended by the OBPRT as an alternative method for supplementing the wild population and to determine if naturally migrating birds are attracted to sites already occupied by OBPs. This could help influence the choice of winter habitat for 'naïve' birds and consequently improve winter survival rates of both wild juveniles and released captive-bred birds.

The first mainland release occurred in 1996 due to the successful establishment of captive birds at Healesville Sanctuary in 1993/94 (Menkhorst, 1997). Six captive-bred birds were successfully released at the Point Wilson Armaments Complex in Victoria in August just prior to the expected timing of migration back to Tasmania (Starks, 1999; OBPRT, 2006a). Despite OBPs being more common at The Spit Nature Conservation Reserve, this site was selected due

to the assured security against unauthorised people (Menkhorst, 1997). The aims for this release were to:

- Determine if captive-bred birds could survive a mid-winter release at a managed mainland site, adapt to local food plants, avoid predation and find suitable roosting sites
- Determine if mainland-released birds could migrate to and from traditional breeding sites in Tasmania
- Determine whether captive-bred released birds which successfully migrate return back to their mainland release site or if they migrate with wild-bred OBPs to other wintering locations

An intensive fox control program was implemented in the surrounding release area prior to the release of the OBPs. Control continued throughout the release trial but at a lower intensity (Menkhorst, 1997). The soft-release method was also employed with birds being housed in the holding aviary for approximately a month at the start of August (Menkhorst, 1997). Access to the aviary and supplementary food were provided for an additional three weeks after release. The release occurred in August to enable the birds to have a couple of weeks to acclimatise to the wild environment and the opportunity to integrate with the wild birds before migration to Tasmania which normally occurs in late September (Smales et al., 2000).

Radio-tracking of the released birds indicated that all birds appeared to have survived for over three weeks and disappeared around the time when wild birds depart on their southwards migration. These birds were never seen again in either of the breeding or non-breeding ranges although it was suspected that they successfully migrated to Tasmania (Loyn et al., 2005). Outcomes from this first mainland-release indicated that released captive-bred birds could initially survive in saltmarsh environments, being able to adapt to local conditions and food sources (Menkhorst, 1997).

13.8.5 Western Treatment Plant, Victoria

In 2004, six captive-bred birds from Healesville Sanctuary fitted with radio-transmitters were released near Point Wilson at The Spit Nature Conservation Reserve (Loyn et al., 2005). This release aimed to evaluate the current suitability of the Big Marsh saltmarsh area as valuable habitat for OBPs in conjunction with a grazing trial (see section 10.7; OBPRT, 2006a). The Big Marsh area was a traditionally important habitat to OBPs up until the mid-1980s when light grazing of sheep stopped (Loyn et al., 2005).

Only one of the released birds used the Big Marsh habitat for less than a day signifying that the habitat had deteriorated in value to OBPs and required restoration. Released birds failed to behave as a coherent flock, foraging and roosting in different locations on the mainland (Loyn et al., 2005). The release however provided the first confirmation that released captive-bred birds can successfully migrate south to Tasmania after being released on the mainland (birds were observed at Birchs Inlet but didn't remain there to breed; Loyn et al., 2005).

In April 2017, 11 captive-bred birds were released at the WTP to increase the number of birds present within winter habitat utilised by wild individuals. For more information about this release please refer to section 10.12.

13.9 Translocation strategy

The movement of individuals between the captive and wild populations is considered to be crucial to meet the objectives of the recovery plan especially through the exchange of genetic material to reduce genetic deficiencies in both populations (DELWP, 2016). It is envisioned that the continued release of captive-bred birds will also increase the population growth rate in the wild and preserve wild behaviours including migration (DELWP, 2016).

A Translocation Strategy was developed in 2014 in response to the growing captive population and the limited space available to house individuals (the population had increased to 322 birds but the captive facilities only had space for 248 birds including 34 display only birds; Hogg et al., 2014). The Translocation Strategy formalises the release of excess captive birds to reinforce the wild population and collection of founders through decision-making processes relating to the genetic management of both populations, population trajectories, disease risk, behaviours, relative value of individuals, outcomes of previous translocations and consideration of the recovery objectives (DELWP, 2016). The main aims of the Translocation Strategy are to:

- Prevent the short-term extinction of OBPs in the wild while maintaining wild behaviours and genetic diversity
- Increase the growth rate in the wild population
- Retain as much genetic diversity as possible in the captive population
- Increase the wild population to a size that will require low levels or no augmentation and/or direct management interventions

In accordance to the Translocation Strategy, there should be enough birds available at Melaleuca at the beginning of November to comprise 10 breeding pairs (Hockley & Hogg, 2013). If there are not enough birds in the wild population to achieve this, captive birds need to be released by 20th November to make up the shortfall (Hockley & Hogg, 2013).

The Translocation Strategy is no longer in use (DELWP, pers. comm.). Translocation trials are now discussed and agreed upon at the SAPG and OBPRT levels. DELWP still leads the facilitation of these discussions and ensures that the focus is on translocations that provide the best opportunities to achieve the goals of the current recovery plan (DELWP, pers. comm.).

13.10 Planting for Parrots

A Take Action Program was initiated by Learning Experiences at Healesville Sanctuary designed to educate school children about some of Australia's most critically endangered species and empowering them to take action (Henry & Penrose, 2010). The Planting for Parrots Take Action Program enabled schools to participate in OBP conservation by providing children with propagation kits or miniature greenhouses to grow selected OBP food plants (Henry & Penrose, 2010). Once plants had outgrown their original containers the children visit Healesville Sanctuary to transfer their food plants to a garden there and to see the captive OBPs. The differing food plants are rotated through the OBP aviaries in the hope of developing food recognition skills in juvenile birds prior to release (Henry & Penrose, 2010). Released birds are thought to have a higher chance of survival if they can recognise the correct plant species to eat.

14. Veterinary Technical Reference Group

The VTRG was formed in 2015 following an OBP emergency intervention meeting held by the Threatened Species Commissioner where Wildlife Health Australia (WHA) proposed the development, implementation and administration of a VTRG to provide veterinary information, advice on health-related management actions and support to the OBPRT and the SAPG on a needs basis (VTRG, 2015; 2017a). This has included:

- Evaluation of issues involving OBP health, disease and biosecurity in relation to the current recovery plan
- Provision of advice on the increase or risk of increase in mortality and morbidity as well as decreases in fecundity
- Helping to oversee investigations into the causes and potential mitigation measures of disease outbreaks and significant changes to mortality, morbidity and fecundity as well as perform risk analyses for emerging health issues
- Development and revision of policies and guidelines regarding the health of OBPs as directed by the SAPG
- Informing the SAPG of any new (and significant) or emerging disease, health or biosecurity issues and provide advice on their priority and the best course of management
- Acting as a link and facilitator to improve collaboration, coordination and communication between the SAPG, OBPRT and veterinary advisors
- Providing a forum for discussions surrounding disease, health and biosecurity issues relating to OBPs

Prior to the establishment of the VTRG, the large number of avian veterinarians and ecologists associated with the OBPRT were being asked different questions at different times (due to availability) with answers differing depending on the individual's background and the amount of background information they were provided (Anon, pers. comm.). Recommendations were consequently developed based on limited knowledge of the situation which prevented appropriate questions being asked (Anon, pers. comm.). For example, when asked about nest boxes and disinfectant protocols, it was recommended to replace nest boxes annually. However, the recommendation was made without knowledge on how many nest boxes were present in the wild and their often difficult accessibility. This recommendation was therefore impracticable (Anon, pers. comm.).

The VTRG is governed by a Terms of Reference which is endorsed by the SAPG. The group has 14 members comprised of veterinary managers from all participating captive-breeding facilities, disease experts directly involved in the management of disease, health and biosecurity of OBPs and relevant experts (i.e. virologists, veterinary pathologists, avian ecologists) with practical experience in the management of wildlife health and aviculture (VTRG, 2015). The group has no maximum limit on member size but it is recommended to keep membership to a minimum to ensure the group remains able to effectively and efficiently function and meet all objectives in full (VTRG, 2015). Membership is granted for three years with new members requiring endorsement from the SAPG (VTRG, 2015). The VTRG meets at least annually and holds teleconferences when necessary. When a member is unable to attend a meeting, their pre-determined alternative is requested to attend on their behalf (VTRG, 2015).

The VTRG reports to the SAPG and provides information regarding best veterinary practice and biosecurity measures for the CMG. As issues surrounding health and welfare arise within the

wild and captive populations, the SAPG or CMG formally writes to the Chair of the VTRG seeking advice. Queries from government agencies and organisations within the OBPRT are made via their VTRG representative. When consensus is not reached within the VTRG, a range of opinions is provided to the SAPG to inform their decision-making (VTRG, 2015). The VTRG do not have the ability to make decisions and there is no guarantee that advice and recommendations made by the VTRG are acted upon by the SAPG (VTRG, 2015). Development and implementation of recommendations is a complex process with members continually reminded that they are part of a bigger picture and recommendations need to align with all of the over-arching recovery actions (Anon, pers. comm.). Compromise is often needed to ensure recommendations are practical and are continually reviewed and modified where necessary (Anon, pers. comm.).

Annual reports and minutes are only made available to the VTRG and the SAPG with annual summaries regarding progress against actions being reported to the OBPRT (VTRG, 2015). The decision to provide documents only to the SAPG was made in relation to the often short timeframes the VTRG has to act within. The distribution of documents to the wider OBPRT would result in delays in the establishment and subsequent implementation of management actions due to the time-consuming questioning of the ins and outs of how tests work (Anon, pers. comm.). The VTRG acknowledges that this is not considered the best approach for inclusion but deems it the best approach to achieve the desired outcomes within the given timeframes and are confident in the proposed protocols and procedures presented to the SAPG for approval which are developed by a range of experts (Anon, pers. comm.). The SAPG will be reviewing the composition, the Chair and the Terms of Reference of the VTRG in August 2018 (VTRG, 2015).

14.1 Outputs

The VTRG (VTRG, 2016; 2017a) has developed several protocols and recommendations for the OBPRT to assist in the management of OBP health including:

- Recommendations for use of disinfectants in wild settings (e.g. Melaleuca; 2016)
- Recommendations for the management of wild OBP nestlings following observation of clinical signs of PBFD (2016)
- Guidelines for OBP release following BFDV testing: 2016 release†
- Guidelines for health assessment and BFDV testing of captive, juvenile OBP prior to release to the wild (2017)†
- Guidelines for OBP release following BFDV testing: 2017 mainland release†
- Recommendations for BFDV testing and management of birds being transferred between captive institutions for breeding purposes 2016†
- Recommendations regarding management of wild OBP nestlings following observation of clinical signs suggestive of Psittacine Beak and Feather Disease (PBFD; 2016)
- Recommendations for testing of Beak and Feather Disease Virus (BFDV) and standardisation of transfer protocols of individuals between captive institutions for breeding (2016)

†Document is reviewed annually by the VTRG.

14.2 In-kind contributions

A large number of the VTRG members volunteer their time and expertise including from members who aren't otherwise involved in the OBPRT (Grillo & Eden, 2017; VTRG, 2017a). This includes staff time, meetings/teleconferences (both VTRG and SAPG), documentation, development of protocols and ad hoc investigations/field work (Grillo & Eden, 2017). Costs associated with meetings and teleconferences are the responsibility of the current Chair and their respective organisation (VTRG, 2015). The average total in-kind contribution for all members is approximately $45,000 per year (Grillo & Eden, 2017). The group recommends that the Chair and Project Officer time be funded through the OBP recovery program and cost recovery of cash contributions (Grillo & Eden, 2017).

15. Funding

During the first OBP recovery plan, the Australian Nature Conservation Agency funded $84,140 per year (1984-1990) to support the recovery actions identified in the OBP recovery plan (Stephenson, 1991). In 1991, funding from the Natural Heritage Trust dropped from $200,000 to $80,000. In 2010, the Commonwealth Government provided $260,000 to implement the emergency recovery actions detailed in the 2010 Emergency Action Plan covering 18 months.

Since the appointment of the Threatened Species Commissioner in 2014, the Australian Government has invested in both targeted projects (precise amounts attached to them) and more tangential projects such as landscape scale projects funded through the National Landcare Program which include improving OBP habitat (difficult to determine a dollar figure on these projects as the work benefiting OBPs is interwoven with a suite of other activities). Specific funding has included:

- Threatened Species Strategy: $525,000 for multi-year emergency intervention biosecurity measures in partnership with the Tasmanian Government
- Threatened Species Recovery Fund Open Round: **$250,000** given to Charles Sturt University to develop a vaccination for controlling PBFD
- National Environmental Science Program: **$180,000** to tackle threats to endangered hollow-nesting birds in Tasmania
- National Environmental Science Program: **$103,585** to learn from successes and failures in threatened species conservation
- Threatened Species Recovery Fund Project: **$160,000** for feral cat management on French Island and the development of a feral cat eradication plan
- Nine Green Army projects and one 20 Million Trees project supporting OBP habitat improvement work
- National Landcare Program: nine projects including habitat restoration works benefiting OBPs
- Threatened Species Commissioner's Office: **$50,000** to conduct a stocktake led by BirdLife Australia in consultation with an array of OBP stakeholders (current project)

Over the last five years, the Victorian and Tasmanian Governments have contributed specific funding to the OBP recovery efforts, as well as delivering Commonwealth funded projects (Tables 7, 8).

From the beginning of the recovery program, direct costs have been minimised due to the enthusiastic support of the numerous volunteers (Stephenson, 1991). Members of the OBPRT and sub-groups, as well as hundreds of volunteers through non-government organisations, contribute a significant amount of in-kind support within all components of the recovery program (volunteers alone contribute approximately $1.25 million dollars worth annually; Holdsworth, 2015).

[Caveat: this was all of the auditable financial information provided for this stocktake].

Table 7: State and Commonwealth funding invested into the Victorian OBP recovery program from 2012/13 to 2019/20 including funds allocated and spent in previous years and funds committed and applied for in current and future years.

Year	Victorian funding	Commonwealth funding: delivery managed by DELWP
2012/13		Commonwealth Caring for our Country Program via Corangamite and Glenelg Hopkins Catchment Management Authorities: **$60,000** Population, habitat and threat monitoring, and some threat management. Delivered in partnership with BirdLife Australia.
2013/14	Victorian Environment Protection Program funding: **$52,000** Manage environmental weeds in key winter habitat areas. Erect fencing to allow appropriate grazing management.	Commonwealth National Research Investment Plan funds: **$40,000** ARI developed a habitat monitoring method, DELWP assisted training ofstaff in the method from land management agencies in Victoria and South Australia. Commonwealth National Landcare Program via Corangamite Catchment Management Authority: **$30,000** Population, habitat and threat monitoring, and some threat management, on the Bellarine Peninsula. Delivered in partnership with BirdLife Australia.
2014/15	Victorian Environment Protection Program funding: **$10,000** Manage environmental weeds in key winter habitat areas. Erect fencing to allow appropriate grazing management.	Commonwealth National Landcare Program via Corangamite Catchment Management Authority: **$30,000** Population, habitat and threat monitoring, and some threat management, on the Bellarine Peninsula. Delivered in partnership with BirdLife Australia.

2015/16	Threatened Species Protection Initiative (TSPI) Critical Actions funding: **$40,000 -** Habitat mapping and modelling project, undertaken by ARI looking at changes in habitat use and extent over time **$49,950 -** Increased population monitoring and review of survey methods, undertaken by Birdlife Australia and Nature Glenelg Trust. TSPI Community Volunteers funding: **$40,000** Habitat protection and weed management of winter sites.	Commonwealth National Landcare Program via Corangamite Catchment Management Authority: **$20,000** Population, habitat and threat monitoring, and some threat management, on the Bellarine Peninsula. Delivered in partnership with BirdLife Australia.
2016/17	Biodiversity On-ground Actions Icon Species funding: **$50,000** OBP Mainland Release Trial to test whether flocks of OBPs can be established in suitable Victorian habitats, and whether flocks attract, and provide benefits to, naturally migrating OBPs.	Commonwealth National Landcare Program via Corangamite Catchment Management Authority: **$20,000** Population, habitat and threat monitoring, and some threat management, on the Bellarine Peninsula. Delivered in partnership with BirdLife Australia.
2017/18	Biodiversity On-ground Actions Icon Species funding: **$50,000:** OBP Mainland Release Trial to test whether flocks of OBPs can be established in suitable Victorian winter habitats, and whether flocks attract, and provide benefits to, naturally migrating OBPs.	Commonwealth National Landcare Program via Corangamite Catchment Management Authority: **$20,000** Population, habitat and threat monitoring, and some threat management, on the Bellarine Peninsula. Delivered in partnership with BirdLife Australia.
2018/19	Biodiversity On-ground Actions Icon Species funding: **$50,000** To support the OBP Mainland Release Trial or for redirection to other OBP priorities identified by the SAPG and DELWP if this trial does not meet criteria for continuation for the planned 4 years.	
2019/20	Biodiversity On-ground Actions Icon Species funding: **$50,000** To support the OBP Mainland Release Trial or for redirection to other OBP priorities identified by the SAPG and DELWP if this trial does not meet criteria for continuation for the planned 4 years.	
Total	**$451,950**	**$220,000**

SUPERSEDED

Table 8: State and Commonwealth funding invested into the Tasmanian OBP recovery program from 2013/14 to 2017/18 including funds allocated and spent in previous years and funds budgeted for in future years.

Year	Tasmanian funding	Commonwealth funding: delivery managed by DPIPWE
2013/14	OBP Salaries: **$199,654** Management and monitoring of the wild population: **$21,293** OBP captive management: **$19,117** Management of the Taroona Wildlife Centre: **$22,711** Total: **$262,776** (budgeted: $293,922)	
2014/15	OBP Salaries: **$223,481** Management and monitoring of the wild population: **$21,458** OBP captive management: **$18,251** Management of the Taroona Wildlife Centre: **$20,012** Total: **$283,202** (budgeted: $355,719)	Australian Government National Landcare Program: Save the Orange-bellied Parrot Program: Implementation of Critical Recovery Actions in Tasmanian (July 2014 – June 2017): **$525,000** To support the monitoring and management of the population at the breeding site as well as translocations of captive-bred birds to enhance breeding success.
2015/16	OBP Salaries: **$333,240** Management and monitoring of the wild population: **$26,162** OBP captive management: **$35,994** Management of the Taroona Wildlife Centre: **$51,735** Total: **$447,132** (budgeted: $340,910)	Australian Government National Landcare Program: Save the Orange-bellied Parrot Program: Implementation of Critical Recovery Actions in Tasmanian (July 2014 – June 2017: **$525,000** To support the monitoring and management of the population at the breeding site as well as translocations of captive-bred birds to enhance breeding success.

2016/17	OBP Salaries: **$292,403** Management and monitoring of the wild population: **$9,602** OBP captive management: **$43,927** Management of the Taroona Wildlife Centre: **$46,909** Total: **$392,841** (budgeted: $336,355) Construction of a new breeding facility: **$2,500,000**	Australian Government National Landcare Program: Save the Orange-bellied Parrot Program: Implementation of Critical Recovery Actions in Tasmanian (July 2014 – June 2017: **$525,000** To support the monitoring and management of the population at the breeding site as well as translocations of captive-bred birds to enhance breeding success. Includes extension of the funding for 12 months to pay for an ecological burn and associated vegetation monitoring including pre- and post-fire vegetation surveys. CF5140 – OBP Parrot*: **$358,344**
2017/18	Budgeted: $829,598 (actual: $0)	

*No further details provided about this project.

16. Barriers to implementing the current Recovery Plan

The overall success of the recovery program (and for threatened species Recovery Plans in general) is dependent upon several factors (DELWP, 2016) including:

- A strong adaptive management framework for program delivery, with the ability for timely and adaptive decision-making based on data analyses
- Sufficient and continued funding enabling completion of priority recovery actions
- A community which values conservation of threatened species
- A culture of inclusiveness, accountability and transparency for all partners of the recovery program
- Dynamic and accessible datasets
- A network of partners and stakeholders which incorporates appropriate delivery partners, experts and affected interests
- Effective methods for communicating with partners and stakeholders

These factors have not always applied to the OBP recovery program which has experienced numerous barriers throughout its existence preventing successful delivery of the recovery plans.

16.1 Funding and resources

A major limiting factor in implementing the OBP Recovery Plan is inconsistent and inadequate funding (no recovery plan has been fully funded) and resources particularly as funding bodies become reluctant to fund projects which are similar (or the same) as previously funded projects (Pritchard, 2014; Holdsworth, 2015; J. Starks, pers. comm.). Commonwealth funding through the Endangered Species Program commenced in 1982 with matching contributions from the three relevant State governments (Saunders, 2002). This funding scheme, albeit to varying levels, has continued up until present (Holdsworth, 2015). Commonwealth funding for the OBP recovery program has often been relatively high compared to most other listed threatened species in Australia. However, over time it has become increasingly challenging for the three State governments to continue providing the level of funding required to support all identified recovery efforts. Additionally, the Commonwealth has become reluctant to commit long-term financial support due to the current species trajectory and are faced with the political decision of whether to direct funds to another species with a higher probability of recovery success, or to continue funding OBPs with no clear outcomes or improvements occurring from currently implemented management actions (Anon, pers. comm.).

As a result of the lack of funding and resource availability, many recovery actions of each recovery plan have either been left incomplete or not attempted with management becoming ad hoc and implemented activities having poor outcomes (Pritchard, 2014). Effective and efficient implementation of the recovery plan requires confirmation of sufficient, multi-year funding. This would allow appropriate staff and resources to be committed to implementing the priority recovery actions (Parks and Wildlife Service, 2016). Upon establishment of successful management processes and protocols the need for resources would decrease over time.

