THREAT ABATEMENT PLAN

Psittacine Beak and Feather Disease Affecting Endangered Psittacine Species

Natural Heritage Trust

Helping Communities Helping Australia

An Australian Government Initiative

Australian Government

Department of the Environment and Heritage

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for

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ISBN 0 642 54911 7

Published 2005

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Front cover photo: Dave Watts

This publication is available online at www.deh.gov.au/biodiversity/threatened/publications/tap/beak-feather/index.html. For additional hard copies, please contact the Department of the Environment and Heritage, Community Information Unit on 1800 803 772.

Note
This threat abatement plan sets out a framework to reduce the impact of Beak and Feather Disease on psittacine species to an acceptable level. The Australian Government is committed to acting in accordance with the plan and to implementing the plan as it applies to Commonwealth areas.

The plan has been developed with the involvement and cooperation of a broad range of stakeholders, but the making of this plan does not necessarily indicate the commitment of individual stakeholders to undertaking any specific actions. The attainment of objectives and the provision of funds may be subject to budgetary and other constraints affecting the parties involved. Proposed actions may be subject to modification over the life of the plan due to changes in knowledge.

Foreword

Psittacine Beak and Feather Disease was listed in April 2001 as a key threatening process under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). A key threatening process is defined as a process that threatens or may threaten the survival, abundance or evolutionary development of a native species or ecological community. A process can be listed under the EPBC Act as a key threatening process if:

- it could cause a native species or ecological community to become eligible for listing as threatened (other than as conservation dependent) *or*
- it could cause an already listed threatened species or threatened ecological community to be listed at a higher endangered level *or*
- it adversely affects two or more listed threatened (other than conservation dependent) species or threatened ecological communities.

Once adopted, the Australian Government implements a threat abatement plan as it applies on Commonwealth land and seeks the cooperation of the states and territories to implement the plan within their jurisdictions. The Australian Government also supports national implementation through financial assistance for key national level actions in the plan, such as research and demonstration model projects to develop tools to address the threatening process.

Australia is renowned for its rich biodiversity and is justly famous for its magnificent bird life, including the great variety of colourful parrots. This country's wildlife is a rich and fundamental element of our natural heritage. However, new and emerging wildlife diseases pose a serious threat to biodiversity. The range of threatening processes makes some already threatened species more vulnerable to disease – including to those diseases already widespread in Australia.

While considered by some to be common, Beak and Feather Disease is a potentially deadly disease of parrots. This virus has the potential to cause impacts that range from inconsequential to devastating. It is currently not possible to eradicate widespread diseases that are continuously present, but an array of targeted actions combined with well developed management plans can assist in reducing the impact of the disease on threatened parrot populations.

Threat abatement plans aim to reduce to acceptable levels the impacts of key threatening processes that jeopardise the long-term survival of native species and ecological communities.

This threat abatement plan has two goals:

- To ensure that Beak and Feather Disease does not increase the likelihood of extinction or escalate the threatened status of psittacine birds.
- To minimise the likelihood of Beak and Feather Disease becoming a key threatening process for other psittacine species.

These goals will be achieved by implementing currently available management techniques to promote the recovery of nationally listed threatened species affected by the disease, providing for the development of new techniques, coordinating management activities, promoting education and awareness and collecting information to improve our understanding of the pathogen and its effects.

David Borthwick
Secretary

Department of the Environment and Heritage

Reader's Guide

The *Threat Abatement Plan for Beak and Feather Disease Affecting Endangered Psittacine Species* consists of the following parts:

The **Executive Summary** summarises the effects of Beak and Feather Disease, the legislative basis for the threat abatement plan's preparation and the plan's goals and objectives.

Part A – Beak and Feather Disease Characteristics and Biology details the information that is known about the disease at present. This includes the symptoms and effects of the disease, issues involved in making an accurate diagnosis, pathology and environmental factors. Part A also covers matters to be addressed in controlling the disease.

Part B – Action Plan sets out the goals and objectives of the threat abatement plan with actions proposed for addressing each objective. These are also summarised in Table 1. Part B also describes the administrative framework for the plan's implementation.

Our readers

The threat abatement plan is intended for use by the Beak and Feather Disease Threat Abatement Plan Implementation Team, members of the communication network that the team will set up, and others with an interest in the impact of Beak and Feather Disease. These include Australian, State and Territory Government agencies, local government, non-government organisations and the general public.

For more information

More information on the matters discussed in the threat abatement plan and on related issues is available online at www.deh.gov.au/biodiversity/threatened/tap/index.html.

Contents

Executive summary

Psittacine Beak and Feather Disease (BFD) is a common and potentially deadly disease of parrots caused by a circovirus named Beak and Feather Disease virus. The disease appears to have originated in Australia and is widespread and continuously present in wild populations of Australian parrots. The potential effects of the disease on parrot populations range from inconsequential to devastating, depending on environmental conditions and the general health of the parrots. In captivity the disease can cause very high death rates in nestlings, and this is likely to also occur in the wild, particularly in cases where the virus is introduced to populations where breeding females have low levels of immunity. The level of threat and distribution of the virus can be altered by the movements of common parrot species; for example the recent arrival of Galahs and Little Corellas on Kangaroo Island, where the endangered Glossy Black-Cockatoo lives and breeds in the same habitat.

BFD affecting endangered psittacine species (parrots and related species) was listed in April 2001 as a key threatening process under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The Minister at the time of listing determined under section 270A of the EPBC Act that having a threat abatement plan was a feasible, effective and efficient way to abate the impact of BFD virus on threatened Australian parrots.

Not all beak or feather abnormalities of parrots are caused by the BFD virus. For this reason, correct diagnosis of the disease is an important factor in its management. While there are distinctive clinical signs, confirmation of diagnosis should be carried out using techniques that detect either the virus or the parrot's antibody response to the virus. Reliable techniques have been developed to achieve this, but a consistent, practical and cost effective approach to diagnosis is required for Australia-wide management of the disease in threatened wild populations of parrots.

While eradication of a widespread and continuously present disease is not possible, well developed management plans based on current knowledge can assist in reducing the impact of the disease on threatened parrot populations.

This threat abatement plan, therefore, has two goals:

- To ensure that Beak and Feather Disease does not increase the likelihood of extinction or escalate the threatened status of psittacine birds.
- To minimise the likelihood of Beak and Feather Disease becoming a key threatening process for other psittacine species.