The sub-groups of the OBPRT are also either under-funded or receive no funding for members to carry out research required to meet the recovery actions outlined in the recovery plan and to support science-based decision-making. For example, the VTRG do not have adequate funding to undertake disease testing to understand what pathogens are a risk and how to best manage them or to perform a Disease Risk Assessment (VTRG, pers. comm.).

One option that has been previously suggested to overcome funding shortages is privatising recovery efforts through corporate sponsors where contracts are provided for specific recovery actions (Holdsworth, 2000; Anon, pers. comm.). Furthermore, crowd funding for threatened species actions with discrete outcomes, including for OBPs, has been relatively successful in recent years.

16.2 Population size and management

A significant obstacle hindering successful recovery of the species is the extremely small number of wild birds, particularly females, and their vulnerability to stochastic events especially during the breeding season when the entire population is located in one location (Anon, pers. comm.). The small population size is also likely to be causing inbreeding depression which may be responsible for the series of health issues experienced over the last five years in both the wild and captive populations as well as the skewed sex ratio (DELWP, pers. comm.). Further

research, thus resourcing, is required to identify possible outbreeding solutions (DELWP, pers. comm.).

The continual competition for maintaining numbers and genetic diversity separately in both the wild and captive populations is also a potential barrier preventing large releases and potential population increases in the wild. This is a necessary consequence of best practice management of captive-release programs involving critically endangered species (Anon, pers. comm.).

The small population size also makes it difficult to determine if results from implemented management actions are statistically significant in order to verify if actions are having a positive impact to the population or not (VTRG, pers. comm.).

16.3 Genetic diversity

It has been noted that many captive-breeding programs fail to collect the required number of founders to retain genetic diversity (Frankham et al., 2010). Success is then dependent upon how rapidly the captive population can reach the target population size and how well founders are managed (Frankham et al., 2010). The inability to accumulate sufficient genetic diversity within a captive population through collection of an adequate number of founders risks the possibility of losing adaptively important genetic variation, increasing the occurrence of inbreeding and failing to meet identified long-term conservation goals (OBPRT, 2009).

The captive population of OBPs is based on a relatively low number of founders. Genetic diversity within the captive population will now experience a slow decline as the small number of individuals remaining in the wild means there are no new blood lines available to be introduced into the captive-breeding population. Consequently, the captive-breeding program is in a dead-end "holding pattern" model. The poor reproductive performance evident in the captive-breeding population and the failure of released captive-bred birds to re-establish a breeding population at Birchs Inlet after numerous releases over 10 years may also be attributed to low genetic diversity (Baker & Holdsworth, unpubl. data). The low fecundity in the captive population needs to be resolved as quickly as possible. Lack of genetic diversity is also evident in regions of the genome that are known to be related to immunity which may have implications in disease prevalence.

16.4 Space availability

Space is now a critical limiting factor in the captive-breeding program as demands continue to grow to provide enough birds for annual releases while maintaining a viable insurance population (ZAA, 2017). The captive-breeding program is now at full capacity with 350 available spaces (a space is defined as the physical space required to house the bird as well as food, medical and veterinarian resources required to maintain a healthy individual; Hogg & Everaardt, 2017). Breeding space is further limited by holding birds that are of low priority for breeding or are non-breeders as identified via ZAA software (Hogg et al., 2012). Management issues, including quarantine of diseased birds, puts further pressure on existing spaces (ZAA, 2017). Other management constraints, particularly due to issues surrounding disease and quarantine further put strains on the limited space available to the captive-breeding program (ZAA, 2017). Insufficient breeding spaces over recent years has prevented the captive population from meeting all identified potential releases to supplement the wild population (DPIPWE, pers. comm.).

Currently, there is no capacity for the captive population to expand further to reach the long-term target of 400 individuals and retain at least 90% of the genetic diversity over the next 30-40 years (Murray, 2010; ZAA, 2017; Anon, pers. comm.). If space restrictions continue, the long-term contribution of new founders and the ability to equalise the representations of all founders within the captive population will be adversely impacted (Hogg, 2013). Expanding the capacity of the captive-breeding program would ensure the genetic gains made under the Insurance Population policy initiated in 2010 would be consolidated (N. Murray, pers. comm.).

An exhaustive search has been conducted within ZAA member facilities over recent years in an effort to acquire further spaces for captive OBPs (Hogg et al., 2015). This has largely been unsuccessful possibly due to the large financial costs that facilities would need to incur. Possible options in response to space limitations if new facilities cannot be secured include reducing breeding, providing excess or over-represented individuals to private aviculturists to help maintain genetic integrity within the captive population, allow private aviculturists to participate in the breeding program or conducting targeted releases ensuring released birds are of suitable genetic quality while maintaining the genetic integrity of the captive population (Hockley & Hogg, 2013). It is not recommended to limit breeding within the current captive population due to the increased probability that rare alleles present in the 2010/11 founders will not be captured within the population (Hockley & Hogg, 2013; Hogg, 2013).

16.5 Captive releases

Some proposed or planned releases have failed to go ahead due to operational constraints, resource limitations and/or inadequate numbers of fledglings available (e.g. due to deaths within captivity such as through disease outbreaks or poor breeding seasons; Hogg & Everaardt, 2017). Decisions to proceed or cancel planned releases requires evaluating the priority of the differing recovery actions (i.e. to supplement the wild population while decreasing the number of birds within the captive insurance population or to maintain the target number within the captive population).

Currently, the VTRG are evaluating the existing quarantine and testing protocols (implemented following recent disease outbreaks) to determine if these can be relaxed in relation to captive releases (e.g. timing and frequency of testing and length of quarantine). The current protocols are extremely time restrictive and have resulted in planned releases at various times of the year not going ahead.

The small wild population may further impede the success of captive releases. The reduced number of wild birds reduces the number of opportunities available for social interactions with captive-released birds for the purpose of transferring knowledge relating to migration routes and location of suitable habitat patches on the mainland (White et al., 2016). The small number of adults left in the wild may also be limiting the transfer of this knowledge between wild-born generations (White et al., 2016).

16.6 Chick survival

High chick mortality rates within captivity limits recruitment into the population impacting both the status of the insurance population and the ability to supplement the wild population via releases (releases are cancelled if there are not enough birds available). Adelaide Zoo experience difficulties in getting more than three chicks within a clutch to survive, where there is often no obvious reason for why chicks don't survive (Anon, pers. comm.). The small genetic diversity of the population may be impacting survival rates (Anon, pers. comm.).

16.7 Supplementary food

Access to, and use of, appropriate nutritious wild food sources may be an issue in the breeding grounds at Melaleuca (Anon, pers. comm.). There appears to be only a small area of accessible foraging habitat surrounding Melaleuca which has been burnt relatively recently containing preferred OBP food plants. This could be increasing the dependency of wild birds on the supplementary food provided at the feed tables (Anon, pers. comm.). The supplemented diet has been referred to as a "dessert banquet" and could be having damaging impacts on foraging behaviours and survival where birds experience excess food until migration then possibly very limited food supply until the return trip to Melaleuca (Anon, pers. comm.). The type of supplementary food provided at the breeding grounds may also be training OBPs to forage on the wrong types of plants during winter (Anon, pers. comm.). Supplementary food may also be having numerous adverse consequences to the health of adults and chicks (Anon, pers. comm.).

16.8 Captivity climate

Another barrier experienced by some of the captive-breeding facilities is the differing climates compared to the conditions experienced in the wild, particularly heat during the breeding season (Anon, pers. comm.). This can have negative impacts on breeding success. For example, after experiencing poor breeding success at the Adelaide Zoo the number of chicks surviving in each clutch increased after installing an air-conditioning unit at the OBP breeding facility (Anon, pers. comm.). They also installed a lighting system in 2017 to mimic daylight savings in the hope that they would breed earlier and avoid having newly hatched chicks during the hottest parts of December (Anon, pers. comm.). Due to this, they are already experiencing successful results this breeding season.

16.9 Threats

The threats identified in the current OBP Recovery Plan (section 2.6, DELWP, 2016; also see section 5 of this report) are significant barriers preventing the recovery of the species. The OBPRT continually try to alleviate these threats throughout the OBP's range through research and management actions.

16.10 Technology

Greater progress towards achieving objectives of the current recovery plan requires improving the understanding of key aspects of OBP ecology, habitat use and threats to their survival particularly on the mainland where their movements are largely unknown. Current tracking technology, such as radio- or GPS-transmitters, are either too large (greater than the recommended weight limit of less than 5% of an animal's body weight), battery life is too short, or detection range is too small thus further limits the opportunity to collect data and monitor OBPs during migration and on the mainland (Adams & Purnell, 2016). While supplementary detection methods exist providing the possibility to enhance winter detection rates and cover more survey sites (e.g. acoustic monitoring, short-term tagging) these methods are still limited in their usefulness (Adams & Purnell, 2016). As such, no current alternative survey method is considered superior for detecting OBPs in the wild and any implemented alternative survey method should be used in conjunction with traditional human-based observational surveys (Adams & Purnell, 2016).

16.11 Recovery team

Migratory species rely on a team approach from all organisations and individuals involved in the recovery program. Delays in decision-making and implementation of management actions is a primary factor leading to species extinctions which occur when responsive and accountable institutional processes are not in place (Clark et al., 1994; Martin et al., 2012). To be effective, the OBPRT must make timely and adaptive management decisions while there is still time to act and have responsive governance and leadership while ensuring institutional accountability (Martin et al., 2012).

The recovery effort for OBPs provides an opportunity to demonstrate how multi-jurisdictional groups can effectively cooperate in a recovery effort (DELWP, pers. comm.). The OBPRT provides a forum for this cooperation and at times has been a leading example of responsiveness and cooperation. However, the effectiveness and cohesiveness of the OBPRT has varied over time as commitments to the team from some partners has varied (DELWP, pers. comm.). The present commitment of involved partners makes the OBPRT a leading example of an effective recovery team once again (DELWP, pers. comm.).

In accordance with the draft recovery team structure document produced by the Commonwealth of Australia, the members of the OBPRT need to ensure that they are working towards a shared goal with a clear understanding of the purpose and direction of the team (Commonwealth of Australia, 2017). The team should exhibit effective leadership and establish a culture of inclusiveness, support, and confidentiality between members. All relevant information should be shared promptly between members and sub-groups with clear, frequent, open and frank communication occurring resulting in effective evidence-based decision-making (Commonwealth of Australia, 2017). However, communication has at times experienced fragmentation between the different sub-groups and broader recovery team (Anon, pers. comm.).

Recovery teams typically draw members primarily from species-specific backgrounds and rarely include members with expertise and skills in other relevant aspects of ecosystem management (e.g. hydrology, fire, climate, behaviour, soil processes, governance, social systems). The narrowness of this expertise affects the success of recovery teams and recovery programs as it affects the ability of a team to detect changes and make informed management decisions in a timely manner (S. Nally, pers. comm.). Furthermore, there is often a human reluctance to intervene in species management due to risks associated with management actions. Consequently, management actions are often delayed as a result of risk aversion. This can be compounded by low representation of decision-making expertise on a recovery team (S. Nally, pers. comm.). As recommended by the Commonwealth, the OBPRT should be comprised of members with varying types of expertise and backgrounds with members having clearly defined roles, yet be small enough to enable equal participation (Commonwealth of Australia, 2017).

The length of membership in the OBPRT may represent a limitation to the recovery effort. It has been suggested that there should be a mandatory membership turnover (e.g. five years sitting on the recovery team) with all members needing to make a specific contribution to the recovery team. This could help encourage new ideas and management actions and prevent the recovery team from becoming stagnant (Anon, pers. comm.). This could also facilitate the ability of members to better critique previous actions and challenge the status quo or proposals without the occurrence of monopolisation (Anon, pers. comm.).

Recovery teams work best when an effective governance system has been established. This includes appointing a dedicated person to coordinate and facilitate communication including the preparation and circulation of key documents (S. Nally, pers. comm.). Furthermore, without a coordinator, recovery teams can struggle to spread information to all members in a way that suits differences in familiarity with technical issues, potentially reducing team cohesion (S.

Nally, pers. comm.). Prior to 2014, there was little attention given to the governance of the recovery program with no clear indications of which organisation was responsible for each recovery action (which were sometimes unclear) resulting in limited accountability and lack of coordination (Pritchard, 2014).

16.12 Politics

One of the most significant barriers to OBP recovery is politics which is compounded by the migratory behaviour of OBPs resulting in the species covering multiple States and jurisdictions (Wildlife and Parks Service, 2016). Consequently, coordination and cooperation between key organisations across the species range is paramount. However, there has previously been challenges in terms of integrated management, governance and delivery of the recovery efforts. For example, management actions such as patch burns and grazing trials continue to be logistically impossible to arrange and implement due to competing interests. One suggestion in the event of conflicting management actions for a site has been to prioritise the management actions of the highest listed species (Anon, pers. comm.). Furthermore, proposed developments or land-use changes after often given precedence over the protection of habitat for threatened species, particularly if there are economic benefits. Subsequently, the OBPRT does not have the ability to control some of the identified key threatening processes to OBPs.

The OBPRT has also been limited in their ability to react to new information due to a lack of resources and government support (J. Starks, pers. comm.).

16.13 Communication and transparency

Communication and transparency in decision-making within the OBPRT, sub-groups and with the public is a complex and challenging issue, with it becoming difficult to maintain effective communication between a large number of people and stakeholders. Consequently, communication and data sharing has at times been lacking resulting in multiple conversations occurring, mis-communication, loss of corporate knowledge, information not being relayed to all members (especially to non-specialists in the area being discussed) and confusion over priorities and management actions requiring implementation. This has then resulted in a lack of cohesiveness. For example, when the guidelines relating to releases of captive birds were circulated, no-one knew the appropriate contact at Moonlit Sanctuary thus the facility did not receive the guidelines. Consequently, birds were not housed correctly and missed out on being available for release (Anon, pers. comm.). The use of technical jargon within the OBPRT further limits effective communication as makes it difficult for all members to understand particular situations. Additionally, the majority of the information regarding the recovery program is often treated as assumed knowledge. Consequently, new people entering the OBPRT or recovery effort don't necessarily know this information including background information on what has happened and what is considered opinion and what is fact with opinion sometimes ruling over fact (Anon, pers. comm.).

Appropriate context has not always been provided to experts who are being requested for input on specific actions (e.g. in terms of logistics, practical aspects; Anon, pers. comm.). Lack of understanding of the issue including constraints has led to ineffective suggestions and protocols being implemented in the past. Moreover, ad hoc input from different experts dependent upon their availability is not useful as has been sought in the past. The VTRG has demonstrated that a consensus can be achieved as a group rather than individually which has resulted in consistent approaches to management of health and disease (Anon, pers. comm.). Application of

consistent harmonisation guidelines and protocols in all sectors of the recovery program will make it easier to know what is working and what isn't (Anon, pers. comm.).

A significant limitation to the recovery program has been relatively poor documentation and sharing of information between members and sub-groups of the OBPRT regarding the results of interventions and research. A recent example includes the reporting for nest monitoring and nestling transfer at Melaleuca during the 2016/17 breeding season which didn't discuss the differences in nest success between captive-born and wild-born breeding females. Even though it is difficult to prove statistical significance of these interventions due to the small population size, it would still be useful to report this information highlighting this limitation in the interpretation (P. Eden, pers. comm.). The recovery program is also associated with a lot of grey literature with minimal information being published in either peer-reviewed scientific journals or within the public domain. Furthermore, all OBPRT discussions, agendas and minutes from meetings and teleconferences including those of sub-groups are considered confidential and are not made available to the public. Requests for information by other OBPRT team members must be made to the corresponding author or speaker. This hinders evaluation of the recovery program and the potential for external aide.

16.14 Timeframes

Science-based decision-making is extremely important in any recovery program. However, a significant challenge in threatened species management is that science-based decisions require time and resources to investigate and collate the knowledge required to support these decisions. In situations where the species is going extinct over a short timeframe, such as the OBP, temporal limits exist which are further compounded by the migratory ecology of the OBP and the often scarce and brief nature of observations each year, putting extra pressure on the need to quickly develop, approve and implement management interventions. Significant investment is required to gather and analyse all available data to adequately support the underlying research (P. Eden, pers. comm.) and significant staffing requirements to implement resulting management actions.

The short timeframes often experienced by the OBPRT and sub-groups between the need to develop protocols and/or make decisions and implementation of management actions is extremely challenging and constraining. Implementation of any new management strategy requires adequate time to ensure all risk factors are appropriately considered by all sub-groups. However, due to short timeframes it is not always possible to complete a comprehensive risk mitigation during the first year of implementation with protocols remaining in draft form at the same time the action is being executed (Anon, pers. comm.). The sub-groups therefore have to exhibit flexibility in their recommendations while acting appropriately and quickly. Short timeframes also make it difficult to understand what management actions are working and what aren't.

16.15 Volunteer support

A significant challenge associated with the winter monitoring program is recruiting sufficient volunteers to survey all potential sites across their large mainland distribution (Nature Glenelg Trust, pers. comm.). Retaining active volunteers and maintaining morale is also challenging, especially when the probability of observing an OBP during a count weekend is extremely low (even when OBPs have been confirmed at a site). Previously, the broadening of search efforts to alternative habitat (late 1990s) helped maintain volunteer interest in the project by

contributing to new research goals (J. Starks, pers. comm.). The role of volunteers and their contribution has remained the same since.

Volunteer burnout has occurred in areas, particularly in SW Vic, where participation has drastically decreased compared to five years ago when OBPs were still being observed in the area and there was a big surge in the conservation awareness for the species (Nature Glenelg Trust, pers. comm.). Recent volunteer workshops have been well attended but do not result in significant volunteer recruitment (Nature Glenelg Trust, pers. comm.). It is assumed that people have lost interest in the monitoring program due to the lack of reward for effort (low enthusiasm) and grown tired of the survey activity (Nature Glenelg Trust, pers. comm.). Securing volunteer participation in some regions requires targeted and relentless efforts to engage volunteers (e.g. personally contacting individuals or groups prior to each count weekend specifically asking them to be involved; Nature Glenelg Trust pers. comm.). Volunteers have also mentioned that they have been put off volunteering due to the amount of processes and paperwork currently in place (e.g. volunteer registration form, OH&S paperwork, phoning in; Nature Glenelg Trust, pers. comm.). In areas of low volunteer support, survey effort relies more heavily on paid staff, yet some of these positions are going unfunded further limiting survey effort (DELWP, pers. comm.).

16.16 Knowledge gaps

There is still a lack of understanding surrounding key factors responsible for the population declines experienced in the wild (Parks and Wildlife Service, 2016). For example, research and implemented management actions have not addressed the fundamental issue of survivability (J. Starks, pers. comm.). Releases have been occurring for years with no signs of increasing the wild population signifying a lack of understanding of what is causing mortality, raising the question of why keep releasing birds if mortality is so high (J. Starks, pers. comm.). It is also unknown why females appear to have a higher mortality rate than males.

It is inherently difficult to address the current knowledge gaps and determine the reasons for mortality due to the wide distributional range of the species (J. Starks, pers. comm.). Furthermore, the rapid decline in numbers has limited the ability of researchers to completely understand the ecology of the species and associated threats and the capacity to address these (Pritchard, 2014). Further research is required to completely understand the impacts of different threat types, how to address these and development of appropriate recovery actions.

16.17 Data management

A significant problem inherent in recovery programs is the absence of data analysis, with members of recovery teams often lacking skills in the areas required to perform necessary analyses. Prior to 2013, delays in data analysis and interpretation prevented the occurrence of adaptive management (Pritchard, 2014). Additionally, lack of documentation of recovery action protocols and storage of monitoring data contributed to resources not being utilised efficiently (Parks and Wildlife Service, 2016). Data has not always been shared between members and groups of the recovery team which has led to analysis of incomplete datasets. In 2010, data sharing was facilitated when numbers were revealed as being critically low in the wild. This enabled complete analyses to be performed providing a comprehensive picture of what was occurring in the population, highlighting the problem at the time. Real-time entry of monitoring data and subsequent analysis of the data is now implemented enabling well informed and timely management decisions to be made (Parks and Wildlife Service, 2016).

17. Potential and existing management actions suggested by stakeholders and review by the Expert Review Panel

With no signs of the wild OBP population increasing there has been a call from some stakeholders to consider new and innovative management actions (Stojanovic et al., 2017; J. Starks, pers. comm.; M. Holdsworth, pers. comm.). New initiatives need to be undertaken to help resolve critical knowledge gaps as the current management regime is failing to stop the population decline within the wild (Stojanovic et al., 2017; J. Starks, pers. comm.). Recovery efforts need to consider how the wild OBP population is currently behaving and using resources against how it traditionally behaved and used resources (Anon, pers. comm.). Previous research regarding migratory species have indicated that management actions within critical habitat, such as breeding grounds, are more effective than actions directed at non-limiting habitats (e.g. Runge et al., 2014; Runge et al., 2015). It is likely that barriers including biosecurity risks, timeframes, political expectations and resourcing, including the requirement of significant funds, will be evident when implementing new techniques but urgent and novel management actions are required to prevent the imminent extinction of OBPs in the wild.