The plan's objectives are:

1. To coordinate a national approach to managing Beak and Feather Disease.
2. To promote and conduct activities that lead to increased knowledge of the disease and to support research that addresses gaps in current knowledge about Beak and Feather Disease.
3. To monitor Beak and Feather Disease and psittacine populations and to analyse the resultant data to inform better management strategies.
4. To identify and implement management actions and strategies to reduce the impacts of Beak and Feather Disease.
5. To share information with Australian, State and Territory Government management agencies, recovery teams, field workers, veterinarians and wildlife carers, so as to achieve better Beak and Feather Disease management outcomes.

Implementing the plan will consolidate and coordinate the process of managing BFD impacts on native parrots. Control programs will have to continue for some time and the costs of these could be considerable.

This plan therefore establishes a framework for allowing the best possible use of resources that are available for managing BFD.

Part 1 – Beak and Feather Disease Characteristics and Biology

The native pathogen Beak and Feather Disease virus causes the disease Psittacine Beak and Feather Disease (BFD) and is classified as a circovirus, which is the smallest group of described disease-causing viruses. BFD is the most common viral disease of parrots in Australia and is widespread and continuously present in wild and captive populations. Although many parrot populations thrive despite continuous exposure to the virus, when a population is threatened, genetic diversity is reduced. Factors such as habitat alteration and diminished food supply can increase susceptibility to disease. When populations become small, the loss of a few breeding individuals can significantly alter their sustainability.

This threat abatement plan has been prepared to meet the Australian Government's obligations under the EPBC Act, following the listing of BFD affecting endangered psittacine species as a key threatening process. The Minister at the time of listing determined under section 270A of the Act that having a threat abatement plan was a feasible, effective and efficient way to abate the impact of BFD on endangered psittacine species.

It appears that there is only one strain of BFD virus and that it specifically affects members of the parrot family. Parrots exhibit two behaviours that particularly favour the transmission of the virus within a population: they live in flocks and they nest in tree hollows. The number of parrots in a population infected with the virus varies between species and locations, and potentially from year to year.

The virus is present in the most widespread and common parrot species; in particular Sulphur-crested Cockatoos (*Cacatua galerita*), Corellas (*Cacatua sanguinea*) and Galahs (*Cacatua roseicapillus*), and so can be expected to have an Australia-wide distribution. Along with the difficulty in observing and controlling this microscopic pathogen, such broad distribution creates a complex management problem. This plan identifies available management opportunities and develops a program for coordinated action to abate the BFD threat.

1.1 The nature of the threat

A major epidemic with massive mortality is unlikely to occur when a disease has been present in a population for a long time. Species that live in very small populations, however, could be threatened with extinction as a consequence of a much less dramatic endemic disease that causes a slow attrition of individuals.

There is the threat of an epidemic where the levels of immunity to the disease fall due to low rates of challenge (i.e. where species have had little contact with the disease) and when environmental conditions favour the reintroduction of the pathogen.

1.2 Virus characteristics

Scientists describe the cause of BFD as 'a 14–17 nm icosahedral non-enveloped virus containing single-stranded circular DNA (deoxyribonucleic acid)'. This virus was classified in the early 1990s into a new family of pathogenic (disease-causing) animal viruses, Circoviridae. This family includes host specific viruses: chicken anaemia virus, columbid circovirus (of pigeons), porcine circovirus (of pigs), goose circovirus and canary circovirus (Ritchie, 1995; Phenix *et al*, 2001). These are currently the smallest pathogenic animal viruses that have been described (Ritchie, 1995). Circovirus infections are commonly associated with immunodeficiency-related diseases that are potentially fatal (Phenix *et al*, 2001). A reliable cell culture system for the Circoviridae is yet to be identified, which has implications for diagnosis and for vaccine production.

1.2.1 Genetic diversity

Analysis of 10 sequenced isolates suggests that only one strain of BFD virus exists. Four clusters of diversity have been identified but with no apparent regional or host species differences (Bassami *et al*, 2001). The shared genetic material (nucleotide identity) of the isolates ranged from 84–97%

(Bassami *et al*, 2001). Raue *et al*, 2004 have investigated sequence diversity of the virus in 31 psittacine species and suggest that virus genotypes may exist. A thorough understanding of the genomic variation of this virus is required before genetic-based techniques for diagnosis and vaccines can be developed. Analysis of further isolates would be desirable to confirm that only one strain exists, so that the use of genetic-based diagnostic techniques and vaccines will not be confounded by virus variability.

1.2.2 Pigeon circoviruses

Columbid birds (pigeons and doves) are well represented in Australia and are also affected by diseases caused by circoviruses (Woods *et al*, 1993; Woods *et al*, 1994). A disease identified in wild Senegal Doves (*Streptopelia senegalensis*) in Western Australia is morphologically very similar to BFD. It has recently been confirmed that it is not due to BFD virus, although it may be due to another antigenically distinct circovirus (Raidal and Riddoch, 1997). Current evidence suggests that it is unlikely that pigeons and doves pose any transmission risk of BFD virus to sympatric threatened parrots, as the known viruses in this family are host specific at the taxonomic order level (but not at the species level).

1.3 Symptoms of the BFD virus

BFD is characterised by progressive symmetrical feather deformity and loss, beak deformities, and eventual death. Development of beak deformities is variable and may include progressive elongation and fractures. The distribution of feather loss depends on the stage of moult when the signs manifest. The time taken for disease to develop varies. It may appear suddenly (peracute) or be acute or chronic.

Peracute infection may occur in hatchlings (particularly Gang-gang Cockatoos (*Callocephalon fimbriatum*) and African Grey Parrots (*Psittacus erithacus*) with signs of septicaemia, pneumonia, enteritis, weight loss and death before feather abnormalities are recognisable (Ritchie, 1995; Raidal, pers. comm. 2002). Diagnosis can be made by DNA probe of blood and histopathology of the bursa (an organ of the immune system located in the cloaca of birds).

Acute infection occurs in chicks around 28–32 days of age (particularly Sulphur-crested Cockatoos) and is characterised by several days of depression followed by sudden changes in the developing feathers including necrosis, fractures, haemorrhage and premature shedding (Ritchie, 1995). Crop stasis, diarrhoea, non-regenerative anaemia (packed cell volume 14–25%) and death in one to two weeks may also occur. Diagnosis can be made by identification of viral inclusions in the thymus, bursa and bone marrow.

Chronic infection occurs in birds that survive the acute phase and is characterised by symmetrical feather abnormalities that progress with each moult. Abnormalities include retained feather sheaths, pulp haemorrhage, fractured shafts, circumferential constrictions, stress lines and curled feathers. The first signs in older birds occur in the powder down and contour feathers. Then the primary, secondary, tail and crest feathers become abnormal progressing to total baldness if birds survive for long enough (Ritchie, 1995). Abnormal colouring of pigmented feathers has also been associated with BFD but the disease cannot be diagnosed by this feature alone.

Beak lesions are relatively common in Sulphur-crested Cockatoos, Galahs, Little Corellas, and Moluccan Cockatoos (*Cacatua moluccensis*), particularly those under one year of age. The upper beak is generally more severely affected and necrosis extends from the tip towards the base (Ritchie, 1995).

Secondary infections associated with immunosuppression are common with BFD, in particular candidiasis, aspergillosis, cryptosporidiosis, chlamydiosis and avian polyoma virus (APV) (Ritchie, 1995). APV infection is generally without symptoms in adult birds, except when there is co-infection with BFD (Phalen, 1997). APV is widespread and common in wild Sulphur-crested Cockatoos in New South Wales (Raidal *et al*, 1998). It is unclear whether BFD virus causes

immunosuppression or merely favours it. If this virus causes immunosuppression then it poses an even greater threat to small populations.

1.4 Geographic distribution

The geographic distribution of the virus is potentially equivalent to the distribution of the wild psittacines known to exhibit clinical disease, in particular Sulphur-crested Cockatoos, Galahs, Little Corellas, Long-billed Corellas (*Cacatua tenuirostris*), Crimson Rosellas (*Platycercus elegans*), Rainbow Lorikeets (*Trichoglossus haematodus*) and Scaly-breasted Lorikeets (*T. chlorolepidotus*). Although infection has not been confirmed in all populations of these species, the distribution is potentially Australia-wide including Tasmania.

Vetgen Europe has detected BFD in wild psittacines in Australia, the Philippines and the Solomon Islands (Scott, 1996). In Africa, BFD virus has been recently identified in wild Cape Parrots (*Poicephalus robustus*) (Perrin *et al*, 1999) and a single Black-cheeked Lovebird (*Agapornis nigrigenis*) chick (Warburton and Perrin, 2001), although these outbreaks may be due to the release of aviary birds. The disease is also widespread in captive collections of psittacines in Europe and the USA (Ritchie, 1995).

1.5 Prevalence

Infection with BFD virus is widespread in wild populations of psittacines in Australia (Raidal *et al*, 1993a). In wild populations of Sulphur-crested Cockatoos, Galahs, Little Corellas and Long-billed Corellas in New South Wales, between 41% and 94% of the flocks had antibodies to BFD virus, showing that the disease is widespread (Raidal *et al*, 1993a).

1.6 Susceptibility

All members of the parrot family are susceptible to BFD virus. We do not currently know the predisposing factors that lead to the development of clinical disease or to protective immunity. However, we do know that susceptibility to infection varies with age and species, and between individuals of the same species. Susceptibility will also be influenced by environmental factors, such as climate, nutrition, habitat quality and social factors.

Climatic conditions and positioning of aviaries were found to be relevant for Orange-bellied Parrots (Brown *et al*, 1994). In Norfolk Island Green Parrots (*Cyanoramphus novaezelandiae cookii*) there is a significant sex bias towards males as a consequence of rats preying on nesting females. This sex bias may increase stress on females during the breeding season, which could predispose the females to disease.

1.6.1 Age

Although BFD is generally a disease of young birds up to three years of age (92%), birds up to 20 years of age have developed clinical signs after years of being clinically normal. In experimental infections birds seven days or younger are most susceptible and develop most severe lesions. Experimentally infected adult birds remain clinically normal and develop antibodies (Ritchie, 1995). Old birds that develop signs were probably infected as youngsters and remained latently infected.

1.6.2 Species

Appendix D lists examples of the bird species currently known to be susceptible to BFD virus. Overall cockatoos, lovebirds and African Grey Parrots seem most susceptible and macaws least susceptible. Sulphur-crested Cockatoo chicks are more likely to develop fatal experimental infections than Galah chicks (Raidal *et al*, 1993b). There is also variable sensitivity of erythrocytes, between species and individuals of the same species, to the haemagglutination assay that has implications for diagnosis (Sanada and Sanada, 2000).

1.7 Incubation period (from exposure to clinical signs)

BFD virus can be detected in the blood by DNA probe as soon as two days after natural exposure. The minimum incubation period for the appearance of dystrophic feathers in experimental infections is 21–25 days (Ritchie, 1995). Birds that become infected after feather development has finished may not develop obvious clinical signs until their next moult six or more months later. The maximum incubation period can be years (Ritchie, 1995). Clarification of the range of the incubation period is desirable to inform decisions on the length of quarantine required.

1.8 Transmission

Natural infection most likely occurs following ingestion or inhalation of BFD virus in the nest hollow from infected faeces or feather dust from the parents. The virus is excreted in the faeces of diseased birds (Wylie and Pass, 1987; Ritchie *et al*, 1991; Raidal *et al*, 1993b). Feather dust may contain as many as one trillion virus particles per millilitre (Ritchie, 1995). Virus particles can also be recovered from crop washings from infected birds (Ritchie *et al*, 1991). Inhalation and ingestion of BFD virus can also potentially occur at feeding, roosting and watering points in flocking birds.

Experimental transmission has been achieved through oral, intra-cloacal, subcutaneous, intraocular and intranasal routes (Ritchie *et al*, 1992; Wylie and Pass, 1987). Vertical transmission (from parents to young prior to birth) has been reported on only one occasion, when artificially incubated chicks from an infected hen developed the disease (Ritchie, 1995). In a German study of captive psittacines, 40% of 146 symptom-free birds were subclinically infected (Rahaus and Wolff, 2003).

1.8.1 Do recovered lorikeets pose a threat?

Rainbow and Scaly-breasted Lorikeets appear to pose a unique problem in that birds with clinical disease are frequently rescued and rehabilitated by wildlife carers in the eastern States. Swift Parrots and other parrot species are also often rescued. Because many lorikeets in particular often make a clinical recovery from BFD and are released, the issue of latent infection arises. Raidal (pers. comm. 2002) found that recovered lorikeets remain latently infected, with virus persisting in their livers.

Release of recovered birds potentially increases the dose of virus in the wild as these birds would die without intervention and therefore cease to circulate the virus. While this may be a problem for wild lorikeet populations, the impact on threatened psittacine birds could be very significant. Educational material prepared as part of the threat abatement plan will assist wildlife carers and government wildlife officers in their decision-making in regard to this issue. Mandatory testing of rehabilitated parrots for BFD virus prior to release may be useful, but cost is an issue. If testing was recommended, a management strategy would be needed for birds found to be positive.