Available evidence implies that OBP recovery will rely on (DELWP, pers. comm.):

- Population supplementation from an effective captive-breeding program, using strategies that have the greatest impact on wild population size and least impact on effective captive population size
- Identification and effective treatment of the causes of low female survival, noting mortality may occur year-round (data may have previously been mis-interpreted as low female breeding participation)
- Identification and effective treatment of the causes of low juvenile survival during their first non-breeding season
- Maintenance of sufficient habitat in the breeding and non—breeding ranges to support the long-term recovery objective of a wild population that, with limited species-specific management, has a high likelihood of persistence in the wild for 100 years
- Management of threats limiting population growth in the breeding and non-breeding ranges
- A well-coordinated and collaborative recovery program allowing partners to make effective contributions across the program

This section outlines potential management actions for the recovery of OBPs based on contributions provided by stakeholders for assessment by the independent Expert Review Panel. Reviewers are not restricted to assessing only the management actions presented in this document, and are invited to provide their own recommendations on management actions and strategies for implementation in future OBP recovery efforts (section 18). The Expert Review Panel were encouraged to review the potential and existing management actions by scoring each one from 1-10 based on the following criteria:

- Impact: the overall impact the management action is likely to have on the recovery of OBPs
- Feasibility: practicability of the management action being implemented
- Value: value for money of implementing the management action

- Likelihood of success: the probability that the management action will be successful in achieving the desired outcome
- Overall rating: a summary of all of the assessment categories generated by adding the values from the previous four criteria

Scores from all reviewers were averaged and presented as a percentage. Standard deviations (an indication of the spread of scores from the reviewers; a high standard deviation signifies a larger difference in opinion between reviewers while a low standard deviation signifies reviewers scored similarly) are also provided in brackets for each criteria to indicate variation in scoring between reviewers. Variation between the raw scores given by each reviewer can be seen in Appendix 5. All text found within the '*Expert Review Panel Summary*' sections are that of the reviewers.

Further information regarding the threats which each potential management action is related to can be found in section 5. Each potential management action relates to one of the primary or supporting objectives in the current recovery plan: achieving a stable or increasing population; increasing the capacity of the captive population; protecting and enhancing OBP habitat; and ensuring effective adaptive implementation of the recovery plan (see section 7.6 for further details; DELWP, 2016). Barriers refer to section 16. Potential management actions are presented in no particular order and have not been costed.

17.1 Potential and existing management actions suggested by stakeholders over entire range and review by the Expert Review Panel

17.1.1 Transparency

It is currently difficult to evaluate the strengths and weaknesses of the OBP recovery program due to limited public access to information and documentation regarding decision-making and outcomes (both successful and unsuccessful) of recovery actions (Stojanovic et al., 2017). A communication plan was developed in 2015 which identified the information requirements of partners and stakeholders and has resulted in the implementation of new methods of communication including the publication of an information brochure and postcards provided at key tourist hotspots, a web page, a DPIPWE OBP Tasmanian Program Facebook page, and written summary sheets which are provided to tourism operators in south-west Tasmania. Despite this plan, communication issues are still evident.

The current recovery plan identifies the need to communicate effectively with all partners and stakeholders to provide a robust recovery effort for the species. This includes developing and implementing a communications plan to encompass the information requirements of all of the differing stakeholders and partners. To improve transparency, it has been suggested that all data and documentation associated with the recovery program should be publicly archived and be shared widely and openly as possible to further build awareness of OBP conservation (Stojanovic et al., 2017; M. Holdsworth, pers. comm.; Nature Glenelg Trust, pers. comm.). This may also help identify and address current knowledge gaps (Stojanovic et al., 2017).

Threat: Negative effects of management

Corresponding Recovery Plan objective: Supporting Objective 4 – effective adaptive implementation of the recovery plan

Action: Develop and implement a communications plan to service the information requirements of a range of OBP partners and stakeholders with coordinated communications products (DELWP, 2016) including the public archiving of documentation

Barriers: Recovery team, politics, communication and transparency, timeframes, data management

17.1.1.1 Expert Review Panel summary

Impact	Feasibility	Value	Likelihood of success	Overall Total
90% (1.7)	63.3% (3.8)	90% (1.7)	86.7% (1.5)	82.5%

The current OBP recovery effort does not meet adequate standards for transparency and provision of information to the public. This is particularly disappointing given the substantial amount of public funding that has gone into the recovery effort, the high public profile of this species, and the array of difficult and contentious choices involved in the recovery. The recovery program needs a commitment for a far more transparent process.

Given the research effort and funding invested over such a long period, the amount of peer-reviewed publications produced is disappointingly small. Too much of the OBP recovery information is found only in internal unpublished reports, with most of these being relatively inaccessible. 'Public archiving' of information alone seems shallow. Unless there are clear risks of detriment to the recovery effort, all information should be readily accessible to the public, in a timely manner. This should include unvarnished accounts of failures, and annual public reporting on the implementation of the recovery plan and of OBP population trends.

17.1.2 Aims and accountability

At times, management interventions have not been associated with clear goals or accountability. Moving forward, each intervention should have clear targets and goals and compulsory reporting against these after the management intervention has occurred. Reports should be provided to the SAPG before wider dissemination (Anon, pers. comm.).

Threat: Negative effects of management

Corresponding Recovery Plan objective: Supporting Objective 4 – effective adaptive implementation of the recovery plan

Action: Develop a clear action framework including the identification of responsible organisations and mechanisms for standardised reporting and progress updates

Barriers: Recovery team, politics, communication and transparency, knowledge gaps, data management

17.1.2.1 Expert Review Panel summary

Impact	Feasibility	Value	Likelihood of success	Overall Total
70% (4.4)	56.7% (3.5)	73% (3.8)	80% (2.6)	70%

It is imperative to improve the overall efficacy of the OBP recovery effort, including the delivery of clearly defined, achievable and measurable targets and thus the OBP recovery effort requires more explicit anchoring of aims and accountability into decision-making and actions. There are many difficult decisions that have been made and that need to be made in this recovery effort, and it may be that at times management actions have been implemented that do not seem to clearly link to goals and are not necessarily accountable.

The necessarily elaborate governance structure (see Figure 3) seems to provide much of this framework already, but it is presumed that there is some scope to improve clarity of responsibilities.

17.1.3 Central database

DELWP and DPIPWE are currently working towards developing an integrated central OBP population monitoring database (combination of the DPIPWE OBP summer database with the mainland *Orange-bellied Parrot Winter and Resights Database*). As part of that process, a DELWP data-management volunteer is currently volunteering for DPIPWE to correct some errors in the DPIPWE database as a precursor to developing the shared database (DELWP, pers. comm.). The database will include data on the number and sex of wild birds returning to the breeding grounds, number and sex of released captive-bred birds, release locations and OBP observations throughout the year (who, where, when). Having all this information in one place will enable more informed decision-making and enhance the understanding of longitudinal data for individual birds (P. Eden, pers. comm.). It will also enable easier reporting of yearly summaries.

Threat: Negative effects of management

Corresponding Recovery Plan objective: Supporting Objective 4 – effective adaptive implementation of the recovery plan

Action: Develop a centralised dynamic database for information sharing and facilitation of informed decision-making

Barriers: Funding and resources, recovery team, politics, communication and transparency, data management

17.1.3.1 Expert Review Panel summary

Impact	Feasibility	Value	Likelihood of success	Overall Total
73.3% (4.6)	50% (4.4)	73.3% (4.6)	73.3% (4.6)	67.5%

This seems to be a relatively straightforward, best-practice management standard, although a single centralised database may be impractical and sub-optimal given the range of information arising from so many diverse components of the recovery effort.

17.1.4 Independent scientific panel

It has been suggested that a scientific committee completely independent of the OBPRT needs to be established to review all management proposals and provide advice on scientific methods. All planned methods would need to be signed off by this panel prior to implementation (Anon, pers. comm.).

Threat: Negative effects of management

Corresponding Recovery Plan objective: Supporting Objective 4 – effective adaptive implementation of the recovery plan

Action: Develop a scientific committee independent of the OBPRT to review all management actions and provide scientifically robust advice

Barriers: Funding and resources, recovery team, politics, communications and transparency, knowledge gaps, data management

17.1.4.1 Expert Review Panel summary

Impact	Feasibility	Value	Likelihood of success	Overall Total
43.3% (5.1)	43.3% (5.1)	40% (5.3)	40% (5.3)	41.7%

Besides providing advice, this action could open up numerous resources. However, the recovery of this species already has a byzantine system of governance and adding another dimension of experts will just as likely clog the decision-making process as to expedite it. There is already good science within the existing organisational structure. The bureaucracy for implementing this >30 year-old OBP recovery initiative has grown to a size that has compromised recovery actions and this proposal should be rejected.

17.1.5 Recovery Project Coordinator

A Recovery Project Coordinator has repeatedly been identified as critical to maintaining a high performing recovery team and is a high priority in the current recovery plan (Saunders, 2002; Pritchard, 2014). This role has not been maintained over the life of the recovery program and has impacted the productivity and effectiveness of the OBPRT (DELWP, pers. comm.). A Recovery Project Coordinator is now required for an extended period of time (minimum 3 years) to help effectively implement the recovery plan. It would be ineffective to fund this position across smaller timeframes especially when it is likely that the same person would not be available each time funding became available. This role is reportedly nearly close to being funded (by offset funds provided under the EPBC Act as agreed by the SAPG) and filled (hosted by DPIPWE).

Threat: Negative effects of management

Corresponding Recovery Plan objective: Supporting Objective 4 – effective adaptive implementation of the recovery plan

Action: Secure funds for a permanent full-time Recovery Project Coordinator

Barriers: Funding and resources

17.1.5.1 Expert Review Panel summary

Impact	Feasibility	Value	Likelihood of success	Overall Total
90% (0.00)	90% (0.00)	100% (0.00)	80% (0.00)	90%

Given the complexities of management, research and governance, and the need for continuity in recovery effort, this position is essential.

17.1.6 General overall monitoring

Continued investment into monitoring the wild population is of high priority so as to measure the outcomes of any implemented management trials, perform necessary data analyses and to allow rapid adaptive management to occur ensuring that investment is directed towards the highest priority actions for the species (DELWP, pers. comm.). Future work should prioritise the need to sufficiently resource regular longitudinal analyses of collected data (Pritchard, 2014).

Data collected through monitoring will continue to be used to identify the annual wild population number, proportion of females participating in breeding, breeding productivity, survival rate, utilised winter sites, changes in behaviour and changes in preferred foraging plants (DELWP, 2016). Data collection largely relies on trained and well-supported volunteers (Pritchard, 2014). Tasks currently include:

- Colour-banding of all birds at the breeding site
- Genetic and disease screening of banded birds through collection of feather or blood samples
- Genotyping blood samples to assess changes in allele frequency and genetic diversity
- Monitoring of the numbers and behaviours of all birds at the breeding site
- Monitoring of annual use of nest boxes and where possible monitoring natural nests
- Surveying historic breeding sites every two years to determine breeding activity
- Monitoring habitat on the migration route in autumn for OBP presence including monitoring changes in habitat on King Island and in western Tasmania

- Continued monitoring of all high-quality mainland habitat during the non-breeding season particularly during the three national count weekends
- Development and employment of monitoring methods to detect changes in mainland habitat at priority sites including the extent of optimal habitat
- Conducting annual monitoring of the diversity and range of preferred age-class food plants across their entire distributional range

When resources are limited, priority will be given to those tasks which address key knowledge gaps or provide essential information for critical decisions (DELWP, 2016).

Detected changes in the population or habitat often require quick yet informed management decisions to be made. A key lesson learnt from the 2014 review was the need to balance high-quality monitoring with regular and appropriate data analyses and interpretation and the use of those analyses to inform timely decisions (Pritchard, 2014). Analysis of the monitoring data therefore needs to minimise the probability of failing to detect trends quickly (e.g. decreasing confidence intervals to 80%; DELWP, 2016). Management decisions will therefore be a trade-off between the greater uncertainty as a result of such analyses and the risk of delaying action (DELWP, 2016).

Threat: Small population size

Corresponding Recovery Plan objective: Supporting Objective 1 – achieve a stable or increasing population

Action: Implement and coordinate monitoring, maintain regular analyses and report results in a timely fashion

Barriers: Funding and resources, knowledge gaps, data management

17.1.6.1 Expert Review Panel summary

Impact	Feasibility	Value	Likelihood of success	Overall Total
80% (0.00)	80% (1.41)	85% (0.71)	90% (0.00)	83.8%

There has been much excellent monitoring, but this has lacked some strategic focus and prioritisation, has not encompassed all of the elements required, has been subject to intermittent and at time sub-optimal analyses, much has not been publicly reported, and it has not always been the basis for adaptive management, or as the basis for population viability that can inform management priorities. It needs much overhaul and more investment.

17.2 Potential and existing management actions suggested by stakeholders on the mainland and review by the Expert Review Panel

17.2.1 Increased survey effort

More surveys outside of the formal count weekends on the mainland should be encouraged by volunteers and Regional Coordinators (funding-dependent). An increased survey effort all throughout winter at both traditional and potential sites will help increase the probability of locating OBPs on the mainland, identify migration corridors and aid habitat management.

Threat: Small population size

Corresponding Recovery Plan objective: Primary Objective 3 – protect and enhance habitat

Action: Establish a more thorough mainland winter survey regime across traditional and potential OBP sites

Barriers: Funding and resources, population size and management, timeframes, volunteer support, knowledge gaps, data management

17.2.1.1 Expert Review Panel summary

Impact	Feasibility	Value	Likelihood of success	Overall Total
56.7% (3.1)	56.7% (3.8)	50% (3.0)	50% (3.0)	53.3%

This action is important to better understand the movements of OBPs across the landscape. However, it is considered to have a low likelihood of locating new areas of significance for the conservation of the species; winter counts are unlikely to be as accurate as breeding counts. But it has some benefit in assessing migration survival and hence narrowing down the timing and placement of main episodes of mortality.

17.2.2 Mainland release and tracking

The Mainland Release Trial Program will continue until 2020 to test the effectiveness of mainland releases for supplementing the wild population and to test whether habitat occupancy improves survival of juveniles in their first non-breeding season (see section 10.12). Although no individuals involved in the 2017 Mainland Release Trial Program were known to have successfully migrated to the breeding grounds, a 2018 program is planned. Monitoring behaviour and movements of these birds will be instrumental in not only reviewing the efficacy of the trial but in identifying limitations of captive release behaviours (site selection, foraging and roosting behaviour) and their ability to "learn" from wild individuals.

Threat: Small population size

Corresponding Recovery Plan objective: Primary objective 1 – achieve a stable or increasing population

Action: Continue, with adjustments, the four-year Mainland Release Trial Program in an effort to supplement and increase the wild OBP population

Barriers: Funding and resources, population size and management, captive releases, technology, politics, knowledge gaps, volunteer support

17.2.2.1 Expert Review Panel summary

Impact	Feasibility	Value	Likelihood of success	Overall Total
83.3% (0.6)	73.3% (2.5)	80% (2.0)	53.3% (0.6)	72.5%

The limited information presented on outcomes of the first year of this trial show some promise, and it merits continuation. However, there is a degree of "optimistic" likelihood of success, with one reviewer not convinced that recapture and re-release are necessary. The death of the recaptured male sets a negative precedent and may need to be a key adjustment. Even if released birds on the mainland become "local residents" the conservation gain would be greater (when factoring in costs also) than loosing birds while "forcing them" to migrate. A necessary investigation, with clear protocols and performance measures. The limited information provided from the first year's trial suggests some promise. An issue for consideration may be the response required if the released birds attempt to reside year-round in the winter grounds.

17.2.3 Volunteer workshops

It has been suggested that workshops for volunteers should be conducted prior to the first winter count in each Victorian site complex to promote the mainland winter program to the public. Other *Neophema* species are more likely to be abundant in the areas where workshops would be held, providing some reward for attendees and to gauge interest in participating in the count weekends, especially in the site complexes where volunteer interest is waning (Nature Glenelg Trust, pers. comm.). For this to occur, funding needs to be secured prior to OBPs migrating to the mainland. Furthermore, new ways are needed to extend the reach to a wider online audience and inform the public of the importance of monitoring (Nature Glenelg Trust, pers. comm.).

Threat: Small population size

Corresponding Recovery Plan objective: Supporting Objective 4 – effective adaptive implementation of the recovery plan

Action: Hold volunteer workshops within each Victorian site complex prior to the first winter count weekend in May

Barriers: Funding and resources, communication and transparency, volunteer support

17.2.3.1 Expert Review Panel summary

Impact	Feasibility	Value	Likelihood of success	Overall Total
53.3% (2.5)	73.3% (2.5)	56.7% (3.2)	60% (1.7)	60.8%

Volunteer workshops will help standardise survey effort (including the need to report on absences), maintain some sense of community, and help maintain and enhance community investment; but may require substantial coordinator effort, and may not deliver information of much management use – it doesn't seem to address key management priority or knowledge gaps.

17.2.4 Monitoring landfall of migrating OBPs

If OBPs are migrating northwards using a compass course, the location of where they will make landfall can be deduced but this has yet to be done. This would require staff or volunteers to monitor the departure of OBPs from King Island noting the direction that birds leave from. From there, available weather data (e.g. sourced from the BOM database) can be accessed to populate the required equations (which are readily available) to approximately calculate where birds will make landfall on the mainland. Search teams on the mainland can then be informed of the predicted locations providing them with a starting point to conduct targeted searches. This would provide insights into where birds end up including if they reach suitable habitat (D. McCarthy, pers. comm.).

Threat: Small population size

Corresponding Recovery Plan objective: Supporting Objective 1 – achieve a stable or increasing population

Action: Develop a protocol to monitor the departure of migrating OBPs from King Island to determine landfall on the mainland following the compass course migration strategy

Barriers: Funding and resources, timeframes, volunteer support, knowledge gaps

17.2.4.1 Expert Review Panel summary

Impact	Feasibility	Value	Likelihood of success	Overall Total
70% (5.2)	66.7% (5.8)	70% (5.2)	70% (5.2)	69.2%

This stands out as a key action due to the geography of OBP migration and the ability to provide valuable information regarding the species migratory route. However, one reviewer is not convinced that this is either feasible or likely to deliver achievable conservation benefit.

17.2.5 Habitat maintenance

The continued management of OBP preferred feeding and roosting sites across the species range is considered a priority to support recovery if other strategies are successful in bolstering the wild population and is already underway in some areas (DELWP, 2016).

The current recovery plan identifies the need to maintain a minimum of six high-quality preferred feeding and roosting mainland sites and improving at least six preferred low-quality winter sites. It is also proposed to increase the diversity and distribution of appropriate age-

class foraging habitat at breeding sites (DELWP, 2016). Tasks to achieve this recovery action would include:

- Trial ecological grazing management regimes to maintain or improve mainland winter habitat
- Trial improved hydrological management regimes to maintain or improve mainland winter habitat
- Manage invasive weeds at priority sites
- Restore high-quality habitat at degraded sites
- Evaluate and manage disturbance caused through human activities in preferred mainland winter habitat
- Incorporate habitat improvement strategies from trials into voluntary management agreements and agency land and water management procedures

Threat: Habitat loss and degradation, invasive weeds

Corresponding Recovery Plan objective: Primary Objective 3 – protect and enhance habitat

Actions: 1) Trial ecological grazing

2) Trial improved hydrological management regimes

3) Manage invasive weeds

4) Restore high-quality habitat at degraded sites

5) Manage human-related disturbance

6) Include habitat improvement strategies into voluntary management agreements

Barriers: Funding and resources, knowledge gaps, volunteer support, timeframes

17.2.5.1 Expert Review Panel summary

Action 1:

Impact	Feasibility	Value	Likelihood of success	Overall Total
65% (3.54)	65% (3.54)	60% (2.83)	60% (2.83)	62.5%

This seems to repeat actions trialled in the past with equivocal results.

Action 2:

Impact	Feasibility	Value	Likelihood of success	Overall Total
65% (3.54)	60% (4.24)	65% (2.12)	55% (3.54)	61.3%

Some chance of local-scale benefits.

Action 3:

Impact	Feasibility	Value	Likelihood of success	Overall Total
55% (3.54)	65% (4.95)	55% (3.54)	55% (3.54)	57.5%

So long as the weeds don't provide important food resources for OBPs.

Action 4:

Impact	Feasibility	Value	Likelihood of success	Overall Total
70% (4.24)	60% (4.24)	60% (4.24)	55% (3.54)	61.3%

Unlikely to achieve significant gains in the short term but has some longer-term merit.

Action 5:

Impact	Feasibility	Value	Likelihood of success	Overall Total
50% (4.24)	55% (4.95)	45% (4.95)	40% (4.24)	47.5%

Seems a low priority action, as no compelling evidence presented of significant detriment from current levels of human activities.

Action 6:

Impact	Feasibility	Value	Likelihood of success	Overall Total
65% (2.12)	70% (1.41)	60% (2.83)	55% (2.12)	62.5%

This seems to be a self-evident action if the research above provides results that indicate significant benefit from grazing, hydrological and other management options. However, it may be a long-term proposition, and 'best-management' practices may be worth implementing based on current knowledge.

17.3 Potential and existing management actions suggested by stakeholders in Tasmania and review by the Expert Review Panel

17.3.1 Nest Intervention Project 2017/18

The ANU researchers will continue their recovery efforts and research at Melaleuca throughout the 2017/18 breeding season. Intensive monitoring of nests will continue with frequent direct observations and motion cameras improving the knowledge surrounding parentage, egg fertility, chick condition and survival rates and increase the capability of managers to identify and respond quickly to potential problems (Stojanovic et al., 2017). Cross-fostering techniques will also continue and be improved helping to increase the usefulness of the limited resources despite the small wild broods and infertile eggs (Stojanovic et al., 2017). Further applications of fostering will also be investigated including the potential to swap chicks to correct sex-ratio biases or increase the representation of specific genotypes (Stojanovic et al., 2017).