1.9 Pathology

The consistent gross changes have been described in section 1.3, Symptoms of the BFD Virus. Less frequent gross lesions include hepatomegaly, small kidneys, and atrophy of the thymus and bursa. Histopathological features are necrosis of the epithelial cells lining the developing feather and large basophilic intracytoplasmic inclusion bodies containing an accumulation of virus particles. Both intranuclear and intracytoplasmic inclusions may be most consistently found in feather epithelium, the thymus and the cloacal bursa (Ritchie, 1995). Intranuclear inclusion bodies were restricted to epithelial cells, and intracytoplasmic inclusions were found only in macrophages in 23 cases with both types of inclusions (Ritchie, 1995 #35).

1.10 Pathogenesis

The pathogenesis is poorly understood. The virus is epitheliotropic, but the primary site of replication is unknown. The gastrointestinal tract is a target organ for BFD virus replication and excretion, and virus replication occurs in the liver early in the disease process and probably continues during chronic disease (Raidal *et al*, 1993b). Cerebellar disease has been infrequently

associated with acute BFD in Sulphur-crested Cockatoo chicks. Sudden death has also been observed. Many infected birds die within six months to one year from the onset of clinical signs. Some captive featherless birds have survived for 10–15 years. Secondary infections are common and include cryptosporidiosis, bacterial, mycotic and viral infections.

1.11 Immunity

Many infected birds mount an effective immune response that protects them from disease. The protective nature of the immune response depends on the antibody titre. The factors which determine whether a susceptible bird mounts an immune response or is fatally infected could include the age of the bird at exposure, the presence and levels of maternal antibodies, the route of viral exposure and the dose of infecting virus. In experimental challenges, hens with haemagglutination-inhibition titres greater than 1:1280 protected their young chicks from virus challenge. Hen titres less than 1:320 were not protective to offspring (Ritchie, 1995). In vaccination and challenge studies in Galah chicks and adults, an antibody titre of $\log_2$ 3 was protective (Raidal *et al*, 1993b). Protective antibody titres in field situations have not been reported in the literature.

1.12 Diagnosis

Symptoms are as described in section 1.3. The currently available methods of diagnosis are as follows:

- Histopathology at post-mortem or biopsy of affected skin may detect virus-induced inclusions, but absence of inclusions does not indicate freedom from infection.
- Haemagglutination is currently the only quantitative method available to detect BFD virus. This test will not detect incubating or latent BFD virus (Raidal *et al*, 1993c). It can be performed on feathers, tissue or faeces.
- The haemagglutination-inhibition (HI) test is a rapid and specific test for anti-psittacine circoviral virus antibodies. It indicates previous exposure to the virus, but does not indicate whether a bird is subclinically infected. Low titres can suggest that a bird is infected or susceptible or previously exposed but not recently challenged. The sample required is a drop (<0.2 ml) of whole blood on filter paper (Raidal *et al*, 1993c; Riddoch *et al*, 1996).
- DNA probe of blood or formalin fixed tissue is used mainly in the USA. The use of a virus-specific DNA probe is the most sensitive and specific test for detecting BFD (Ritchie, 1995) and detects viral nucleic acids in circulating white blood cells before clinical changes are apparent. The sample required is 0.2–1.0 ml of heparinised blood. DNA probes can also be used to detect environmental contamination. Fresh blood is required and results are not quantitative. Polymerase chain reaction (PCR) testing can be more sensitive, but DNA *in situ* hybridisation is less subject to false positive tests than PCR (Campagnoli and Latimer, 1998).
- A PCR test developed at the University of Georgia is used by Vetgen Europe to diagnose BFD (Scott, 1996). Detection is straightforward because a long-lasting viremia is developed with BFD. Fresh blood is required and results are not quantitative. Recently, a universal PCR assay has been developed in Australia which can consistently amplify a 717 base pair product from blood and/or feathers (Ypelaar *et al*, 1999).

The most useful diagnostic tests are the HI (antibody) and PCR (viral DNA) tests. In Australia, HI has been the diagnostic test most widely used because of its simplicity, the small sample volume required, and the fact that it is quantitative. However, since it is an antibody test it does not provide information about whether the individual bird is currently infected. A PCR test is now available in Australia (although not currently in use by recovery teams) and will detect the presence of viral DNA. However, it is not a quantitative test. A combination of HI and PCR tests is most useful, but when resources are limited judgement is required on which tests provide relevant information and are cost effective for population management.

1.13 BFD-like symptoms in other disease viruses

As with the BFD virus, polyoma virus can cause feather dystrophy. Polyoma virus, Pacheco's disease virus and adenovirus can all produce nuclear inclusion bodies which can look similar to BFD inclusions, particularly in the early stages of disease. Polyoma virus intranuclear inclusions typically contain 40–50 nm viral particles and a specific polyoma virus neutralising antibody test is available (Ritchie, 1995).

1.14 Control

1.14.1 Environmental stability of the virus

The environmental stability of the virus is unknown but it is possible that it may remain viable in nest hollows for many years. The related chicken anaemia virus (CAV) is environmentally stable and remarkably resistant to inactivation. CAV is susceptible to iodine (1%), sodium hypochlorite, and heating to 80ºC for one hour (Ritchie, 1995).

1.14.2 Therapy of individual cases

Some birds recover from BFD, and treatment of individuals is a consideration. Supportive treatments, including maintaining body temperature and giving supplements which support the immune system, have been used (Perry, 1981). Clinically recovered birds can remain latently infected, with the virus persisting in the liver (Raidal, 1994).

1.14.3 Vaccine development

A vaccine is unlikely to be available as a management tool in the short term. At present a recombinant protein vaccine shows the most promise. It may be many years before all regulatory requirements are fulfilled so that a vaccine could be trialled in the field. It may be necessary to carry out initial trials on an analogue species (e.g. Blue-winged Parrots (*Neophema chrysostoma*) for Orange-bellied Parrots) and that will also delay the vaccine's use on threatened species.

Investigations of novel methods of vaccine delivery to the nest hollow are also warranted.

1.14.4 Practicality of vaccination

The use of intramuscular vaccination with irritant adjuvants is an issue particularly in small birds, and more particularly those such as the Orange-bellied Parrot that regularly fly across Bass Strait. Irritant drugs injected intramuscularly can cause inflammation of the pectoral muscles that are used for flying. A double oil emulsion vaccine proved to be less irritating than a Freund's adjuvant vaccine (Raidal *et al*, 1993b). Other methods of delivery are possible e.g. spray vaccine onto food or into nest boxes (Raidal, pers. comm. 2002). Because the bursa of Fabricius in the cloaca of birds is capable of ingesting particulate matter, it is possible for vaccine to be applied to the nest hollow as it relies on intracloacal immunisation. These ideas are yet to be tested.

The development of DNA or recombinant protein vaccines will overcome the issue of reversion to virulence. It may be possible to develop novel applications for vaccinating nestlings in the wild.