Furthermore, trials are suggested to evaluate the potential of fostering eggs or older chicks to improve survival rates (Stojanovic et al., 2017). Fostering success from the 2016/17 breeding season may be improved by fostering captive-bred eggs to prevent vocal mis-match based on the inheritance of vocal signatures from parents in the egg phase where incubating females may be communicating with the eggs (Berg, et al., 2011; Colombelli-Negrel et al., 2012; Mariette & Buchanan, 2016; Stojanovic et al., 2017). Fostering older chicks is also suggested as could help correct the sex-ratio bias in the wild, enhance the genetic management of the wild population and help ailing chicks by inserting them into nests where they will be more competitive (Wedekind, 2002; Stojanovic et al., 2017).

In addition to continuing the management actions within the wild population, the project proposes to supplement the captive population in the future with wild-born juveniles. Potential options include:

- Transferring nestlings from supplemented broods to captivity
- Transferring nestlings from second broods in the wild to captivity
- Transferring a percentage (yet to be discussed) of wild-born juveniles from first clutches to captivity
- Transferring all of the wild-born juveniles from second clutches to captivity

Threat: Small population size

Corresponding Recovery Plan objective: Primary Objective 1 - achieve a stable or increasing population

Actions: 1) Continue intensive monitoring of all wild nests through direct observations and motion cameras

2) Continue implementing current cross-fostering techniques and investigate the potential to swap captive and wild chicks to correct sex-ratio biases or genetic representation while developing protocols for trialling fostering eggs or older chicks to improve survival rates while supplementing the captive population with wild-born juveniles

Barriers: Funding and resources, population size and management, genetic diversity, chick survival, threats, technology, politics, timeframes

17.3.1.1 Expert Review Panel summary

Action 1:

Impact	Feasibility	Value	Likelihood of success	Overall Total
93.3% (1.2)	80% (2.0)	96.7% (0.6)	93.3% (1.2)	90.8%

Since most of the breeding activity in the wild occurs in nest boxes it makes sense to invest in this component to fill gaps in knowledge and structure interventions (i.e. egg swapping, cross-fostering etc.). This is considered a necessary action to acquire information on key demographic parameters, and on some threats, and hence on prioritisation of management responses. Extending the nest network prioritising accessible sites for maintenance and biosecurity would also be necessary. Nest monitoring should be coupled with nest maintenance, cleaning and biosecurity protocols.

Action 2:

Impact	Feasibility	Value	Likelihood of success	Overall Total
70% (4.4)	56.7% (4.0)	76.7% (2.5)	70% (2.6)	68.3%

Egg-swapping (or fostering eggs) between wild and captive nests should be trialled as could increase fledging success at Melaleuca, with the added benefit that any chick fledged in the wild (even from captive parents) will be exposed to the behavioural repertoire of wild OBPs, including migratory behaviour. In the long run, this approach appears cost-effective as it removes the cost associated with 'teaching' a captive OBP how to migrate, forage, etc. Pilot studies could occur between captive-breeding facilities, where acceptance or rejection ages of chicks by foster parents could be investigated in adherence to all biosecurity measures.

Such highly active intervention seems now to be necessary given the consequences to population viability of current low reproductive success. It has risks and needs to be undertaken with appropriate (but pragmatic) hygiene and disease-risk protocols. Fine-tunning pre-transfer feeding and biosecurity measures would contribute to make this a successful management action. Perhaps trials with a surrogate species could assist fine-tuning. Results from the nest research and cross-fostering programs from ANU need to be circulated in short time-frames to facilitate decision-making.

17.3.2 Fire regimes

The recovery plan identifies the need to incorporate ecological fire management requirements of OBPs into relevant fire management plans in the breeding range (see section 12.7 for further details). Controlled burns have been a recurring recommendation in OBP recovery plans but have not been implemented due to costs and priority issues within the Tasmanian Wilderness World Heritage Area.

The size of the breeding habitat at Melaleuca appears to be adequate to support the current wild population but fire suppression has likely resulted in a reduced availability and diversity of preferred OBP food plants, including appropriate age-classes, around Melaleuca (DELWP, 2016). Consequently, this may be contributing to the decline in female breeding participation. The use of Melaleuca as the only current breeding location emphasises the critical importance for appropriately managing this habitat to improve the quality and availability of preferred OBP food plants. The extent and quality of the breeding habitat will only increase via the implementation of the species Fire Management Plan including implementation of targeted small-scale mosaic burns between April and September when the birds are on the mainland (DELWP, 2016; Parks and Wildlife Service, 2016). Alternatively, large-scale burns may be necessary to achieve high densities of OBP preferred food plants (Stojanovic et al., 2017). However, controlled patch burns may be more beneficial as previous studies have indicated that fertility of OBPs significantly decreases during the breeding season following a large landscape-scale burn. Fertility did increase in the following breeding season and was one of the most productive but the current wild population could not withstand an initial poor breeding season (M. Holdsworth, pers. comm.). While local burns are likely to be beneficial and reduce the reliance on supplementary seed diets, they may not be immediately applicable and therefore supplementary feeding would still need to occur in the interim (N. Murray, pers. comm.).

Fire regimes are also recommended at historic breeding sites to provide high-quality habitat for undetected individuals in areas outside of Melaleuca and at areas where new sub-populations may be established in the future (Stojanovic et al., 2017).

Threat: Habitat loss and degradation

Corresponding Recovery Plan objective: Primary Objective 3 – protect and enhance OBP habitat

Action: Implement regular patch-burning at known and potential OBP breeding locations

Barriers: Funding and resources, politics

17.3.2.1 Expert Review Panel summary

Impact	Feasibility	Value	Likelihood of success	Overall Total
96.7% (0.6)	60% (1.7)	96.7% (0.6)	90% (1.0)	85.8%

It appears that a fire regime is associated with bureaucratic challenges (for permission) requiring substantial lobbying with the Tasmanian Wilderness World Heritage Area and adequate resourcing. There is also the risk that controlled burns can become an unmanageable wildfire.

If the available information suggests that OBPs preferred foods thrive eight years after fire, this action should be ranked as high priority in preparation for OBP cohorts 5-10 years from now, particularly if it contributes to improved breeding success. Lamentable that there has not been more active fire management in the breeding area in recent years. Note that the enhanced fire management should not be restricted to the Melaleuca area but should also encompass other potentially suitable areas within the OBP's historic breeding range (requires a landscape perspective, not only a local site perspective e.g. Melaleuca), to enable maintenance or enhancement of habitat in such areas which may be needed for future recovery efforts.

17.3.3 Reducing supplementary feeding

Seed-based diets, such as those provided at Melaleuca, are associated with nutrient deficiencies in birds (Koutsos et al., 2001) with impacts of the supplementary diet provided to wild OBPs being unknown. The type of food provided and the possible nutritional impacts, both positive and negative, are undergoing review by the VTRG. Furthermore, the OBPRT is reviewing the possibility of revising the type of food provided and reducing the amount of supplementary food to minimise the dependency of wild birds on this food source with the ultimate aim of removal (OBPRT, 2017). This would require a gradual reduction over time to avoid compromising the body and health condition of individuals (OBPRT, 2017). It is envisioned that the reduction of supplementary food will increase nutritional diversity as well as the fitness, health and reproductive success of wild birds through reduced infertility and reduced male-bias in offspring and minimise the risk of disease (OBPRT, 2017). It is also hypothesised that it will prevent reduced calcium absorption (Anon, pers. comm.).

If fire regimes are successfully implemented and correspond with an increase in preferred OBP food plants within the breeding area, supplementary feeding can further be limited for monitoring purposes only, with tables being located near natural food plants to encourage natural foraging (Stojanovic et al., 2017).

If supplementary feeding continues, it has been suggested that the nutritional profiles of natural food plants should be identified urgently and used as a guide for formulating the supplementary diet with the inclusion of relevant native seeds collected from recently burnt areas as close to Melaleuca as possible (Stojanovic et al., 2017; N. Murray, pers. comm.). However, this will require a significant increase in effort beyond the current duties of volunteers. A dedicated person with expertise in food plants and a dedicated facility to store collected seeds would be required (M. Holdsworth, pers. comm.). Any changes to the supplementary diet could be trialled in captivity to evaluate effects to body condition and overall health (Stojanovic et al., 2017).

Threats: Negative effects of management

Corresponding Recovery Plan objective: Primary Objective 1 – achieve a stable or increasing population; Primary Objective 3 - protect and enhance OBP habitat

Actions: 1) Reduce the amount of supplementary food provided at the breeding grounds with the aim of complete removal

2) Investigate the nutritional profiles of natural food plants to guide the formulation of the supplementary diet

Barriers: Funding and resources, supplementary food, volunteer support

17.3.3.1 Expert Review Panel summary

Action 1:

Impact	Feasibility	Value	Likelihood of success	Overall Total
53.3% (4.0)	73.3% (2.5)	46.7% (4.6)	43.3% (4.9)	54.2%

Supplementary feeding can be fine-tuned to address the negative impacts of this intervention with some attempt to transition OBPs to find more of their food via natural sources appearing sensible. In particular, supplementary feeding could be changed from an "ad lib" scheme of "high" versus "low" to "medium" supplementary food availability to encourage OBPs to seek wild foods, keeping in mind the biosecurity requirements to manage BFDV transmission. Complete removal seems less sensible; besides the provisioned food allows for OBPs to be readily monitored and captured.

Action 2:

Impact	Feasibility	Value	Likelihood of success	Overall Total
70% (2.6)	60% (1.7)	70% (2.6)	60% (1.7)	65%

Captive OBPs use feeding tables, which can in turn be used to assist population monitoring schemes. A better understanding of the dietary requirements of wild foods could help fine-tune the "supplementary formula". Perhaps it is a good idea to seek advice from established successful supplementary feeding programs for Kakapo in New Zealand and Echo Parakeet in Mauritius.

17.3.4 Pro-active predator control

During the 2016/17 breeding season, an undisclosed number of OBPs were attacked by a raptor and one adult likely suffered injuries (it did not breed and later died; M. Holdsworth, pers. comm.). The current control of predators at Melaleuca is reliant on largely unskilled observers carrying out observations and reporting their sightings for further consideration (M. Holdsworth, pers. comm.). The ability to take immediate actions is not within the current protocol corresponding to a risk of attack before control actions can be implemented (M. Holdsworth, pers. comm.). A pro-active predator control program may mitigate this risk. A skilled raptor trapper proficient in a range of trapping techniques is required throughout the breeding season to implement predator control without delay through trapping and relocation or lethal means if necessary (M. Holdsworth, pers. comm.).

Threat: Predators and competitors

Corresponding Recovery Plan objective: Primary Objective 1 – achieve a stable or increasing population

Action: Develop and implement a pro-active predator control program at the breeding grounds in Melaleuca

Barriers: Funding and resources, threats, timeframes

17.3.4.1 Expert Review Panel summary

Impact	Feasibility	Value	Likelihood of success	Overall Total
63.3% (4.0)	50% (4.4)	56.7% (4.0)	53.3% (4.2)	55%

Probably most effectively achieved through prevention of predator access to nest sites rather than by blasting goshawks. Some research seeking nest-box designs that attract OBPs but not Tree Martins (or which displace them) or other competitors may be worthwhile (e.g. bird spikes on top of OBP nests or a 45° angle metal sheath so Tree Martins can't perch. Alternatively, can nest boxes be modified to mimic natural OBP nests where Tree Martins don't block entrances?). Ongoing monitoring for Sugar Gliders may also be worthwhile. Any management action that may increase annual reproductive output is likely to be beneficial to the wild population.

17.3.5 Closing museum feed table

The museum feed table is situated in close proximity to the King's Garden which provides ambush cover for accipiters and currawongs and corresponds with a significant predation risk (M. Holdsworth, pers. comm.). An OBP was taken by an accipiter in the 2016/17 breeding season and Beautiful Firetails (*Stagonopleura bella*) have previously been predated from this feed table. Additionally, OBPs have been observed flying into the museum windows which could cause injury or death (M. Holdsworth, pers. comm.). The closure of this feed table would increase the capacity of volunteers to monitor the remaining feed tables (M. Holdsworth, pers. comm.). The feed table continues to be operated despite previous recommendations to close it.

Threat: Predators and competitors

Corresponding Recovery Plan objective: Primary Objective 1 – achieve a stable or increasing population

Action: Close the museum feed table at Melaleuca

Barriers: Recovery team, threats

17.3.5.1 Expert Review Panel summary

Impact	Feasibility	Value	Likelihood of success	Overall Total
63.3% (4.7)	76.7% (2.5)	70% (3.6)	73.3% (3.1)	70.8%

A small management action that may have a very minor benefit – the scoring system seems to over-rate the value of the action, basically because it is of such practical simplicity and low cost.

Unless an efficient method to discourage accipiters from the area is found, the closure of this feed table appears as a low-cost, high impact action.

17.3.6 Increase release numbers and sites

Increasing the number of captive-bred birds released into the wild has been suggested as necessary to ensure the wild population increases in size (Stojanovic et al., 2017). Spring releases will continue to help correct sex-ratio biases evident each breeding season and help provide all returning wild birds with the opportunity to breed (Stojanovic et al., 2017). However, this action will be dependent on the productivity within the captive-breeding population each season and the need to maintain genetic viability within the insurance population.

A trial involving the release of a minimum of 10 (subject to availability) captive-bred juveniles approximately 6-7 weeks of age (2 weeks' post-fledgling) at Melaleuca at the end of the breeding season (i.e. early Jan) has been proposed by the OBPRT. This age-cohort is thought to be more adaptable and therefore more likely to survive after release and experienced breeding adults are needed to be retained in the captive-breeding program (Menkhorst, 1997). Such a release had been planned for the last two seasons but have been cancelled by the Tasmanian Government. A juvenile release is now proposed for 2018 based on the following rationale (DPIPWE, pers. comm.):

- Other management programs have found that survival rates of young captive-bred birds released to the wild exceed those of older captive-bred birds released to the wild
- Captive-bred released adult OBPs have low survival rates
- Juvenile birds, although inexperienced, may be more adaptable to new conditions
- Juvenile birds may be less conditioned to life in captivity and more able to learn from wild birds and develop wild behaviours compared to released captive-bred adult OBPs

The release of this age-cohort will help determine if released juvenile birds have a higher return rate than released captive-bred adults (OBPRT, 2017). Preference is for a male-bias release cohort due to the excess of males in captivity and these birds appear to be more driven (OBPRT, 2017). This may result in the need to re-catch some males at the beginning of the following breeding season if there is a high return rate to avoid a highly skewed sex-ratio in the wild breeding population. The exact number and source of these juveniles will not be known until eggs have hatched in captivity. There are concerns that juveniles may learn undesirable behaviours from released captive-bred adults thus it has been suggested to release the juveniles after adults have left (possibly via the assisted migration program).

New breeding sites have the potential to significantly increase the security of the breeding population as well as the population size (OBPRT, 2017). Establishment of breeding populations at alternative breeding sites has been tried before (e.g. Birchs Inlet, see section 13.8.3) but failed with reasons for failure still being poorly understood. Establishment of additional release sites away from Melaleuca may help establish new breeding populations which would reduce the inherent risk associated with a single population (DPIPWE, pers. comm.). New breeding release sites, initially on the south coast of Tasmania, are currently being investigated by the OBPRT but further mapping work is required to identify all potential breeding habitat in SW Tasmania (OBPRT, 2017). Releases of OBPs at alternative sites however is not currently a priority.

DPIPWE and the OBPRT are also investigating the establishment of extra release sites and release aviaries in unoccupied habitat near Melaleuca to expand the area of occupancy of OBPs (OBPRT, 2017; DPIPWE, pers. comm.). Additional aviaries will allow more birds to be released over a greater range including the possibility of new release locations. Furthermore, a softer release process could be adopted providing more release options which may result in higher survivorship of released birds. More aviary space will also decrease the current stocking pressures and may help minimise the territorial and swamping behaviour of all the OBPs being released in the one spot (Anon, pers. comm.). Additionally, extra aviaries could provide the potential for onsite captive-breeding and egg/neonatal supplementation.

Threat: Small population size

Corresponding Recovery Plan objective: Primary Objective 1 - achieve a stable or increasing population

Actions: 1) Increase the number of captive-bred birds released into the wild each year

2) Implement a juvenile release program at Melaleuca

3) Investigate the potential of unoccupied habitat near Melaleuca to be used as extra release sites

4) Investigate the establishment of additional release site aviaries at Melaleuca

Barriers: Population size and management, captive releases, chick survival, timeframes

17.3.6.1 Expert Review Panel summary

Action 1:

Impact	Feasibility	Value	Likelihood of success	Overall Total
93.3% (0.6)	73.3% (2.5)	90% (1.0)	80% (2.0)	82.5%

The wild population is likely to persist if and only if it is bolstered, at least in the short term, by injections from the captive population. Age- and sex-class mixes need to be carefully considered to maximise potential benefits.

This action ranks "high" as this will occur alongside other actions (i.e. improved nest management, predator/competitor control, fire burning). Also, the evidence shows that captive-bred birds increased the number of breeding pairs at Melaleuca.

Action 2:

Impact	Feasibility	Value	Likelihood of success	Overall Total
80% (0.00)	65% (2.12)	85% (0.71)	70% (2.83)	75%

Disconcerting that the planned release in two previous years has 'been cancelled by the Tasmanian government'. That seems to reflect badly on project governance or its operability. The rationale for release of captive-bred juveniles is sound. The disease-screening protocol appears reasonable. This issue highlights the occasional complications of potentially competing concerns – here, the need for rapid response verses the need to ensure the lowest possible risks of disease transmission to wild birds.

Action 3:

Impact	Feasibility	Value	Likelihood of success	Overall Total
95% (0.71)	80% (2.83)	100% (0.00)	65% (2.12)	83.8%

Not a useless activity but needs to be done as part of a broader consideration of establishment of additional breeding populations and linked to enhanced fire management. Could unoccupied sites be "improved" by installing feed tables, predator control (e.g. Sugar Gliders), and nesting boxes? Even if this leads to an OBP colony not behaving like the "wild type" it could have the effect of bolstering OBP numbers in the wild. It could also provide a unique opportunity to test fire burning regimes. A necessary action, as there is an unacceptable risk (notably of unplanned catastrophic fire) with restriction of the breeding population to one site only. It is a shame that the reason(s) for failure of the Birchs Inlet breeding population and subsequent releases were not determined. That site may be worth re-trying, albeit with much more intensive and considered monitoring of fate.

Action 4:

Impact	Feasibility	Value	Likelihood of success	Overall Total
80% (1.41)	85% (2.12)	75% (2.12)	70% (2.83)	77.5%

The case made for this action is convincing, as it will allow more rapid and adaptive responses.

17.3.7 Expansion of aviary space

As the captive population is at full capacity there is an urgent need to expand beyond the current captive facilities to meet long-term insurance population targets, annually produce sufficient birds for release into the wild and to possibly improve public engagement (DELWP, 2016). Additional ZAA members have requested to participate in the display of OBPs over the years but are not willing to participate in the breeding program. This is likely due to the substantial costs associated with breeding OBPs including regular movements of individuals between captive-breeding facilities which requires expensive pre- and post-quarantine testing and housing (Anon, pers. comm.). Tasmania has recently received $2.5 million from the Tasmanian government to build a new OBP breeding facility 5 km east of Hobart at 5 Mile Beach. This facility will double the capacity of the Taroona Wildlife Centre with the aim of

gradually increasing the capacity to 300 individuals to increase the size of the captive insurance population and to facilitate increased releases of captive-bred OBPs to supplement the wild population (DPIPWE, pers. comm.). This facility may also open up spaces to hold non-breeding birds from other breeding facilities enabling more breeding opportunities. The essential infrastructure components required to expand the breeding capacity are expected to be in place prior to the 2018/19 breeding season (DPIPWE, pers. comm.). However, there is still the need to increase holding capacity (for quarantined and non-breeding birds) at some of the other already established breeding facilities (DELWP, pers. comm.).

Currently, non-ZAA member institutions or private aviculturists are not permitted to participate in the OBP captive-breeding program. However, private aviculturists are recognised as having the potential to assist in conservation efforts for a species and have been requesting involvement in the OBP recovery program for decades. The benefits of incorporating private aviculturists in the OBP recovery program include the increased ability to breed birds for subsequent release into the wild (provided that strict quarantine requirements are met) as well as holding surplus individuals due to age, genetic over-representation, health status and adverse behavioural traits. The primary concerns with permitting the inclusion of private aviculturists is studbook management, retaining sufficient individuals in the insurance program and quarantine issues (Anon, pers. comm.).

The CMG has recommended the inclusion of private aviculturists as potential holders or breeders of OBPs to the OBPRT (DELWP, 2016). The political challenge is to have ZAA recommend that non-ZAA member institutions can hold OBPs (Anon, pers. comm.). Currently, new captive institutions can only become involved in holding and breeding captive OBPs if they join the ZAA and become accredited. An alternative option where ZAA membership is not a prerequisite is being evaluated, with the CMG producing guidelines including the requirement of private aviculturists to obtain a Scientific License from their relevant State government environmental department and would house a minimum of two birds due to welfare issues (Anon, pers. comm.). These documents have been provided to the SAPG in 2015 but no further progress has been accomplished and the matter is still under review (Anon, pers. comm.). If the inclusion of non-ZAA member institutions is signed off by the OBPRT, they could potentially enter the recovery effort within months (Anon, pers. comm.).