Part 2 – Action Plan

The following goals, objectives and actions have been identified to abate the threat posed by BFD virus.

Goals

The plan has two goals:

- To ensure that Beak and Feather Disease does not increase the likelihood of extinction or escalate the threatened status of psittacine birds
- To minimise the likelihood of Beak and Feather Disease becoming a key threatening process for other psittacine species.

These goals will be achieved by conducting action under the following objectives.

Objectives

The plan's objectives are as follows:

Objective 1: To coordinate a national approach to managing Beak and Feather Disease.

Objective 2: To promote and conduct activities that lead to increased knowledge of the disease and to support research that addresses gaps in current knowledge about Beak and Feather Disease.

Objective 3: To monitor Beak and Feather Disease and psittacine populations and to analyse the resultant data to inform better management strategies.

Objective 4: To identify and implement management actions and strategies to reduce the impacts of Beak and Feather Disease.

Objective 5: To share information with Australian, State and Territory Government management agencies, recovery teams, field workers, veterinarians and wildlife carers, so as to achieve better Beak and Feather Disease management outcomes.

2.1 Objective 1: National coordination

Coordinate a national approach to managing Beak and Feather Disease

The success of this threat abatement plan depends on a high level of cooperation and communication between Australian Government and state and territory agencies and a range of interested parties, including university researchers, recovery teams, zoos involved in captive breeding components of recovery plans, aviculturists, non-government conservation agencies, veterinarians and community groups.

The activities and priorities defined in the plan must be adaptable, so that ongoing field experience and research results can be applied to improve BFD management.

A BFD Threat Abatement Plan Implementation Team comprising government officials and relevant experts will be established to monitor progress, review actions, highlight gaps and identify priorities. Progress will be reviewed regularly.

Action 1.1: Convene an implementation team with skilled personnel and effective lines of communication

The Department of the Environment and Heritage will convene a BFD Threat Abatement Plan Implementation Team that includes people with technical and practical skills and responsibilities in BFD management and research to oversee implementation of the plan. The team will link with state and territory BFD Threat Abatement Teams (or their equivalents), relevant regional natural resource management authorities and local bodies and other expert bodies. The team will establish clear lines of communication that promote and manage best practice in on-ground actions.

Action 1.2: Establish a communication network to update stakeholders on the plan's implementation and to promote exchange of information on BFD
A communication network will be established to update stakeholders on the plan's implementation and to allow for exchanging information. The following groups will be invited:

- Australian, State and Territory Government conservation agencies
- Australian Wildlife Health Network
- OIE (World Organisation for Animal Health)
- Taronga Pathology Register
- Australian Wildlife Collection (managed by CSIRO (Commonwealth Scientific and Industrial Research Organisation))
- Australian Committee of Avian Veterinarians
- Birdmed (an avian veterinary chat group moderated by Shane Raidal)
- national and state museums
- aviculturists
- overseas organisations
- Chair of the circovirus section of the ICTV (International Committee on the Terminology of Viruses)
- non-government conservation organisations
- parrot recovery teams (national and international)
- ARAZPA (Australasian Regional Association of Zoological Parks and Aquaria)
- Non-passerine Bird Taxon Advisory Group.

2.2 Objective 2: Research

Promote and conduct activities that lead to increased knowledge of the disease and support research that addresses gaps in current knowledge about Beak and Feather Disease

The following areas are identified as priorities for research.

Action 2.1: Add to or delete from the priority species list
Although all parrots are susceptible, some species appear to suffer greater impacts from this disease than others. Priority under the plan needs to be given to those nationally listed threatened species found most likely to be at risk from the disease, or to species that are not currently nationally listed but which are at risk of becoming listed due to BFD. The following Australian parrots have experienced clinical disease or mortality due to BFD, and meet the above criteria:

- Orange-bellied Parrot (*Neophema chrysogaster*)
- Norfolk Island Green Parrot (*Cyanoramphus novaezelandiae cookii*)
- Swift Parrot (*Lathamus discolor*).

This list must remain open to regular review, but at present these species should receive the highest priority in the abatement of this disease.

Action 2.2: Evaluate existing data
It is necessary to collate and analyse all existing data on clinical signs, mortality and immunity in threatened psittacine birds and use these results to:

- encourage the development of new management techniques
- evaluate effectiveness of hygiene procedures under different environmental conditions in order to refine them.

Action 2.3 Continue vaccine development and investigation of delivery methods
At present a recombinant protein vaccine shows the most promise. There is a need to carry out trials on an analogue species (e.g. Blue-winged Parrots (*Neophema chrysostoma*) for Orange-bellied Parrots) to test the recombinant protein's effectiveness as a vaccine and to investigate novel methods of vaccine delivery to nest hollows.

Action 2.4: Clarify the quarantine period necessary to avoid spread of the disease between populations
The incubation period of the virus has been estimated from experimental infections to be 21–25 days but longer incubation periods of up to six months or more have been observed in natural infections. Knowing the quarantine period – the sum of the incubation period and the viremic period (time in which the virus is circulating in the blood) – is necessary in order to make sound recommendations on suitable quarantine periods for managing captive breeding populations of threatened psittacine birds and to avoid spreading the disease between populations. Quarantine periods exceeding six months may be required, with diagnostic tests being carried out at 90-day intervals.

Action 2.5: Test effectiveness of disinfectants used on closely related viruses
Circoviruses are highly persistent and the environmental stability of BFD virus has not been specifically investigated. Disinfection methods used for chicken anaemia virus may be relevant, but a bioassay is required to evaluate disinfectants (in the absence of proven disinfection procedures for nest boxes, information on infective dose may help in control).

Disinfection of nest and transport boxes may be required to reduce spread of the BFD virus during management of threatened psittacines. The circoviruses are highly stable and difficult to inactivate. Until suitable disinfectants which specifically inactivate BFD virus have been identified, it will be necessary to trial disinfectants used on closely related viruses, particularly porcine circovirus and the other avian circoviruses.

Action 2.6: Evaluate BFD prevalence in common parrot species
Some investigations have been carried out on the prevalence of the disease in wild populations of cockatoos (Raidal *et al*, 1993a). It would be advisable to evaluate BFD prevalence in common parrot species that share habitat or may come into contact with threatened parrot species.

Action 2.7: Identify BFD hotspot areas
It appears that the distribution of BFD is Australia-wide, but there are likely to be hotspots where the disease occurs more frequently. Assessing such hotspots may reveal the circumstances under which psittacines are susceptible to BFD and to improved management responses.

Action 2.8: Undertake research to confirm that only a single strain exists
BFD virus is genetically diverse but does not appear to vary enough to be considered to have species-specific strains. Further research is required to confirm that only a single strain exists as this has potential significance for vaccine production, distribution, host specificity and the possibility for variable pathogenicity.

Action 2.9: Identify the minimum antibody titre associated with protective immunity
It is important to identify the minimum antibody titre associated with protective immunity. The antibody titre present in hens at the time of breeding is also critical in determining whether maternal immunity will be imparted to young. Maternal immunity can interfere with active immunity produced by vaccination.

Action 2.10: Determine whether vertical transmission occurs
It is important to know whether vertical transmission from infected hens to eggs is possible. Ritchie (1995) recounts that three eggs from an infected hen were artificially incubated and the chicks developed BFD, an apparent case of vertical transmission. However, horizontal transmission cannot be ruled out in this case (Raidal, pers. comm. 2002).

Action 2.11: Determine which diagnostic tests are most appropriate
Standardised diagnostic tests are needed that allow for differentiation between prior exposure, active infection and protective immunity. Minimum standards should be established for testing. These standards should cover:

- which test to use
- how many birds from a population to sample
- what age groups to sample
- sampling frequency.

The most useful diagnostic tests are the HI (antibody) and PCR (viral DNA) tests. In Australia, HI has been the diagnostic test most widely used. A combination of HI and PCR tests is most useful, but judgement is required on which tests provide relevant information and are cost effective.

2.3 Objective 3: Monitoring the disease

Monitor Beak and Feather Disease and psittacine populations and analyse the resultant data to inform better management strategies

Action 3.1: Initiate wild parrot surveillance
Wild parrot surveillance should be initiated that:

- monitors changes in population dynamics
- monitors relevant environmental change (changes in habitat that may impact on infection rates)
- evaluates the ongoing impact of the disease on threatened parrots, with a view to providing an early warning of any significant increase in the number of observed cases
- allows for collection and storage of samples if there are insufficient resources for immediate testing
- is long-term so that a natural decline in disease prevalence can be distinguished from the absence of the disease in a population.

Action 3.2: Evaluate mortality and survival rates
It is important to evaluate the number of clinical cases, number of deaths including nestling death data when possible, and the level of immunity in breeding females.

Action 3.3: Determine and monitor BFD extent and pattern
Studies should be established of sufficient duration to determine and monitor:

- reductions in the number of clinical cases of BFD in threatened wild psittacines
- the prevalence of the disease in populations of priority species
- populations most likely to come into contact with target species
- populations living in proximity to threatened or potentially threatened psittacines
- the presence of any cyclical pattern in the disease (e.g. declining natural immunity).

Action 3.4: Determine early signs of epidemics
Nothing is known about how monitoring systems will be able to detect BFD in wild populations, and what level of disease constitutes an epidemic. Early indications of epidemics need to be determined for field use.

2.4 Objective 4: Identifying and implementing management strategies

Identify and implement management actions and strategies to reduce the impacts of Beak and Feather Disease

Ensuring that field experience and research are used to improve management programs is an important element of the plan. It is important to improve understanding of the disease's effects on a range of native species, particularly those currently listed nationally as threatened.

The presence of good quality habitat with ample foraging, roosting, and breeding opportunities is essential to the survival of threatened parrots. Wild parrots occupying good habitat will be more resistant to disease. In captivity, critical factors that will favour the host to resist disease include attention to social groupings, aviary design, nest box design, ambient temperature of enclosures, nutrition, and hygiene.

It may be possible to reduce the impact of the disease by identifying factors which favour the host over the virus. Habitat issues such as availability of a suitable variety of food plants year round, and availability of suitable nest hollows and roost sites may play an important role in protecting the host from susceptibility to this disease.

Action 4.1: Assess the threat
It is important to determine the seriousness of the threat posed by BFD and the level of management necessary to secure recovery of any species. Many of the actions identified in the plan will contribute to this.

Action 4.2: Establish trial management programs
Experimental management programs should be developed and implemented in areas of habitat critical for species perceived to be threatened by the disease, taking into account factors that favour the host over the virus (e.g. habitat quality).

Action 4.3: Consider management of BFD in recovery plans adopted under the EPBC Act
A number of existing recovery plans identify species threatened by BFD. In terms of national action to abate the threat posed by BFD, implementation of recovery plans for these species must be accorded high priority. The priority species identified under action 2.1 above should be the focus for management actions. Management actions for other BFD-affected threatened species should be identified as recovery plans for these species are developed, and consideration given to incorporating those actions into relevant regional natural resource management (NRM) plans and investment strategies.

Action 4.4: Investigate *ex situ* conservation of species threatened by BFD
A successful captive breeding program has been undertaken for the Orange-bellied Parrot. In captivity, this species has experienced significant problems with BFD in the past. The disease has been largely controlled by improved husbandry, especially moving the aviary to a site protected from wind and rain (Brown *et al*, 1994). Experience controlling the disease in this intensively managed species may provide a useful model for other captive-bred threatened species populations.

Action 4.5: Perform population viability analyses
It is important to perform population viability analysis modelling of different disease rates and different management strategies for each priority parrot species and provide the information to managers. Such models will be most useful if prepared in advance of a disease outbreak.

Action 4.6: Develop emergency response planning
Emergency response plans are needed to guide response to disease outbreaks.

2.5 Objective 5: Education and extension

Share information with Australian, State and Territory Government management agencies, recovery teams, field workers, veterinarians and wildlife carers, so as to achieve better Beak and Feather Disease management outcomes

Successful assessment and control of BFD's impact on priority psittacine species depends on detection. Field workers must be provided with educational material to allow them to identify clinically affected birds and to deal appropriately with dead birds.

Field workers, captive and wild animal managers, veterinarians and pathologists need protocols to enable consistency in post-mortem, quarantine and transport activities. Data from these people's experiences must be disseminated to recovery teams, perhaps through a centralised database.

Action 5.1: Educate for disease detection
Effective education and extension material such as clinical evaluation and post-mortem protocols is needed by field workers and wildlife managers, to promote detection of the disease in priority psittacine species so that the true impact of the disease is identified.

Action 5.2: Develop and distribute protocols
There is a need for clinical evaluation, post-mortem, quarantine and transport protocols that set out:

- handling and disposal procedures for dead birds
- procedures for transport of bodies and tissues
- disinfection procedures
- which pathologist/laboratory samples should be sent to
- who needs to be notified in the event of positive or negative diagnosis.

Action 5.3: Provide access to web-based information
A web site should be developed and maintained to provide the latest data to interested parties.

2.6 Table 1 Performance indicators and timelines

The following table outlines performance indicators and timelines associated with BFD actions.