Threat: Small population size, stochastic factors

Corresponding Recovery Plan objective: Primary Objective 2 – increase the capacity of the captive population

Action: 1) Creation of a captive-breeding facility at 5 Mile beach

2) Allow non-ZAA members to contribute to the captive-breeding program

Barriers: Funding and resources, recovery team, politics, data management

17.3.7.1 Expert Review Panel summary

Action 1:

Impact	Feasibility	Value	Likelihood of success	Overall Total
85% (0.71)	95% (0.71)	70% (1.41)	85% (0.71)	83.8%

High priority to establish a large core captive-breeding facility, so long as its ongoing management can be securely and sufficiently resourced.

Action 2:

Impact	Feasibility	Value	Likelihood of success	Overall Total
25% (0.71)	50% (4.24)	15% (0.71)	35% (3.54)	31.3%

This seems to be a 'tail-wagging-the-dog' consideration. For genetics, disease-risk and governance issues, the captive-breeding program needs to be tightly coordinated and regulated. There is little to be gained with substantial risks associated with this proposal.

17.3.8 Ranching

Over the last three breeding seasons, juvenile survival over winter has declined to an average of 0.16 compared to the long-term average of 0.56 corresponding to a third of what is required to sustain current population levels (M. Holdsworth, pers. comm.). The reasons for the decline in juvenile survival are unknown but may be partly due to the release of naïve captive-bred birds (M. Holdsworth, pers. comm.). Based on previous experience with founder OBP captures, it is thought that ranching (capturing of wild birds at the breeding grounds prior to migration to undergo assisted migration to be held over winter in a captive facility) juveniles could result in more than a 0.90 survival rate for this cohort (M. Holdsworth, pers. comm.).

Ranching of half of the wild juvenile cohort from the 2017/18 breeding season as well as all of the captive-bred females that were released at Melaleuca in spring 2017 will occur on the mainland during winter 2018 with birds being re-released at Melaleuca in early October. Birds will be ranched at already established captive-breeding facilities. There are concerns though that the ranched birds should be housed separately from the captive population (M. Holdsworth, pers. comm.).

Ranching or re-trapping the captive birds released on the mainland in autumn which failed to migrate has also been proposed largely due to welfare concerns. However, concerns have been raised about the inability of these individuals to migrate raising the question of whether these genes should be kept in the gene pool (J. Starks, pers. comm.). These birds have exhibited adaptability and survival skills over summer and if survive, could attract migrating birds through con-specific cueing thus should be left in the wild (J. Starks, pers. comm.).

Threat: Stochastic factors

Corresponding Recovery Plan objective: Primary Objective 1 - achieve a stable or increasing population

Action: Ranch half of the wild juvenile cohort and all of the spring 2017 captive-released females over winter on the mainland through assisted migration

Barriers: Funding and resources, population size and management, space availability, captive releases, chick survival, politics, timeframes, knowledge gaps

17.3.8.1 Expert Review Panel summary

Impact	Feasibility	Value	Likelihood of success	Overall Total
63.3% (1.5)	50% (2.0)	46.7% (3.5)	50% (3.0)	52.5%

Somewhat risky to capture and transport such a large and important proportion of the population, and with potential loss of migratory capability. Is also considered risky based purely on welfare grounds and the risk of disease transmission if birds are to be held close to captive parrots.

However, this action clearly addresses a major demographic weak point (low migration survival of juveniles), especially based on the presented potential survival rate (0.9 if ranched) and therefore definitely warrants examination. More proof of concept is required before implementation on a large-scale. It is therefore suggested to trial this management action with a smaller proportion of the wild cohort and based on results, upscale or downscale the operation.

17.3.9 Veterinary care

It has been proposed that any wild bird observed with an injury or appearing to be in poor condition should be immediately captured and undergo a health examination by an avian veterinarian and receive appropriate treatment (M. Holdsworth, pers. comm.).

Threat: Disease

Corresponding Recovery Plan objective: Primary Objective 1 - achieve a stable or increasing population

Action: Develop protocols to immediately capture any wild OBP in poor condition to receive a health assessment

Barriers: Funding and resources, recovery team

17.3.9.1 Expert Review Panel summary

Impact	Feasibility	Value	Likelihood of success	Overall Total
40% (3.6)	56.7% (4.0)	36.7% (3.8)	43.3% (3.5)	44.2%

Straightforward to develop such a protocol, but any action may be at some risk of further stressing (through capture) individuals. Benefits may be to reduce risk of nascent outbreak of disease or to identify needs for food supplementation.

17.3.10 Obtaining wild genotypes

The acquirement of under-represented wild genotypes has recently been suggested to help maintain genetic diversity through capturing wild adults for addition into the captive-breeding program or through the harvesting of wild eggs and/or chicks (Stojanovic et al., 2017). Wild birds may attempt a second clutch if eggs are harvested, helping to minimise the impact of this management action (Stojanovic et al., 2017). However, second clutches have often failed in the past.

Threat: Small population size

Corresponding Recovery Plan objective: Primary Objective 2 – increase the capacity of the captive population

Actions: 1) Obtain wild birds with under-represented genotypes in captivity for inclusion into the captive population

2) Develop protocols to harvest the first clutch of eggs from the wild for inclusion into the captive population

Barriers: Funding, population size and management, genetic diversity, timeframes

17.3.10.1 Expert Review Panel summary

Action 1:

Impact	Feasibility	Value	Likelihood of success	Overall Total
23.3% (4.0)	40% (5.3)	10% (1.7)	23.3% (2.5)	24.2%

Many birds have already been taken from the wild population to captivity, sometimes likely at the expense of the viability of the wild population. It is unlikely that there is much genotypic variation remaining in the wild population that is not also present in the captive population. The cost to the wild population outweighs the purported benefit.

Very low priority in the current suite of proposed management actions and should be considered only as a last resort in conjunction with the proposal to remove all birds from the wild and place in captive breeding facilities.

In light of the combined evidence, this looks like a risky move in the short-term. There is no guarantee that improved genetic diversity would necessarily fix low fertility in wild nests. Further, it carries the risk of losing adult wild birds in the process. This action would appear better suited for when the wild population recovers to a desired target number.

Action 2:

Impact	Feasibility	Value	Likelihood of success	Overall Total
23.3% (3.5)	36.7% (3.8)	26.7% (2.1)	20% (2.0)	26.7%

This is a high-risk strategy that seems to prioritise genetic management of the captive population as more important than the viability of the wild population. Removing fertile eggs from the wild, where infertility is an issue could reduce nestling success in the wild to even lower values. The ranking for this action needs to be revised once the results of the egg-fostering trial are available.

Nestling mortality is described as an issue when cross-fostering chicks. Potentially nesting females are more likely to accept eggs than chicks. The greater advantage of an egg-swapping programme would be that chicks hatched on site are exposed to OBP wild behaviours.

17.3.11 Studbook extension

It has been suggested to extend the OBP studbook to include wild nests. In doing so, the two-way flow between the wild and captive populations could ensure that the genetic diversity within the wild population is not reduced by released captive-bred birds (Stojanovic et al., 2017). This will also help to improve the representation of the remaining wild genotypes within the captive population (Stojanovic et al., 2017).

Threat: Small population size

Corresponding Recovery Plan objective: Primary Objective 2 – increase the capacity of the captive population

Action: Extension of the OBP studbook to include wild nests

Barriers: Genetic diversity, communication and transparency, data management

17.3.11.1 Expert Review Panel summary

Impact	Feasibility	Value	Likelihood of success	Overall Total
53.3% (4.5)	60% (4.6)	50% (5.0)	60% (4.6)	55.8%

Seems straightforward and appropriate for enhancing management links between the wild and captive populations. Providing that biosecurity measures are in place and fledging of chicks in the wild is a priority, this action could positively contribute to juvenile recruitment at Melaleuca in the short- and medium-terms. Improving the genetic diversity of captive stock should come second to increasing the fledging success in the wild.

17.3.12 Phytoestrogens

In 2017, new research was published revealing that breeding success in New Zealand parrots including the critically endangered Kakapo (*Strigops habroptila*) was not facilitated by a general nutritional effect but rather through the plant oestrogen binding to the bird oestrogen receptor and stimulating more egg maturation (Davis et al., 2017). This ability is mediated by an extra eight amino acid sequence in the oestrogen receptor protein. The Australian Cockatiel (*Nymphicus hollandicus*), Japanese Quail (*Coturnix japonica*) and the chicken were also

examined. Sequences in the Australian Cockatiel were identical (not a mutated relic) to that of the New Zealand parrots indicative of having been maintained by selection and potentially functions in the presence of phytoestrogens despite having an Australian seed-based diet (Davis et al., 2017). This finding has potential significance for OBPs as OBPs share this sequence with New Zealand parrots and the Australian Cockatiel thus there is a potential for discovering a crucial link between reproductive success and diet.

Currently, little is known about the phytoestrogens in native OBP plants. It has been suggested that the genomics project could direct some focus to the oestrogen receptor to confirm if the findings from Davis et al. (2017) are relevant to OBPs (N. Murray, pers. comm.). If so, gauging an understanding of which local plants within the breeding area are the best sources of phytoestrogens may help in effectively supplementing feed tables and diets within captivity to increase breeding productivity as well as help direct fire management (N. Murray, pers. comm.).

Threat: Small population size

Corresponding Recovery Plan objective: Primary Objective 1 - achieve a stable or increasing population

Action: Investigate the role of phytoestrogens in relation to OBP breeding productivity

Barriers: Funding and resources, genetic diversity, timeframes, volunteer support, knowledge gaps

17.3.12.1 Expert Review Panel summary

Impact	Feasibility	Value	Likelihood of success	Overall Total
63.3% (4.7)	40% (3.6)	56.7% (4.2)	43.3% (3.5)	50.8%

It is worth exploring a little the recent advances from the Kakapo research, and there may be some obvious OBP management improvements that may arise if the research does indeed demonstrate that phytoestrogens influence productivity. Low reproductive success in the wild and captive populations is a major driver of ongoing population decline, so any factor that may substantially improve this may have major benefits.

Although this action, if successful, could "boost" productivity in the wild population and in captivity, it appears that it would have only moderate success until the causes for the loss of birds on the mainland and during migration are resolved.

17.3.13 Nutritional analysis

Trials to improve the nutrition in the breeding range from natural food plants and/or supplementary foods is considered a priority project to determine whether inadequate nutrition may be responsible for lower female survival, lower juvenile survival, or both (DELWP, pers. comm.).

The Tasmanian Government and the ANU are trying to establish a project involving the collection of 200g of seed from several key food plant species for OBPs for analysis for key

nutritional attributes. The aim of this research would be to better inform the diet of captive birds and supplementary food provided at the breeding grounds to develop a nutritionally balanced seasonal pellet diet (DPIPWE, pers. comm.). It has been identified that this project would only work if it was funded for delivery in Tasmania (all field work to be conducted in the Tasmanian Wilderness World Heritage Area). Additional Victorian funding would then be required to cover the collection and preparation of key mainland food plants (DELWP, pers. comm.).

Threat: Small population size, habitat loss and degradation, invasive weeds

Corresponding Recovery Plan objective: Primary Objective 1 - achieve a stable or increasing population; Primary Objective 2 – increase the capacity of the captive population

Action: Conduct nutritional analyses on Melaleuca food plants

Barriers: Funding and resources, volunteer support, timeframes

17.3.13.1 Expert Review Panel summary

Impact	Feasibility	Value	Likelihood of success	Overall Total
75% (2.12)	75% (3.54)	80% (2.83)	65% (2.12)	73.8%

There is a valid argument that the viability shortcoming of low reproductive output may be linked to provided foods having less nutrient content than traditionally-used wild food sources. This analysis may also help to fine-tune fire management to provide the most benefit to those plant species of most pivotal nutritional content.

17.3.14 Tagging

Owing to the significant proportion of birds not returning to Melaleuca each season, it has been suggested that some birds should be fitted with satellite transmitters each year to determine their movements and to help identify what is happening to these individuals (Adams & Purnell, 2016; J. Starks, pers. comm.). It is argued that these birds have a high probability of not returning to Melaleuca so why not try and fill some vital knowledge gaps. Use of transmitters would be restricted to released captive-bred birds.

Radio Frequency Identification Devices (RFID) are currently being discussed as a potential monitoring option for OBPs at feed tables and nest boxes at Melaleuca (DPIPWE, pers. comm.). VHF radio-telemetry is also being discussed to monitor OBPs away from the feed tables and nest boxes (DPIPWE, pers. comm.).

Threat: Small population size

Corresponding Recovery Plan objective: Primary Objective 1 - achieve a stable or increasing population

Action: Develop a protocol for tagging released captive-bred OBPs

Barriers: Funding and resources, population size and management, captive releases, technology, recovery team, knowledge gaps

17.3.14.1 Expert Review Panel summary

Impact	Feasibility	Value	Likelihood of success	Overall Total
63.3% (4.7)	60% (4.6)	66.7% (4.9)	56.7% (4.5)	61.7%

Understanding the migration route of OBPs and the fate of released birds is paramount, not only to better understand the biology of the species but also to better target management actions (i.e. predator control or supplementary feeding). Tagging that allows for definitive information on dispersal and survival will fill many critical knowledge gaps that currently hamper key management decision-making processes. But the technology has not yet allowed for such tagging. It is likely to in the next few years. Leading up to a time when this can be done, it would be worthwhile to continue to hone transmitter methodologies on captive birds and similar species. Perhaps a good idea is to seek technical advice from animal tracking companies/experts to trial prototypes.

17.4 Potential and existing management actions suggested by stakeholders for the captive population and review by the Expert Review Panel

17.4.1 Metapopulation approach

Movements of individuals between the captive and wild populations is likely to be crucial for achieving the objectives associated with each population under the current recovery plan (DELWP, 2016). The OBPRT have recently investigated using a metapopulation approach, combining the wild and captive population gene pools to reduce some of the genetic deficiencies due to previous genetic declines via a two-way genetic exchange to benefit both populations (Hogg et al., 2015). A metapopulation model is envisioned to help reduce loss of genetic diversity and inbreeding in the wild population as well as help achieve the insurance goal for the captive population by retaining 90% of the genetic diversity present in the 2010/11 founders for 50 years. Under this model, future captive releases would be guided by full genetic and demographic analyses.

Implementation of a metapopulation approach may however compromise the insurance objective of the captive population if more birds are released as well as jeopardise the already small wild population through further collection from the wild (OBPRT, 2017). The small size of the wild population further limits its ability to function as part of a metapopulation. The metapopulation approach is currently on hold pending results from preliminary molecular genetics work carried out by the Australian Museum and University of Sydney (ZAA, 2017).

DELWP are currently developing new Bayesian Network Models for 10 icon species, for which the OBP is one, funded under the Biodiversity On-ground Actions program. The models attempt to use expert knowledge and recovery planning documents to build a model that outlines the connections between threats and actions in Victoria and key outcomes for the species (amount of habitat, population size etc). DELWP aim to use these models to help identify where priority investments are best made to facilitate recovery. They will also provide a mechanism to record

information on action delivery of observed outputs and outcomes to test whether investments are having the anticipated impact (DELWP, pers. comm.).

Threat: Small population size

Corresponding Recovery Plan objectives: Primary Objective 1 - achieve a stable or increasing population; Primary Objective 2 – increase the capacity of the captive population

Action: Develop and implement a metapopulation approach for the species

Barriers: Population size and management, genetic diversity

17.4.1.1 Expert Review Panel summary

Impact	Feasibility	Value	Likelihood of success	Overall Total
46.7% (3.5)	50% (3.6)	40% (2.6)	36.7% (2.5)	43.3%

The wild and captive population are already managed at least in part as a meta-population. It is important to recognise and optimise linkages, but any approach must recognise a primary objective of attempting to maintain a wild population that can persist in nature. Some aspects of a metapopulation approach (e.g. taking more individuals from the wild) may be inconsistent with that primary objective. So long as a metapopulation approach does not subvert the likelihood of a viable OBP population in the wild or the maintenance of an insurance population, it can provide useful general guidance.

The current small population size in the wild stands out as a major limitation to the establishment of this approach. A way to preserve genetic material without compromising individuals or populations could be cryopreservation. Advice from experts in this matter is needed.

17.4.2 Colonial breeding

Breeding OBPs have largely been housed as single pairs in aviaries throughout the breeding season (Hockley & Hogg, 2013). One possible solution proposed to address the current space limitation within the captive-breeding program and investigate impacts to breeding productivity is colonial breeding (Hockley & Hogg, 2013). Disadvantages of housing breeding birds as a colony includes the potential for adverse behavioural issues to arise negatively impacting welfare and the loss of absolute certainty in parentage (Anon, pers. comm.). However, advances in DNA technologies including parental testing will enable the integrity of genetic management and pedigree analyses to be maintained (Hockley & Hogg, 2013).

The Priam Parrot Breeding Centre has had success in breeding trios of OBPs with a combination of two females and a male. However, most captive breeding facilities either haven't trialled this arrangement or haven't had success (Anon, pers. comm.). This arrangement was suggested to the OBPRT a few years ago when the captive population had an excess of females.

Threat: Small population size

Corresponding Recovery Plan objective: increase the capacity of the captive population

Action: Develop a protocol for colonial breeding within the captive population

Barriers: Genetic diversity, space availability

17.4.2.1 Expert Review Panel summary

Impact	Feasibility	Value	Likelihood of success	Overall Total
80% (2.6)	60% (1.7)	76.7% (3.2)	73.3% (3.1)	72.5%

There seems to have been many husbandry approaches trialled to date, at several different facilities, so it is disconcerting that there is still such uncertainty (and so little evidence or analysis) about optimal husbandry to achieve maximum reproductive output for captive birds. It could definitely act as a way to increase genetic diversity. Practicality of this management action is contingent on the availability and suitability of existing aviary facilities.

17.4.3 Threatened Species Prospectus

To secure the species from extinction, the Threatened Species Prospectus has announced $1 million over three years to secure OBPs at Healesville Sanctuary. The project will enable Healesville Sanctuary to conduct research to maximise the reproductive productivity of the captive population; provide medical and food resources for the captive population; provide adequate staff for Healesville Sanctuary and Werribee Open Range Zoo; and maintain current breeding facilities (DEE, 2017). Partners include Zoos Victoria, the OBPRT, ZAA and the Tasmanian Government.

The Threatened Species Prospectus has also announced $5.5 million over 5 years to enable the captive population to reach the target of 400 birds and develop novel research, quarantine and breeding facilities following the drastic declines in the wild and captive populations due to disease. Funding would cover essential genetic sampling and research to provide precise knowledge about the genetic diversity within the captive population; conduction of a disease risk analysis to enhance both wild and captive population management; research into PBFD and development of a vaccine in collaboration with world experts in Psittacine disease; expansion of aviaries to house an additional 160 birds; and to conduct research to enhance breeding success in the captive population (DEE, 2017). Genetic sampling and research is crucial to ensure the maintenance of genetic diversity enabling improvements to breeding productivity in the captive population and success of releases. Partners include Priam Psittaculture Centre Research and Breeding, Charles Sturt University, Australian Centre for Wildlife genomics, ZAA and the University of Sydney.

Threat: Small population size, disease

Corresponding Recovery Plan objective: Primary Objective 1 - achieve a stable or increasing population

Actions: 1) Conduct novel research into the reproductive productivity of the captive population

2) Maintenance of the current captive-breeding facilities and provision of adequate medical, food and staff resources

3) Conduct a disease risk analysis

4) Construct quarantine and extra captive-breeding facilities

5) Conduct research into PBFD and develop a vaccine

Barriers: Funding and resources, genetic diversity, space availability, captive releases, chick survival, knowledge gaps

17.4.3.1 Expert Review Panel summary

Action 1:

Impact	Feasibility	Value	Likelihood of success	Overall Total
60% (4.4)	56.7% (4.5)	50% (3.6)	50% (3.6)	54.2%

The relatively low and possibly diminishing reproductive success of the captive population is disconcerting and a major drag on the recovery effort, so it is important to trial new approaches that may lead to improvements.

While this action appears to be well-funded in the short-term, it is unlikely to have a high overall impact at the metapopulation level unless restoration activities on the ground are equally well funded. However, if this action proceeds and the funding is indeed available (i.e. $6.5 million over five years), a recovery in the captive population can galvanise further political support for actions in wild habitats.

Action 2:

Impact	Feasibility	Value	Likelihood of success	Overall Total
100% (0.0)	96.7% (0.6)	96.7% (0.6)	93.3% (1.2)	96.7%

This action seems to be an essential business-as-usual component of the overall recovery effort. The species will almost certainly become extinct, soon, if the captive-breeding facilities and effort are diminished. The captive-breeding component of the OBP program is paramount. Ultimately, it serves as an insurance population in case of a catastrophic event(s) in the wild.

Action 3:

Impact	Feasibility	Value	Likelihood of success	Overall Total
73.3% (1.2)	53.3% (3.8)	50% (3.6)	56.7% (4.0)	58.3%

It would provide a clear, robust and strategic foundation and context for responses to disease outbreaks and priority management approaches to reduce risks and consequences of disease. Any such framework should allow for some pragmatic flexibility rather than as a straitjacket for management. Potentially valuable for informing long-term management actions, however its utility in the immediate future is questionable. Scoring allocated here assumes that it should be straightforward to develop and conduct a disease risk assessment.