Actions	Performance indicators	Indicative timelines
OBJECTIVE 1: NATIONAL COORDINATION *Coordinate a national approach to managing BFD*		
Action 1.1: Convene an implementation team with skilled personnel and effective lines of communication The Department will convene a BFD Threat Abatement Plan Implementation Team that includes people with technical and practical skills and responsibilities in BFD management and research to oversee implementation of the plan. The team will link with state and territory BFD Threat Abatement Teams (or their equivalents), relevant regional natural resource management authorities and local bodies and other expert bodies. The team will establish clear lines of communication that promote and manage best practice in on-ground actions.	BFD Threat Abatement Plan Implementation Team established	Within 6 months of the plan being adopted
Action 1.2: Establish a communication network to update stakeholders on the plan's implementation and to promote exchange of information on BFD A communication network will be established to update stakeholders on the plan's implementation and to allow for exchanging information.	Communication network established between all stakeholders	12 months
OBJECTIVE 2: RESEARCH *Promote and conduct activities that lead to increased knowledge of the disease and support research that addresses gaps in current knowledge about BFD*		
Action 2.1: Add to or delete from the priority species list Although all parrots are susceptible, some species appear to suffer greater impacts from this disease than others. Priority under the plan needs to be given to those nationally listed threatened species found most likely to be at risk from the disease, or to species that are not currently nationally listed but which are at risk of becoming listed due to BFD. The following Australian parrots have experienced clinical disease or mortality due to BFD, and meet the above criteria: • Orange-bellied Parrot (*Neophema chrysogaster*) • Norfolk Island Green Parrot (*Cyanoramphus novaezelandiae cookii*) • Swift Parrot (*Lathamus discolor*). This list must remain open to regular review, but at present these species should receive the highest priority in the abatement of this disease.	Parameters for reviewing priority species list established Priority species list reviewed at regular intervals to be agreed Priority list keeps pace with increased knowledge and changes in status of nationally listed species	12 months

Actions	Performance indicators	Indicative timelines
Action 2.2: Evaluate existing data It is necessary to collate and analyse all existing data on clinical signs, mortality and immunity in threatened psittacine birds and use these results to: • encourage the development of new management techniques • evaluate effectiveness of hygiene procedures under different environmental conditions in order to refine them.	Existing data on clinical signs, mortality and immunity of threatened psittacines collated, analysed and reported to relevant managers The development of new management techniques supported Effective hygiene procedures evaluated	1–5 years
Action 2.3 Continue vaccine development and investigation of delivery methods At present a recombinant protein vaccine shows the most promise. There is a need to carry out trials on an analogue species (e.g. Blue-winged Parrots for Orange-bellied Parrots) to test the recombinant protein's effectiveness as a vaccine and to investigate novel methods of vaccine delivery to nest hollows.	Vaccine developed to trial stage Vaccine trialled on analogue species Vaccine delivery methods developed and tested	1–3 years
Action 2.4: Clarify the quarantine period necessary to avoid spread of the disease between populations The incubation period of the virus has been estimated from experimental infections to be 21–25 days but longer incubation periods of up to six months or more have been observed in natural infections. Knowing the quarantine period– the sum of the incubation period and the viremic period (time in which the virus is circulating in the blood) – is necessary in order to make sound recommendations on suitable quarantine periods for managing captive breeding populations of threatened psittacine birds and to avoid spreading the disease between populations. Quarantine periods exceeding six months may be required, with diagnostic tests being carried out at 90-day intervals.	BFD virus incubation period established Viremic period established From this information, quarantine period established	1–3 years
Action 2.5: Test effectiveness of disinfectants used on closely related viruses Circoviruses are highly persistent and the environmental stability of BFD virus has not been specifically investigated. Disinfection methods used for chicken anaemia virus may be relevant, but a bioassay is required to evaluate disinfectants (in the absence of proven disinfection procedures for nest boxes, information on infective dose may help in control). Disinfection of nest and transport boxes may be required to reduce spread of the BFD virus during management of threatened psittacines. The circoviruses are highly stable and difficult to inactivate. Until suitable disinfectants which specifically inactivate BFD virus have been identified, it will be necessary to trial disinfectants used on closely related viruses, particularly porcine circovirus and the other avian circoviruses.	Disinfectants tested by bioassay Disinfectants effective on related viruses trialled on BFD virus Procedures established for disinfecting nest and transport boxes	1–5 years

Actions	Performance indicators	Indicative timelines
Action 2.6: Evaluate BFD prevalence in common parrot species Some investigations have been carried out on the prevalence of the disease in wild populations of cockatoos (Raidal *et al*, 1993a). It would be advisable to evaluate BFD prevalence in common parrot species that share habitat or may come into contact with threatened parrot species.	Common parrot species that share habitat or may come into contact with threatened parrot species identified BFD prevalence in these common parrot species evaluated	1–5 years
Action 2.7: Identify BFD hotspot areas It appears that the distribution of BFD is Australia-wide, but there are likely to be hotspots where the disease occurs more frequently. Assessing such hotspots may reveal the circumstances under which psittacines are susceptible to BFD and to improved management responses.	Distribution of BFD across Australia mapped BFD hotspots identified Factors that allow BFD to thrive in these areas identified and assessed Effective management responses identified and trialled in these areas	1–5 years
Action 2.8: Undertake research to confirm that only a single strain exists BFD virus is genetically diverse but does not appear to vary enough to be considered to have species-specific strains. Further research is required to confirm that only a single strain exists as this has potential significance for vaccine production, distribution, host specificity and the possibility for variable pathogenicity.	Existence of only one strain of BFD confirmed through further research	1–3 years
Action 2.9: Identify the minimum antibody titre associated with protective immunity It is important to identify the minimum antibody titre associated with protective immunity. The antibody titre present in hens at the time of breeding is also critical in determining whether maternal immunity will be imparted to young. Maternal immunity can interfere with active immunity produced by vaccination.	Minimum antibody titre needed to give immunity established Antibody titre in breeding hens needed to give immunity to young established Relationship of maternal immunity on active immunity by vaccination established	1–5 years
Action 2.10: Determine whether vertical transmission occurs It is important to know whether vertical transmission from infected hens to eggs is possible. Ritchie (1995) recounts that three eggs from an infected hen were artificially incubated and the chicks developed BFD, an apparent case of vertical transmission. However, horizontal transmission cannot be ruled out in this case (Raidal, pers. comm. 2002).	Possibility of vertical transmission established	1–3 years