Action 4:

Impact	Feasibility	Value	Likelihood of success	Overall Total
96.7% (0.6)	63.3% (4.0)	83.3% (2.9)	86.7% (2.3)	82.5%

The recommended size of the insurance population is *circa* 410 individuals in order to retain ~95% of the genetic diversity over ~30 to 40 years. In order to achieve this target, the captive-breeding program needs to be producing an annual minimum surplus of 100 fledglings for release to the wild. Facilities for the captive population must therefore be capable of maintaining 510 individuals with further space to quarantine and treat birds that have tested positive to one of the many emerging diseases.

Beak and Feather Disease Virus (BFDV) and a number of other emerging diseases demonstrate the need for effective quarantine checks for transfers between facilities and to/from the wild. Without quarantine we run the risk of spreading pathogens, viruses, fungi and bacteria throughout the entire population (captive and wild). This will become even more critical if dwindling wild stocks and captive stocks are managed as a metapopulation. A facility specifically for the purpose of quarantine will aide BFDV research and vaccine development. The same facility can enable a smooth flow of bird movements, as positive results will not hider or delay movements of individuals necessary for breeding, release or holding over winter. There is therefore a need to expand or increase the number of facilities to accommodate the increased size of the insurance population with additional spaces in order to isolate diseased birds and implement correct quarantine protocols at any time of the year without inhibiting the breeding program or impacting adversely on individual welfare. A quarantine research and breeding facility should be established, accountable to the Commonwealth Government.

Increased capacity for captive populations and quarantine will help reach and maintain an insurance population of approximately 400 individuals, and also allow for substantial ongoing supplementation of the wild population. This action could "future proof" the OBP recovery once the captive population grows as more space would be necessary to hold birds for release and to nurse wild birds back to health. It also has potential to increase public support and engagement.

New, state-of-the-art quarantine facilities are urgently needed for use in housing confiscated exotic species and/or breeding endangered native species. Proposed facilities should be an entirely Commonwealth initiative (funded and operated) and be available for State and Territory wildlife agencies for captive breeding and re-introduction programs.

Action 5:

Impact	Feasibility	Value	Likelihood of success	Overall Total
56.7% (4.0)	30% (2.6)	36.7% (3.1)	40% (3.0)	40.8%

This could be a costly cul-de-sac, with low possibility of success. But there's a small chance that such research could deliver a tool that is of great benefit to OBPs and other species. The biosecurity measures described appear to have significantly decreased the detection of BFDV in OBP by PCR. Potential resources for BFDV vaccine could thus be better used in other actions in the short-term. Based on incidence of BFDV in subsequent years, the vaccine option could be revisited. Low scores reflect the utility of this initiative in recovering OBP because of the timeframe of research, efficacy testing and commercial production of a PBFD vaccine.

17.4.4 Force-flying birds

In order to improve the fitness of OBPs scheduled for release, force-flying of birds has been proposed. A new free-flight aviary was constructed at the Werribee Open Range Zoo (completed mid-2016 after several years of construction) to encourage birds designated for release to fly more to gain physical fitness, flight and foraging skills by having keepers usher them up and down the aviary to improve probability of survival in the wild (ZAA, 2013). An estimated 30 birds could be housed in the aviary for 3-6 months prior to release (Anon, pers. comm.). Force-flying has not yet been actioned due to disease issues which are preventing the movement of birds into this aviary (Anon, pers. comm.). It is anticipated that juveniles selected for release from Healesville Sanctuary will be transferred to the aviary in late 2017.

The aviary, including an attached visitor walk-through aviary, cost approximately $500,000 which was funded entirely by Zoos Victoria although external funding had been sought (Anon pers. comm.). Several other potential uses for the aviary are being investigated including ranching of wild birds over the winter months and breeding of 3-5 pairs of birds during spring and summer (Anon, pers. comm.).

Threat: Small population size

Corresponding Recovery Plan objective: Primary Objective 1 - achieve a stable or increasing population

Action: Implement a force-flying strategy for captive-bred birds prior to release into the wild to increase fitness

Barriers: Funding and resources, space availability, captive releases

17.4.4.1 Expert Review Panel summary

Impact	Feasibility	Value	Likelihood of success	Overall Total
60% (3.6)	56.7% (4.0)	50% (4.6)	60% (3.6)	56.7%

Sustained flight does not appear to be a critical factor (some birds, albeit small percentage, have demonstrated the ability to migrate to and from the breeding sites). Flight 'training' and planned public access is likely to cause injury and/or stress to OBPs.

Some behavioural training is worth trying given the low survivorship of captive-bred birds released to the wild, but likely gains may be small.

This is an important component as it will allow for survival comparisons between "force-flight" and "non-force flight" released birds. This action could help understand the role of physiological status among captive-bred birds released into the wild.

17.4.5 Genetic intervention

Declines in genetic diversity from within both the wild and captive populations can partly be reduced by following a Mean Kinship strategy and trying to equalise blood lines (Hogg & Everaardt, 2017). The focus on Mean Kinship is currently directed at the captive insurance population and not the wild population enabling decisions to be made to ensure that the captive population looks good genetically through selective releases of individuals into the wild but does not consider the wild population (Anon, pers. comm.). Mean Kinship of individuals released into the wild should also be investigated (Anon, pers. comm.).

Following the loss of genetic diversity from within the species, genome editing technology such as CRISPR-Cas9 which has the ability to modify an organism's DNA could be investigated as a tool to restore ancestral genetic diversity (Reardon, 2016; Stojanovic et al., 2017). Losses in genetic diversity within the wild population could then be restored through the selective release of captive-bred birds (Stojanovic et al., 2017).

OBP pairings are closely managed in captivity to maximise retention of genetic diversity and to equalise founder contributions with the population doing as well as it can with the genetic material remaining within the species. However, over a long timeframe, it is statistically likely that genetic diversity will further decline, which can already be seen in the low genetic diversity present within the immune regions. If genetic problems arise within the captive population, there are no significant genes left in the wild that are not present within captivity as far as the OBPRT are aware. The only tool that may therefore be available to correct any future genetic issues is outcrossing with another *Neophema* parrot species. Genetic rescue trials in captivity are currently considered a priority project to determine whether outbreeding can remedy the likely impacts of inbreeding on the captive and wild populations without having important fitness costs. Trials would need to be conducted over an appropriate time period to investigate what the impacts of outbreeding may be including measuring the fitness benefits and costs (e.g. maintaining fertility and the ability to migrate) and what is required to achieve a desired level of outbreeding. This action has therefore been flagged to start trials sooner rather than later so a genetic remedy is available if and when it is needed (DELWP, pers. comm.). At present, there are no known outbreeding options or trials for OBPs.

Threat: Small population size

Corresponding Recovery Plan objective: Primary Objective 1 - achieve a stable or increasing population

Actions: 1) Implement a Mean Kinship strategy for both the captive and wild populations

2) Utilise genome editing technology to restore ancestral genetic diversity and selectively release captive-bred birds into the wild

3) Genetic rescue trials including the outcrossing with another *Neophema* species

Barriers: Funding and resources, population size and management, genetic diversity, captive releases, technology

17.4.5.1 Expert Review Panel summary

Action 1:

Impact	Feasibility	Value	Likelihood of success	Overall Total
40% (3.5)	46.7% (3.1)	43.3% (4.0)	43.3% (4.0)	43.3%

There seems to be some contestation between husbandry that may be based on behavioural approaches to increase reproductive success and genetic approaches that instead seek to maximise genetic heterogeneity. It may be that some mix of both approaches is needed, but there seems inadequate justification to apply Mean Kinship as the over-riding criterion. Low score awarded because proposed selection of breeding pairs on the basis of Mean Kinship conflicts with the (preferred) proposed communal breeding strategy.

To successfully implement a Mean Kinship strategy first it is necessary to understand the current genetic population structure of the OBP. This approach would require ongoing revision. Perhaps it can be implemented in steps? Firstly, experiment with the captive population, then upscale to the wild population based on results.

Action 2:

Impact	Feasibility	Value	Likelihood of success	Overall Total
70% (1.0)	40% (2.6)	43.3% (2.3)	46.7% (2.5)	50%

Adventurous option that, if practical, may serve to enhance genetic diversity in the wild and captive populations, and hence improve some demographical and behavioural problems. Low scores as there are more pressing, cheaper alternatives that could bolster the OBP population. Perhaps a cheaper alternative to genetic intervention is cryopreservation.

Action 3:

Impact	Feasibility	Value	Likelihood of success	Overall Total
45% (4.95)	50% (5.66)	35% (4.95)	40% (4.24)	42.5%

This approach is simply a directed gradational extinction. There is little or no compelling evidence that population decline in the wild has anything to do with limited genetic variability. Is a potentially expensive endeavour that is not needed and potentially unfeasible.

17.4.6 Hybridisation

Hybridisation has successfully been used in other Australian avian species to prevent species extinction. The Norfolk Island Boobook (*Ninox novaeseelandiae undulata*) was reduced to a single female in 1986. Two males from the New Zealand Boobok (*N. n. novaeseelandiae*), the closest living relative, were introduced to Norfolk Island resulting in the production of viable offspring which then went on to breed with one another. The population has reached over 40 individuals although the species now exists solely as hybrids. Despite this, the mitochondrial DNA and approximately half of the nuclear genome from the original Norfolk Island Boobook species is conserved in the remaining population (Garnett et al., 2011).

Threat: Small population size

Corresponding Recovery Plan objective: Primary Objective 1 - achieve a stable or increasing population

Action: Develop a protocol for hybridising OBPs with a suitable species

Barriers: Population size and management, genetic diversity, recovery team, politics, knowledge gaps

17.4.6.1 Expert Review Panel summary

Impact	Feasibility	Value	Likelihood of success	Overall Total
10% (1.0)	26.7% (3.8)	20% (2.6)	23.3% (3.2)	20%

This is extinction under a different mechanism; it is likely to be challenging and costly to achieve; and will degrade the public's commitment to preventing OBP extinction through environmental care. This is a highly controversial subject and given the available evidence, not necessary a priority for political support or funding. Needs further, more detailed elaboration.

17.4.7 Aviary-only species

One proposal to stop the decline in the wild OBP population and to conserve the species is to collect the remaining wild birds and bring them into captivity. The species would therefore exist as an aviary-only species. This could also help to increase the genetic diversity within the captive population and potentially enhance breeding productivity within captivity. More resourcing to house these extra birds and resulting progeny would be required.

Threat: Small population size

Corresponding Recovery Plan objective: Primary Objective 2 – increase the capacity of the captive population

Action: Collect all remaining wild OBPs and incorporate them into the captive population so the population exists as an aviary-only species

Barriers: Funding and resources, space availability, recovery team, politics

17.4.7.1 Expert Review Panel summary

Impact	Feasibility	Value	Likelihood of success	Overall Total
0% (4.0)	46.7% (4.0)	0% (5.0)	3.3% (0.6)	10.8%

The captive-breeding of OBPs is an essential component for the recovery of the species but the available evidence indicates that the species can still be managed in the wild. There is no evidence demonstrating that captive-breeding of the entire species would improve the conservation prospects of the species. Most significantly, this step could eliminate important behavioural traits of OBPs, making the ecological restoration of the "OBP-saltmarsh-migration" impossible in the future. This move could also bring significant negative publicity. Definitively a "last resort" move. Besides, the death of at least 60 captive OBP indicates the need to further improve housing conditions, husbandry and handling within the captive population to minimise loses. Would a more effective "insurance" be to cryopreserve tissue for future cloning? Staff at San Diego Zoo might be interested if they have not been contacted already (institute.sandiegozoo.org/resources/frozen-zoo).

There is still hope and potential to maintain a wild population, and while that is the case, that should be the primary objective. While the importance of captive-breeding in assisting the recovery of OBPs is undeniable, maintaining the entire population of OBP in captivity (which is at capacity and requires ongoing funding and maintenance) cannot be presently thoroughly justified. Furthermore, there is no evidence supporting the view that managing the species entirely in captivity would bolster population size or maximise genetic diversity. This action is regarded as a very low priority in the current suite of proposed management actions and should be considered only as a last resort.

18. Additional recommendations provided by the Expert Review Panel

The following comments and recommendations have been provided by the three independent reviewers comprising the *Expert Review Panel.* **These comments and recommendations have not been assessed and weighted as in the previous sections and consequently only reflect the views of each reviewer.**

Reviewer 2: It is disconcerting that after 30+ years of research, it is still not clear the extent to which the limiting factors and those driving decline are related to wintering habitat quality or factors occurring in the breeding habitat, or a complex mix of both. If the problems largely arise in the breeding grounds, then any actions invested in improving quality of winter habitat may be entirely unrewarding. The current recovery plan seems to be bet-hedging (i.e. investing in actions to maintain or enhance habitat everywhere). This may not be a strategic approach.

There are many competing possibilities for research and management attention, for wild and captive populations; but there does not seem to be a current quantitative framework for evaluating the benefit and context of any action to the overall objective of recovering this species. For example, it does not seem clear whether demographic decline is mostly driven by low reproductive success or high mortality rates, and whether the latter occur mostly in breeding areas, on migration or in winter grounds; and hence where actions need to be directed most urgently to have the highest likelihood of improving those parameters that are most driving the decline. Therefore, it is recommended to use Bayesian networks linked to population viability analyses to help identify key knowledge gaps whose filling may most effectively resolve management uncertainties, and to prioritise management direction.

The recovery process to date has been possible only through substantial investment by governments, competitive research grants, philanthropic donations, and very substantial in-kind contributions by partners and the community. Funding allocated to this species dwarfs that provided to most Australian threatened species. However, funding to date has typically been short-term, unpredictable and insufficient for the very complex recovery management needs. Recovery, if at all possible, is likely to need continued funding at least at the past level for many decades to come. Although ongoing government investment is appropriate, what is needed is a large and secure long-term (multi-decadal scale) funding allocation. This may be possible only through a substantial investment from philanthropists (as is done routinely for many medical research facilities) or business. To achieve such a bequest may require the development and dissemination of a compelling prospectus.

18.1 Migratory and mainland sites

R1. Given ongoing floristic dynamics at winter grounds (and presumably also at migration sites), there is merit in determining which (native and introduced) plant species provide key nutritional resources at these sites. Also, given ongoing encroachment of introduced plant species at some sites, there may be merit in assessing whether any of these weed species are likely to have detrimental (toxic) impacts on OBPs (Reviewer 2)

R2. Restore, maintain or enhance some controls of mammalian predators (at least fox, cat) at key wintering and migration sites (Reviewer 2)

R3. As some of the coastal vegetation used by OBPs during migration and on the mainland may be affected by even small changes in sea level and hydrological processes, assess impacts of climate change on coastal floristic dynamics, and implement appropriate management responses if possible (Reviewer 2)

R4. Identify current key sites and management requirements of OBPs on King Island; if required engage with landholders to implement management that can enhance habitat quality and security (Reviewer 2)

18.2 Breeding sites

Because Melaleuca is the last remaining location where OBPs are known to nest, it is assumed that this site represents prime breeding habitat for OBPs. The opposite may be the case. The Melaleuca site may in fact provide sub-optimal breeding habitat and to persist in attempts to re-establish the species from this site may be counter-productive. No priority appears to be given to identifying and surveying west coast habitats to determine whether or not additional

sites of 'suitable' nesting habitat exist that could be utilised in the recovery program as possible release sites.

R5. Investigate the presence (and distribution) of areas of currently suitable habitat along the west coast of Tasmania that could serve as possible future breeding and release sites under the recovery program (Reviewer 1)

Most (or all) of the breeding adults leave Melaleuca on their return to mainland Australia before their fledgling offspring. This begs the question of how do naive fledgling OBPs know (or learn) to migrate? This behaviour of parent birds to 'abandon' their offspring makes no evolutionary sense unless, by doing so, it creates a role for post-reproductive adults to 'shepherd' fledglings on their initial northwards migration so that it becomes imprinted in the young birds. This hypothesis, if correct, provides a potentially valuable function for post-reproductive captive birds that are currently considered to have no role to play in the recovery program and are maintained by zoos and other institutions for display purposes only.

R6. Intensive monitoring should be undertaken at the Melaleuca breeding site to establish behaviour patterns of post-reproductive males, particularly during the period when breeding parents depart Melaleuca, to determine when post-reproductive males leave and whether they remain and depart with the fledglings (Reviewer 1)

R7. Appropriate and co-opt into the recovery program a selection of disease-free, biologically fit 'post-reproductive' males currently being used by zoos for display purposes and develop a strategy to release these colour-banded birds from a mainland over-wintering site with suitable habitat (Reviewer 1)

R8. Any disease-free, wild-caught, post-reproductive males, currently maintained in captivity for display purposes should be colour banded and released at Melaleuca in spring to coincide with the arrival of breeding adults (Reviewer 1)

18.3 Captive population

R9. Investigate cryopreservation of tissues to act as an insurance against extinction (Reviewer 3)

18.4 Studbook management

The current studbook program (PMX2000) is based on an algorithm that does not consider individual outcomes. Indeed, the studbook algorithm, developed for Tamarins, is being applied by the ZAA for a wide range of diverse species (e.g. Tasmanian Devil, OBP). The studbook algorithm has a starting point that every founder is 'unrelated', without supporting data. Furthermore, there is no evidence that studbook recommendations will not be harmful to the genetic/biological fitness of OBP.

The current studbook managers do not have practical experience or knowledge on breeding birds. The pairing recommendations produced by the Annual Report and Recommendations require multiple transfers between institutions yearly within restricted timeframes. This management regime will impede breeding results and significantly increase overall costs of the breeding program.

The ZAA Mean Kinship strategy for captive-bred birds has improved the Mean Kinship of the captive population, however it has had no obvious benefit to the wild population. Although the strategy may ensure that the insurance population looks healthy from an average Mean Kinship perspective, it may impact adversely on the fertility and fitness of the wild population. Wild OBP Mean Kinship is a metric not currently contained in the Annual Report and Recommendations.

R10. Employ all relevant data, including basic biology, to strengthen pairing recommendations generated by the theoretically-based genetic algorithm studbook program (Reviewer 1)

R11. Incorporate up-to-date information on known Mean Kinship characteristics of the wild population in future OBP Annual Report and Recommendations documents (Reviewer 1)

Rigorous monitoring and detailed record-keeping of incubation and neonate metrics (e.g. egg density, weight gain, incubation time, feed response, digestive time frame, balance, etc.) are standard biological practices that are used widely to determine biological fitness of individuals and pairings. These data can be fed back into the process to better inform future studbook pairing recommendations.

R12. Use standard biological husbandry metrics to ensure studbook recommendations are optimal or indeed beneficial (Reviewer 1)

18.5 Staffing issues

It is evident that government facilities holding OBPs have experienced regular mass mortality events due to a lack of knowledge and long-term experience in psittacine husbandry.

Release sites are currently monitored by volunteers and are managed by staff that have limited husbandry experience, perhaps only once a year for two weeks during a release. The absence of personnel experienced in captive husbandry of OBP, with staff/volunteers in the physical release of birds is a major welfare concern. Deaths of wild and captive OBPs at Melaleuca from contaminated seed during the 2016/17 season, caused by inexperienced staff, were clearly detrimental to the recovery program and could have been avoided if personnel charged with the responsibility of feeding and caring OBP received appropriate training.

R13. Care and handling of captive and wild OBPs should be restricted to trained staff with experience in OBP husbandry requirements (Reviewer 1)

R14. Release sites should be managed in a similar manner to captive facilities to ensure a consistent level of handling and care of OBPs that transition to the wild (Reviewer 1)

R15. Secure long-term reliable and adequate funding (Reviewer 2)

18.6 Political considerations

Both the structure and actual administration of the OBP recovery efforts have been modelled on the structure and administration of the Australian and New Zealand Environment Conservation Council. As a consequence, the OBPRT has become over-bureaucratised which, over the 30+ years of the initiative, has had a profoundly negative impact of the efficacy of recovery efforts.

An apparent lack of leadership or a policy of 'inclusiveness' and desire to involve all interested parties has resulted in available funds for the OBP recovery efforts being used to 'satisfy' all the different stakeholders. The various iterations of recovery plans do not provide performance indicators to assess whether or not sanctioned activities have achieved their objectives. This apparent absence of prioritising research and management activities has been perennial for the life of the initiative such that we know little more about OBP now than we did back in the 1980s.

There appears to be little or no consultation by independent researchers with the Captive Management Group or other expert bodies within the OBP Recovery Team. Concerns have been expressed that researchers have little or no experience with handling OBPs, use techniques that have an adverse effect on wild OBPs and do not measure or report these impacts. During the 2016/2017 season the experimental movement of captive fledglings into wild nests led to the deaths of the majority of chicks moved and the introduction of two, possibly three bacteria/viruses from captive birds to a wild OBP fledgling.

R16. Establish a mechanism to ensure that all actions by contracted researchers that impact negatively on the wild population are reported to the OBP Recovery Team, at regular intervals, such as in the Annual Report and Recommendations (Reviewer 1)

R17. Undertake an independent review of the composition and administrative infrastructure of the OBP recovery program, including the Terms of Reference of the OBP Recovery Team and all sub-ordinate groups with a view to down-sizing the number of participants and administration of OBP recovery efforts (Reviewer 1)

R18. Conduct a regular 3-5 year external (independent) review of progress, including assessment of recovery plan implementation, governance, budget stability, and prioritisation. This action may help to avoid capture by dominant in-house personalities, provide fresh eyes to seemingly intractable problems, and provide a re-assurance to funding bodies by holding recipients accountable as well as ensure outcomes are delivered in a timely manner (Reviewers 1, 2)

R19. Out-source all future recovery efforts, including captive-breeding activities to the private sector by contracting a suitably qualified entity capable of delivering conservation outputs. Such an entity would report and be accountable to a reconstituted OBP Recovery Team (Reviewer 1)

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Appendix 1: Acronyms

ABBBS	Australian Bird and Bat Banding Scheme
ANU	Australian National University
ASMP	Australasian Species Management Program
BFDV	Beak and Feather Disease Virus
BWP	Blue-winged Parrot
CASA	Civil Aviation Safety Authority
CMG	Captive Management Group
CMP	Captive Management Plan
DASETT	Department of Arts, Sport, the Environment, Tourism and Territories
DCE	Department of Conservation and Environment (Victoria). Now DELWP
DELWP	Department of Environment, Land, Water and Planning (Victoria)
DEWNR	Department of Environment, Water and Natural Resources (South Australia)
DPIPWE	Department of Primary Industries, Parks, Water and Environment (Tasmania)
DPIW	Department of Primary Industries and Water
DPWH	Department of Parks, Wildlife, and Heritage (Tasmania)
EPBC Act	*Environment Protection and Biodiversity Act* 1999
IUCN	International Union for Conservation of Nature
KINRMG	King Island Natural Resource Management Group
MERI	Monitoring, Evaluation, Reporting and Improvement
NPWS	National Parks and Wildlife Service
OBP	Orange-bellied Parrot
OBPRT	Orange-bellied Parrot Recovery Team
PBFD	Psittacine Beak and Feather Disease
PCD	Psittacine Circoviral Disease
PIT	Passive Integrated Transponder
PVA	Population Viability Analysis

RAOU	Royal Australasian Ornithologists Union
RFID	Radio Frequency Identification Device
rPOM	Relative Potential Occurrence Model
SAPG	Strategic Action Planning Group
VBA	Victorian Biodiversity Atlas
VHF	Very High Frequency
VTRG	Veterinary Technical Reference Group
WHA	Wildlife Health Australia
WTP	Western Treatment Plant (Werribee)
WWF	World Wildlife Fund
ZAA	Zoos and Aquarium Association

Appendix 2: Orange-bellied Parrot stakeholders

Government Agencies
Department of Primary Industries, Parks, Water and Environment (Tasmania)
Department of Environment, Land, Water and Planning (Victoria)
Department of Environment, Water and Natural Resources (South Australia)
Department of Environment and Energy (Australian Government)
Zoos Victoria
Adelaide Zoo
Taroona Captive Wildlife Breeding Program
Tasmanian Parks and Wildlife Service
Parks Victoria
Non-government Organisations
BirdLife Australia
Tasmanian Conservation Trust
Threatened Species Network (World Wide Fund for Nature)
La Trobe University (School of Genetics and Human Variation)
Sydney University
Australian National University
Moonlit Sanctuary Wildlife Conservation Park
Nature Glenelg Trust
Wildlife Health Australia
Zoos and Aquarium Association
Priam Parrot Breeding Centre
Recovery Groups
Orange-bellied Parrot Recovery Team
Strategic Planning Action Group
Captive Management Group
Veterinary Technical Reference Group
Environment Orange-bellied Parrot Group (Tas)

SUPERSEDED

Orange-bellied Parrot Tasmanian Program

Support Groups/Affiliations

Wildcare Friends of the OBP

Melbourne Water

Bush birds and beyond: Chris Tzaros

Appendix 3: Progress summary – 2006-2011 OBP Recovery Plan

The following table outlines the specific progress summaries against the 2006-2011 OBP Recovery Plan objectives and actions (sourced and adapted from Pritchard, 2014).

Objective	Action	Priority	Progress summary
To monitor the population size, productivity, survival and life history of the OBP	1.1	High	Standardised observations of breeding birds focussed on records of banded birds sighted on the feed table at Melaleuca. These data have proved to be invaluable to estimate annual survival, population trends, and to identify low breeding participation of females. the high quality of field data collected provided reliable information for decisions. Demographic analyses in 2010 identified a very low proportion of females participating in breeding and a declining population, promoting urgent actions, including supplementary feeding to encourage more females to participate in reproduction. Analysis of data did not occur until 2010 because this activity was not given the appropriate level of priority or resources.
	1.2	High	The annual summer monitoring has delivered on many of the specified activities. Nest boxes were checked annually and their nestlings banded, physical attributes of nests were recorded, samples were collected for later PCD analysis, and blood samples were taken for later DNA analysis. It is not possible to determine clutch and brood size at all natural nests, and because some unbanded birds persist in the wild population, it is not possible to determine parentage of all broods.
	1.3	High	May, July, and September counts occurred each year. Regional Coordinators and Project Officers from the Mainland Habitat Project worked with volunteers to improve their identification skills, ability to record coloured leg-bands, and to improve the quality of survey reports to include both null and positive sightings. A detailed analysis of records of banded birds on the mainland has yet to be undertaken.
	1.4	High	No progress due to lack of funding and limited staff time.
To identify all sites used by OBPs and better understand migration movements	2.1	High	There was no funding to undertake this activity. However, the Mainland Habitat Project improved definitions of non-breeding habitat and mapped all saltmarsh and pasture habitats areas in Victoria and South Australia at 1:10,000. More detailed vegetation maps for saltmarsh have or are being prepared in each state as part of saltmarsh conservation projects. Significant habitat identification work was also completed on King Island.
	2.2	High	The Mainland Habitat Project increased the capacity of volunteers to report sightings and made detailed assessments of the foraging and roosting habitat use of birds between 2006 and 2008. The project report provides contemporary and broad ranging data on

			habitat use on the mainland. Results have been directly applied to some habitat restoration projects in Victoria and South Australia.
	2.3	High	A major survey was conducted in the first year of the Recovery Plan which identified low numbers of birds at three other sites. Surveys were repeated in January 2010 and failed to detect and breeding birds outside the Melaleuca area.
	2.4		A review of available technologies was undertaken early in the implementation phase. At the time, radio- and satellite-tracking technology was not available for such a small bird. Prototype acoustic monitoring technology was trialled but does not yet meet the needs of the recovery program. The expectations of technological development were unrealistic.
To increase the carrying capacity of habitat through active management of sites throughout the species' range	3.1	Medium	Fire Management Plans for south-west Tasmania were not implemented to the benefit of OBP habitat management until 2011. In addition, a new small-scale tourist development in south-west Tasmania failed to appropriately engage species experts at an early stage to avoid impacts on habitat. Few new management plans of relevance to OBP habitat were developed. Where plans were drafted, project staff working on OBP provided direct input. No staff were available to undertake a major review of all plans and strategies to identify new linkages of benefit to the recovery program.
	3.2	High	There was no progress until 2010. Delays were due to the complexities surrounding fire management in the World Heritage Area and resource limitations for the Tasmanian Parks and Wildlife Service. This lengthy delay may have had a serious impact on the quantity of quality feeding habitat for OBPs and subsequently on breeding productivity and population decline. The first burns of strategic and ecological importance occurred in autumn 2011. No fire ecology research was conducted due to limited resources.
	3.3	High	Nest boxes have been maintained and monitored, facilitating the colour-banding program and monitoring of nest productivity. These activities provided high quality demographic data for monitoring the population. Nest boxes have continued to be important. Control of starlings and honeybees has been implemented as required.
	3.4	High	Little information was provided to assess this action. Available information suggested that there has been little progress due to competing pressures for resources.
	3.5	High	Habitat restoration activities focussed largely on roost site revegetation near existing feeding habitats in Victoria and South Australia. This approach sought to improve the amenity of feeding areas by providing roosting locations. Some saltmarsh revegetation occur in Victoria, but in many cases establishment of the new plantings was poor. The Werribee River Mouth was afforded greater protection when it was protected as the Werribee

			River Park for management by Parks Victoria, but the Saltmarsh Revegetation Plan has not been implemented. Much habitat protection and management on private land occurred as part of broader land stewardship programs undertaken by NRMs and CMAs. Because the objectives of the stewardship programs were much broader than OBP habitat management, it is difficult to ascertain exactly how much habitat was created or better managed under these programs. Habitat restoration activities were not implemented with an adaptive experimental approach due to funding limitations which are often provided for on-ground works, but not lasting monitoring of the impacts of those works.
	3.6	Medium	No releases were made on the mainland. The OBPRT determined that the higher priority for releases during this period was Birchs Inlet where an attempt was made to establish a second breeding population.
	3.7	High	A small study, funded from an offset payment, investigated the impacts of sheep grazing at the Spit Nature Conservation Reserve. The study did not find a significant effect of sheep grazing. However, the results should be used to inform a more thorough investigation in the future.
To identify, measure and ameliorate threats, particularly in migratory and winter habitats	4.1	High	Monitoring of human activity at the listed sites was not seen as a priority for limited resources. However, controls are in place to restrict access to Swan Island and sensitive areas of the Western Treatment Plant which have potentially limited the impacts of human activity.
	4.2	High	State and Commonwealth Government agencies have procedures for managing the risks of wind farms and these procedures effectively detect potential risks to OBPs and manage them through standard protocols for managing risks to EPBC-listed birds. Media coverage surrounding the Bald Hills Windfarm in 2007 raised the profile of potential conflicts between OBPs and wind farms making the industry, the public and agencies sensitised to the issue.
	4.3	Medium	Little progress has been made. Anecdotal reports of parrots attracted to squid boats are occasionally reported but it is unclear if these stem from a single or multiple occurrences. Recent investigations (2010) suggest that squid fisheries would rarely overlap with migrating OBPs so the risk would only be present in a small proportion of migration events. However, no progress has been made to determine the degree of risk posed when squid boats and OBP migration do overlap.
	4.4	Medium	Some predator control programs have been implemented but have been lacking a specific research or monitoring component to address the efficacy for OBP protection. In the majority of cases, predator control has been implemented for broader biodiversity conservation objectives with potential benefits for OBPs. As an exception, a Cat Management Plan was developed for King Island

		with funding to specifically address risks to migrating OBPs. Implementation of the Cat Management Plan has been hampered by limited support from the broader King Island community.
4.5	Low	No progress due to resource limitations.
4.6	High	There has been little coordinated progress on this action. Some habitat restoration projects targeted weed infestations in an opportunistic manner and some land management agencies have site-specific control programs. It is also likely that NRM bodies provide incentives for the control of key weeds in some locations. Because there has been little coordination of this activity, it is very difficult to measure the success of control measures. Significant effort has been made by (Sea) Spurge Remote Area Teams to control Sea Spurge along the west coast of Tasmania. This invasive weed has been effectively controlled within the WHA through this program which is coordinated and funded through Wildcare Inc.
4.7	High	A new PVA model was prepared at an OBPRT workshop in 2007. The model was not used to examine the threats to the species as envisaged by the recovery plan. Instead, the model was explored to examine the impacts of removing 8 juvenile models from Melaleuca to add to the captive-breeding population. The model also considered population growth at Melaleuca, the captive population and the Birchs Inlet translocated population in a metapopulation model. This approach identified that low survival at Birchs Inlet was limiting the growth of that sub-population, During the modelling exercise, the percentage of females contributing to reproduction had to be reduced to produce population growth figures approaching the apparent stability of the wild population. Without this adjustment the models predicted population growth far beyond what was observed in the wild. Further interrogation of the model assisted in the identification of low female breeding participation as a potential factor limiting population growth. Analysis of observational data from Melaleuca suggested that this was indeed occurring in the wild. During 2011, a simplified PVA was used to examine the impacts on the wild population of collecting new birds for the captive-breeding program. The simplified approach was used because the model was examining a very small wild population, which PVA approaches have limited capacity to estimate. Nevertheless, the modelling approach provided some information on the relative impacts of different harvest scenarios which helped to inform the OBPRT decision to collect most of the juveniles produced in summer 2010/11.
4.8	High	Little information was provided to assess this action. Implementation is suspected to be limited. A new interpretative trail established at Melaleuca failed to take into account OBP requirements in the early planning phase and necessitated relocation of the supplementary feeding table away from the new trail.

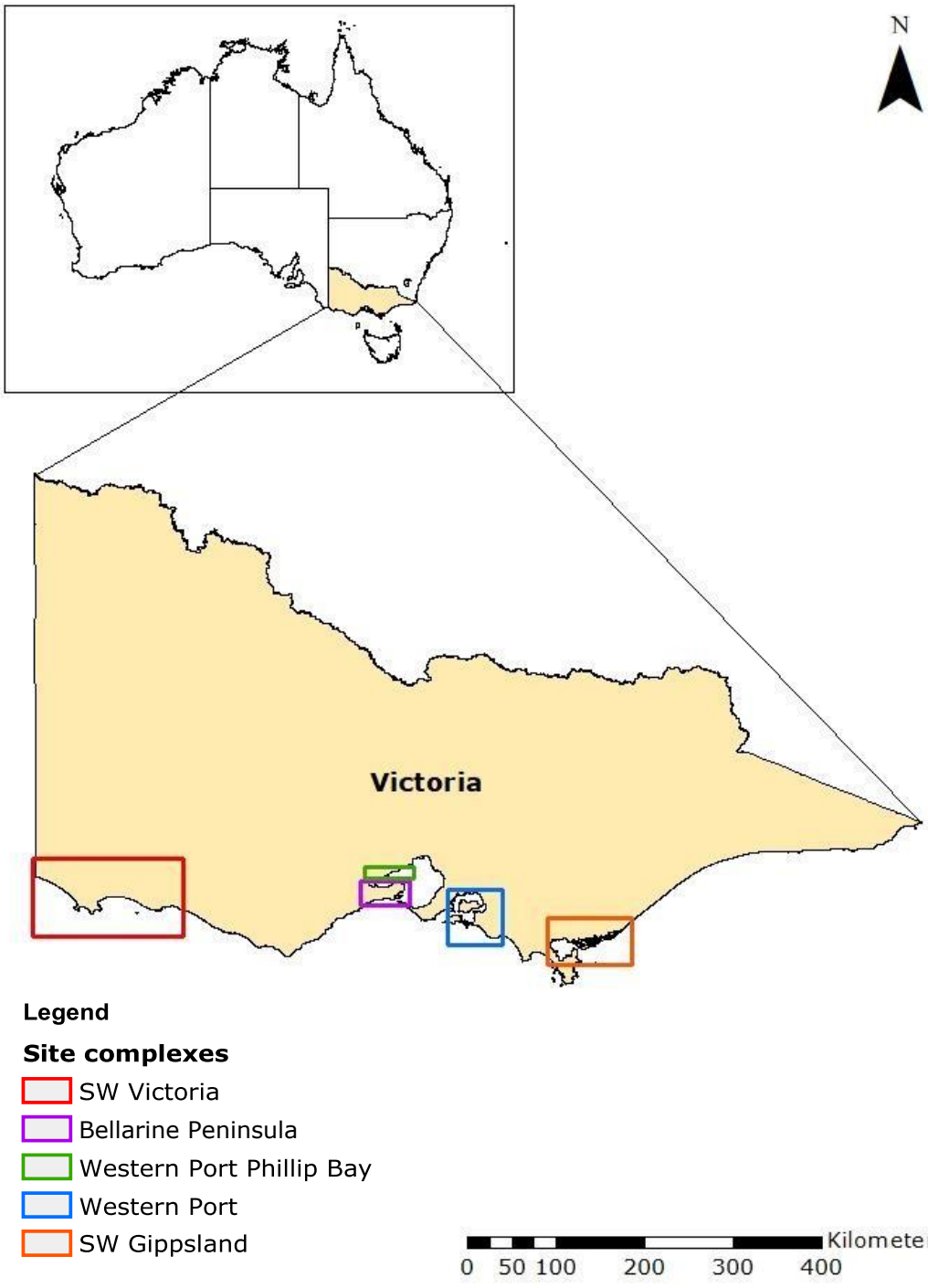
To increase the number of breeding sub-populations or groups	5.1	High	Birds were released at Birchs Inlet in most years. Many aspects of the release program were successful - captive-bred birds were available for release, volunteers assisted with husbandry of birds at the Taroona Wildlife Centre and monitored released birds, and potential competitors were monitored by volunteers and controlled by DPIPWE when required. Released birds had good post-release survival and some paired and bred at the site before undertaking migration. Breeding success was, however, low, as was annual survival. Fire management was not undertaken due to the complexities of applying fire in the WHA. Strategic reviews of the effectiveness of the release program were limited to the 2007 PVA metapopulation analysis and the 2010 report to the OBPRT which resulted in a recommendation to cease the release program.
	5.2	Medium	No progress because of the focus of the release program was Birchs Inlet. Limited funding resulted in no staff capacity to investigate other options for the future.
To maintain a viable captive population	6.1	High	New aviaries were constructed at the Taroona Wildlife Centre and Healesville Sanctuary in 2008/09 when funding became available. The captive population was maintained at around 150 birds. This population size and level of productivity produced sufficient juveniles to support the release program at Birchs Inlet.
	6.2	High	Funding limitations prevented monitoring of heterozygosity in the wild and captivity. A Melbourne Water funded project at the University of Melbourne is currently examining the loss of genetic variation from the wild and captive populations over time. However, the need for more genetic variation in the captive population was inferred by persistent low egg fertility rates despite improved husbandry and an association between inbreeding coefficients and infertility in the captive population. Two founders were collected in 2008. When the severe decline of the wild population was identified in 2010, a concerted effort was made to collect new founders for the captive-breeding program, with 23 individuals collected in 2010 and 2011.
Foster community support and involvement in the conservation and recovery of the species and its habitat	7.1	High	Significant progress was made during the Mainland Habitat Project. Project Officers prepared identification brochures, an up- to-date website hosted by BirdLife Australia and held identification workshops and field days to build the capacity of volunteers to assist in the winter survey effort. Some of the communications tools identified in the plan became redundant and were therefore not produced, for example internet based media has superseded the need for a multi-media CD-ROM. Many of the coordination tasks were not fulfilled because of lack of resources to undertake the work.
	7.2	High	During the period of the plan the Regional Group network expanded to include three South Australian, three Victorian, and one Tasmanian group. The Mainland Habitat Project provided significant support to mainland groups, preparing reference

			materials and holding *Neophema* and food identification training workshops to increase the capacity of volunteers. The Regional Group model worked well to mobilise support from volunteers and landholders. Regional workshops increased the skill level in volunteers and improved the quality of sightings reported. Other improved volunteer services included improved coverage of habitat areas for surveys, and an increase in the reporting of relevant anecdotal observations. This model of regional coordination also improved access to local news outlets and raised community understanding of OBP conservation issues.
	7.3	High	The *Trumped-up Corella* was not published until 2009. This delay was due to the absence of funding for the Recovery Project Coordinator and the Winter Project Officer positions and therefore a lack of staff to support the volunteer editor. In 2009, the publication was reinvigorated under the voluntary support of one of the Regional Coordinators and the Birds Australia Threatened Bird Network Coordinator.
	7.4	High	There was no central coordination of volunteer activities across the recovery program. However, Friends of the OBP WildCare provides support of the summer volunteer program, and Regional Coordinators and the Winter Count Coordinator provide management and support of the winter volunteer program. Where other OBP projects occurred, Project Officers determined the level of volunteer involvement and managed volunteer participation locally.
Develop and implement a Recovery Fund Plan	8.1	High	No progress was made on this action due to resource limitations.
	8.2	High	An initial attempt to outline research priorities was made in 2009, with more discussion at the OBPRT meeting in 2010. However, no formal process for seeking collaborative research opportunities has been undertaken. The limited progress results from a lack of funding for the Recovery Program Coordinator position.
Manage, review and report on the recovery process	9.1	High	The OBPRT met at least annually throughout the life of the recovery plan. In most years, the team held two face-to-face meetings, and additional meetings and teleconferences were held as the group agreed. It is possible, however, that more frequent working group meetings or teleconferences may have assisted in the implementation of actions that received little attention. The Chair was rotated among the three range states. Meetings were used as a forum to update the team on progress against key actions in the plan, hear from stakeholders working on external projects of significance and to discuss issues. Terms of Reference for the OBPRT were drafted in early 2011 to guide team function.
	9.2	High	A Recovery Program Coordinator was not appointed because the position was unfunded. In 2010, under the funded Action Plan for the OBP, an Action Plan Coordinator role was created which effectively provided coordination services to the OBPRT.

9.3	High	In 2010 monitoring data suggested there were less than 50 OBP remaining in the wild. This indicates that the current Critically Endangered status is still correct.

Appendix 4: Project site complexes

Location of the five identified OBP winter site complexes located in Victoria.



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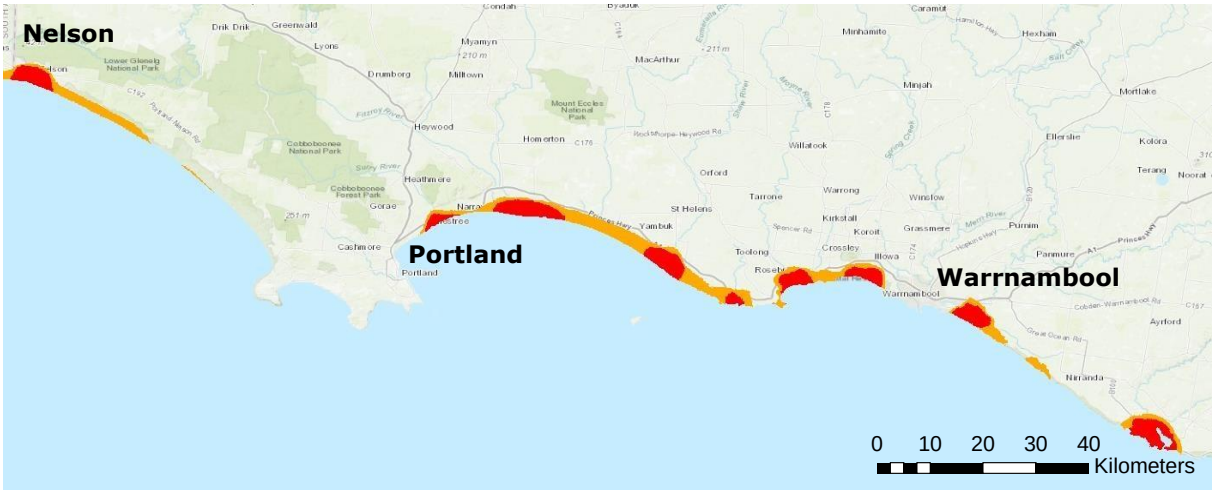
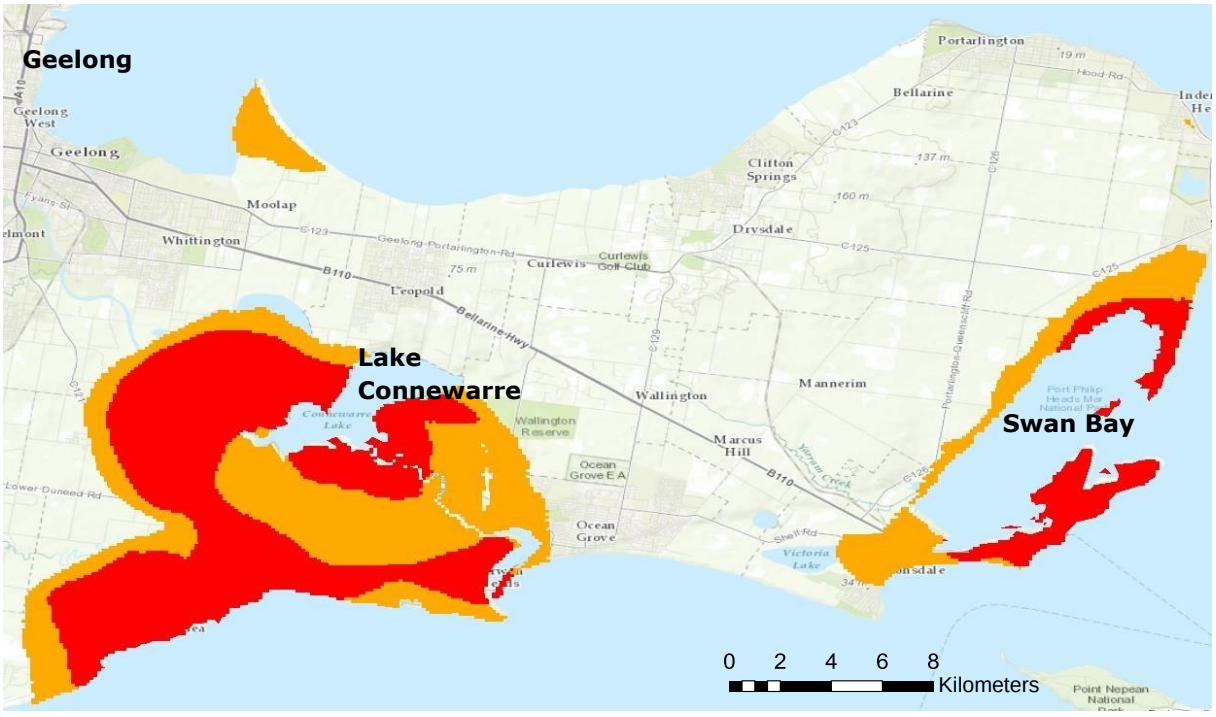
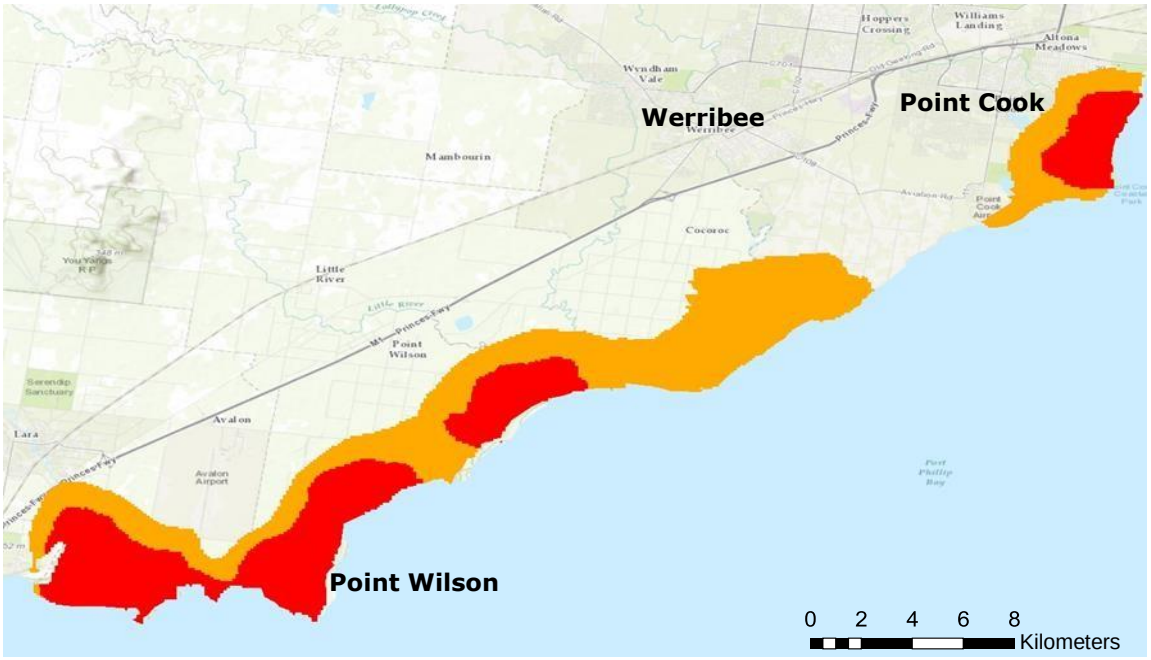
A) SW Victoria site complex (red represents habitat with high relative probability of OBP occurrence values, orange represents habitat associated with medium relative probability of OBP occurrence values; Ehkme, 2009)



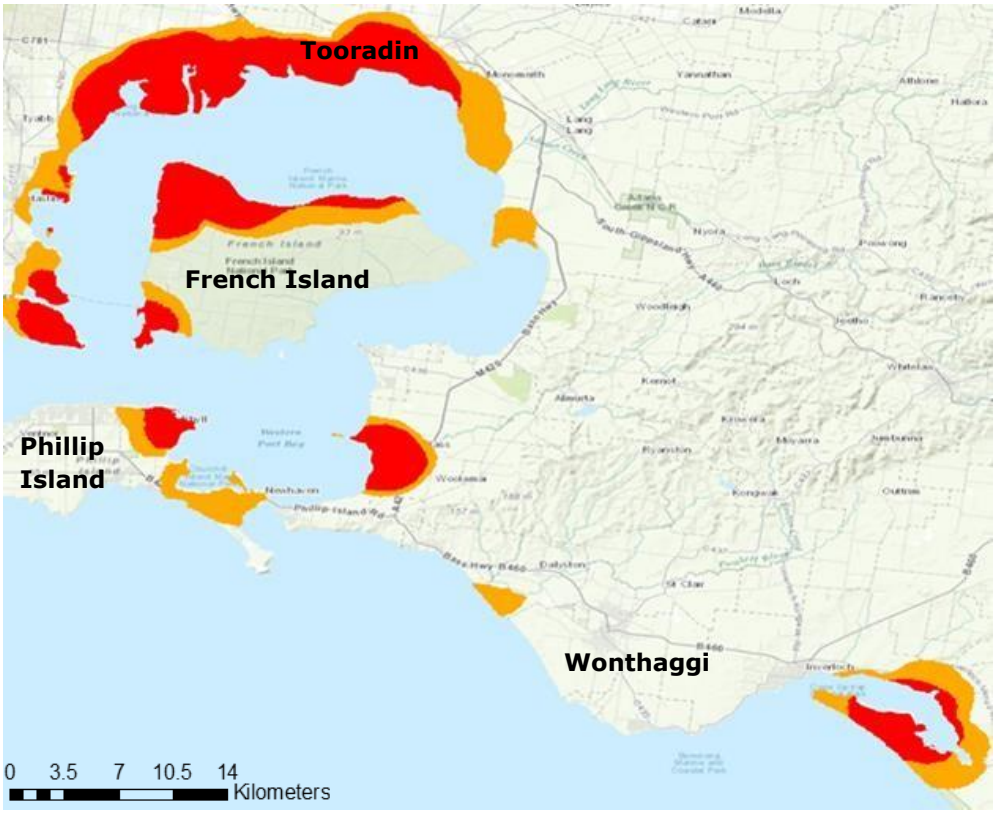
B) Bellarine Peninsula site complex (red represents habitat with high relative probability of OBP occurrence values, orange represents habitat associated with medium relative probability of OBP occurrence values; Ehkme, 2009)



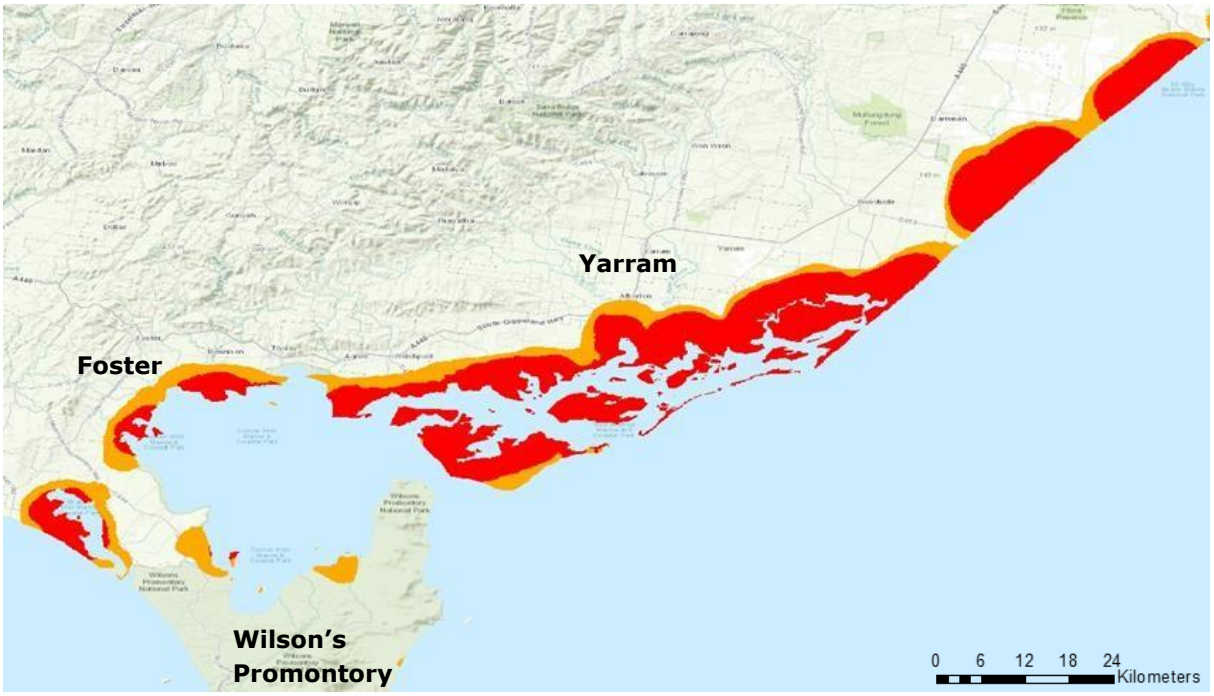
C) Western Port Phillip Bay site complex (red represents habitat with high relative probability of OBP occurrence values, orange represents habitat associated with medium relative probability of OBP occurrence values; Ehkme, 2009)



D) Western Port site complex (red represents habitat with high relative probability of OBP occurrence values, orange represents habitat associated with medium relative probability of OBP occurrence values; Ehkme, 2009)



E) SW Gippsland site complex (red represents habitat with high relative probability of OBP occurrence values, orange represents habitat associated with medium relative probability of OBP occurrence values; Ehkme, 2009)



Appendix 5: Process for reviewers: recommendations on potential management strategies for the OBP

Table 9 represents a summary of potential and existing management actions and strategies suggested by stakeholders for OBPs (covered in detail in section 17). Potential management actions are listed under the threat category (see section 5) that they target. However, this does not necessarily mean that they are inclusive of this threat only as they may be linked to other threatening processes.

It is suggested that the reviewers sitting on the Expert Review Panel use the summary table to independently rank each potential management action by impact, feasibility, value, likelihood of success, and overall rating using a scoring system from 1 (very low) to 10 (very high).

- Impact refers to the overall impact the management action is likely to have on the recovery of the OBP
- Feasibility refers to practicability of the management action being implemented
- Value refers to value for money of implementing the management action
- Likelihood of success refers to the probability that the management action will be successful in achieving the desired outcome
- Overall rating refers to a summary of all of the assessment categories and is generated by adding the values from the previous four columns

Management actions are in no particular order and have not been costed, so these assessments will necessarily be a qualitative judgement based on the reviewer's knowledge, expert opinion, and the information presented in this report.

Reviewers are not restricted to assessing only the potential management actions provided by stakeholders, and are invited to provide their own recommendations on management actions and strategies for implementation in future OBP recovery efforts. Reviewers are also encouraged to assess and comment/provide recommendations on the current priority actions identified by the OBPRT (refer to section 17).

Reviewers are encouraged to identify their top five priority management actions and strategies, and to give their recommendation on the optimal timing and/or order of their identified priorities.

Upon receipt of the recommendations from each reviewer, a teleconference may be held to discuss and finalise recommendations.

Table 9: Summary of the potential management actions provided by stakeholders for the recovery of OBPs listed under the threat that they directly target and a ranking matrix completed independently by each reviewer on the Expert Review Panel.

Management action	Sought outcome	Impact*			Feasibility*			Value*			Likelihood of success*			Overall rating†			Overall total‡
Habitat loss and degradation																	
Implement regular patch-burning at known and potential OBP breeding locations	Improve breeding success	10	9	10	5	5	8	10	9	10	10	9	8	35	32	36	**103**
Small population size																	
Establish a more thorough mainland winter survey regime across traditional and potential OBP sites	Increase the probability OBPs are located on the mainland improving knowledge	5	3	9	3	4	10	5	2	8	5	2	8	18	11	35	**64**
Continue, with adjustments, the four-year Mainland Release Trial Program in an effort to supplement and increase the wild OBP population	Bolster the wild population	9	8	8	5	7	10	10	6	8	5	5	6	29	26	32	**87**
Increase the number of captive-bred birds released into the wild each year	Bolster the wild population	10	9	9	5	7	10	10	8	9	10	6	8	35	28	36	**99**
Develop a protocol for tagging released captive-bred OBPs	Address current knowledge gaps in OBP ecology, movements and habitat use	1	8	10	1	7	10	1	9	10	1	6	10	4	30	40	**74**
Continue intensive monitoring of all wild nests through direct observations and motion cameras	Improve wild breeding success	10	8	10	6	8	10	10	9	10	10	8	10	36	33	40	**109**
Continue implementing current cross-fostering techniques and investigate the potential to swap captive and wild chicks to correct sex-ratio biases or genetic representation	Improve wild breeding success	2	9	10	2	5	10	5	8	10	5	6	10	14	28	40	**82**
Develop protocols to harvest the first clutch of eggs from the wild for inclusion into the captive population	Improve genetic diversity and representation in the captive population	2	-1	6	2	1	8	2	1	5	2	0	4	8	1	23	**32**
Investigate the potential of unoccupied habitat near Melaleuca to be used as extra release sites	Bolster the wild population	10	3	8	10	5	9	10	3	8	10	3	8	40	14	33	**87**
Extension of the OBP studbook to include wild nests	Improve genetic diversity and representation in the captive population	1	5	10	1	7	10	0	5	10	1	7	10	3	24	40	**67**
Obtain wild birds with under-represented genotypes in captivity for inclusion into the captive population	Improve genetic diversity and representation in the captive population	0	0	7	0	2	10	0	0	3	0	2	5	0	4	25	**29**
Develop and implement a metapopulation approach for the species	Reduce loss of genetic diversity and inbreeding in the wild population; achieve insurance goal for the captive population	1	5	8	1	8	6	1	6	5	1	6	4	4	25	23	**52**

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Develop a protocol for colonial breeding within the captive population	Improve breeding success	10	5	9	5	5	8	10	4	9	10	4	8	35	18	34	**87**
Investigate the role of phytoestrogens in relation to breeding productivity	Improve breeding success	1	8	10	1	3	8	1	7	9	1	4	8	4	22	35	**61**
Conduct novel research into the reproductive productivity of the captive population	Improve breeding success	1	8	9	1	6	10	1	6	8	1	6	8	4	26	35	**65**
Maintain the current captive-breeding facilities and provide required medical, food and staff resources	Improve breeding success	10	10	10	10	9	10	10	9	10	10	8	10	40	36	40	**116**
Construct quarantine and extra captive-breeding facilities	Improve breeding success and survival	10	9	10	2	7	10	10	5	10	10	6	10	32	27	40	**99**
Implement a force-flying strategy for captive-bred birds prior to release into the wild to increase fitness as well as develop a protocol for vigilance and predator-avoidance training prior to release	Improve survival of captive-released birds to bolster wild population	5	3	10	5	2	10	1	4	10	5	3	10	16	12	40	**68**
Collect all remaining wild OBPs and incorporate them into the captive population so the population exists as an aviary-only species	Conservation of remaining birds; improved genetic diversity in captivity	0	-5	3	0	7	7	0	-5	5	0	0	1	0	-3	16	**13**
Implement a Mean Kinship strategy for both the captive and wild populations	Conserve genetic diversity in both wild and captive populations	2	2	8	2	4	8	2	2	9	2	2	9	8	10	34	**52**
Utilise genome editing technology to restore ancestral genetic diversity and selectively release captive-bred birds into the wild	Restore genetic diversity to the species	7	6	8	3	2	7	3	3	7	5	2	7	18	13	29	**60**
Develop a protocol for hybridising OBPs with a suitable species	Prevent total extinction of the species	0	2	1	0	1	7	0	1	5	0	1	6	0	5	19	**24**
Develop a protocol to monitor the departure of migrating OBPs from King Island to determine landfall on the mainland following the compass course migration strategy	Improve population management	10	1	10	10	0	10	10	1	10	10	1	10	40	3	40	**83**
Hold volunteer workshops within each site complex prior to the first winter count weekend in May	Improve volunteer morale and support	5	3	8	5	7	10	7	2	8	5	5	8	22	17	34	**73**
Predators and competitors																	
Develop and implement a pro-active predator control program at the breeding grounds in Melaleuca	Improve survival within the wild population	2	7	10	2	3	10	2	5	10	2	4	10	8	18	40	**66**
Close the museum feed table at Melaleuca	Improve survival within the wild population	10	1	8	5	8	10	10	3	8	10	4	8	35	16	34	**85**

Stochastic factors																	
Ranch half of the wild juvenile cohort and all captive-released females over winter on the mainland through assisted migration	Improve survival within the wild population	5	6	8	5	3	7	1	5	8	5	2	8	16	16	31	**63**
Disease																	
Conduct a Disease Risk Assessment	Enhance population management	8	6	8	1	7	8	1	6	8	1	8	8	11	27	32	**70**
Conduct research into PBFD and develop a vaccine	Improve survival	1	8	8	1	2	6	1	3	7	1	4	7	4	17	28	**49**
Develop protocols to immediately capture any wild OBP in poor condition to receive a health assessment	Improve survival within the wild population	1	3	8	1	8	8	1	2	8	1	4	8	4	17	32	**53**
Negative effects of management																	
Develop and implement a communications plan to service the information requirements of a range of partners and stakeholders with coordinated communications products including the public archiving of documentation	Provide a robust recovery effort for the species	10	7	10	2	9	8	10	7	10	10	7	9	32	30	37	**99**
Develop a clear action framework including the identification of responsible organisations and mechanisms for standardised reporting and progress updates	Provide a robust recovery effort for the species	10	2	9	2	6	9	10	3	9	10	5	9	32	16	36	**84**
Develop a centralised dynamic database for information sharing and facilitation of informed decision-making	Provide a robust recovery effort for the species	10	2	10	2	3	10	10	2	10	10	2	10	32	9	40	**81**
Develop a scientific committee independent on the OBPRT to review all management actions and provide scientifically robust advice	Provide a robust recovery effort for the species	0	3	10	0	3	10	0	2	10	0	2	10	0	10	40	**50**
Reduce the amount of supplementary food provided at the breeding grounds with the aim of complete removal	Improve survival and breeding productivity	10	3	3	5	7	10	10	2	2	10	2	1	35	14	16	**65**
Investigate the nutritional profiles of natural food plants to guide the formulation of the supplementary diet	Improve survival and breeding productivity	5	6	10	5	5	8	5	6	10	5	5	8	20	22	36	**78**

*Score: 1 (very low) to 10 (very high); †Sum of the previous four columns; ‡Sum of the overall totals from the three reviewers