Actions	Performance indicators	Indicative timelines
Action 2.11: Determine which diagnostic tests are most appropriate Standardised diagnostic tests are needed that allow for differentiation between prior exposure, active infection and protective immunity. Minimum standards should be established for testing. These standards should cover: • which test to use • how many birds from a population to sample • what age groups to sample • sampling frequency. The most useful diagnostic tests are the HI (antibody) and PCR (viral DNA) tests. In Australia, HI has been the diagnostic test most widely used. A combination of HI and PCR tests is most useful, but judgement is required on which tests provide relevant information and are cost effective.	Currently available diagnostic tests evaluated Most effective tests chosen Protocols established for deciding which test(s) to use according to circumstances Minimum testing standards established for producing a reliable diagnosis	1–5 years
OBJECTIVE 3: MONITORING THE DISEASE *Monitor BFD and psittacine populations, and analyse the resultant data to inform better management strategies*		
Action 3.1: Initiate wild parrot surveillance Wild parrot surveillance should be initiated that: • monitors changes in population dynamics • monitors relevant environmental change (changes in habitat that may impact on infection rates) • evaluates the ongoing impact of the disease on threatened parrots, with a view to providing an early warning of any significant increase in the number of observed cases • allows for collection and storage of samples if there are insufficient resources for immediate testing • is long-term so that a natural decline in disease prevalence can be distinguished from the absence of the disease in a population.	A national monitoring program established to evaluate the ongoing impact of the disease on threatened parrots Ongoing analysis of surveillance results established Data made available to on-ground managers Long-term wild parrot surveillance programs established	2 years
Action 3.2: Evaluate mortality and survival rates It is important to evaluate the number of clinical cases, number of deaths including nestling death data when possible, and the level of immunity in breeding females.	Data available on the number of sick and dead birds affected by BFD, and where applicable, antibody titres known for breeding females for priority species	1–5 years
Action 3.3: Determine and monitor BFD extent and pattern Studies should be established of sufficient duration to determine and monitor: • reductions in the number of clinical cases of BFD in threatened wild psittacines • the prevalence of the disease in populations of priority species • populations most likely to come into contact with target species • populations living in proximity to threatened or potentially threatened psittacines • the presence of any cyclical pattern in the disease (e.g. declining natural immunity).	Prevalence data exists for common parrot species in proximity to threatened parrots Patterns of changes in prevalence analysed and reported to relevant managers	1–5 years

Actions	Performance indicators	Indicative timelines
Action 3.4: Determine early signs of epidemics Nothing is known about how monitoring systems will be able to detect BFD in wild populations, and what level of disease constitutes an epidemic. Early indications of epidemics need to be determined for field use.	Possible early signs of epidemics determined Monitoring of wild populations established to test usefulness of these signs Level of disease that constitutes an epidemic determined	1–5 years
OBJECTIVE 4: IDENTIFY AND IMPLEMENT MANAGEMENT STRATEGIES *Identify and implement management actions and strategies to reduce the impacts of BFD*		
Action 4.1: Assess the threat It is important to determine the seriousness of the threat posed by BFD and the level of management necessary to secure recovery. Many of the actions identified in the plan will contribute to this.	Seriousness of threat and required level of management determined for priority species	2 years
Action 4.2: Establish trial management programs Experimental management programs should be developed and implemented in areas of habitat critical for species perceived to be threatened by the disease, taking into account factors that favour the host over the virus (e.g. habitat quality).	Experimental management programs in place for key species in habitat critical areas	1–5 years
Action 4.3: Consider management of BFD in recovery plans adopted under the EPBC Act A number of existing recovery plans identify species threatened by BFD. In terms of national action to abate the threat posed by BFD, implementation of recovery plans for these species must be accorded high priority. The priority species identified under action 2.1 above should be the focus for management actions. Management actions for other BFD-affected threatened species should be identified as recovery plans for these species are developed, and consideration given to incorporating those actions into relevant regional natural resource management (NRM) plans and investment strategies.	Implementation under way of recovery plans already prepared for listed species threatened by BFD Recovery plans developed and implemented for other listed BFD-affected species Action on BFD incorporated in relevant natural resource management plans and investment strategies	1–5 years
Action 4.4: Investigate ex situ conservation of species threatened by BFD A successful captive breeding program has been undertaken for the Orange-bellied Parrot. In captivity, this species has experienced significant problems with BFD in the past. The disease has been largely controlled by improved husbandry, especially moving the aviary to a site protected from wind and rain (Brown *et al*, 1994). Experience controlling the disease in this intensively managed species may provide a useful model for other captive-bred threatened species populations.	Species and organisations identified for *ex situ* effort, plans in place	1–5 years

Actions	Performance indicators	Indicative timelines
Action 4.5: Perform population viability analyses It is important to perform population viability analysis modelling of different disease rates and different management strategies for each priority parrot species and provide the information to managers. Such models will be most useful if prepared in advance of a disease outbreak.	PVA models exist for different rates of disease and different management strategies as determined by the team	1–5 years
Action 4.6: Develop emergency response planning Emergency response plans are needed to guide response to disease outbreaks.	An emergency response plan available	2 years
OBJECTIVE 5: EDUCATION AND EXTENSION *Share information with Australian, State and Territory Government management agencies, recovery teams, field workers, veterinarians and wildlife carers, so as to achieve better BFD management outcomes*		
Action 5.1: Educate for disease detection Effective education and extension material such as clinical evaluation and post-mortem protocols is needed by field workers and wildlife managers, to promote detection of the disease in priority species of psittacine birds so that the true impact of the disease is identified.	Information distributed to wildlife managers, veterinarians and wildlife carers	1–5 years, ongoing
Action 5.2: Develop and distribute protocols There is a need for clinical evaluation, post-mortem, quarantine and transport protocols that set out: • handling and disposal procedures for dead birds • procedures for transport of bodies and tissues • disinfection procedures • which pathologist/laboratory samples should be sent to • who needs to be notified in the event of positive or negative diagnosis.	Materials prepared and distributed to field workers to assist in field detection of the disease in priority species	2 years
Action 5.3: Provide access to web-based information A web site should be developed and maintained to provide the latest data to interested parties.	Web site developed and maintained	2–4 years

2.7 Implementation, evaluation and review

The Department of the Environment and Heritage will facilitate implementation of the plan, encouraging involvement of key stakeholders and expertise. The Australian Government will implement the plan as it applies to its land and act in accordance with the provisions of the plan.

Funds are available under the Natural Heritage Trust for the implementation of key national environmental priorities, such as the actions listed in this plan and on-ground implementation of actions identified in regional natural resource management plans.

As specified in actions under Objective 1 (national coordination), the Department will convene a BFD Threat Abatement Plan Implementation Team to oversee and advise on the implementation of the plan. The team will include people with relevant and technical expertise in BFD management and research, especially on nationally listed threatened species and ecological communities. It will also include stakeholders such as state and territory agencies. The primary task of the team will be to oversee implementation of the plan.

The making of this plan does not necessarily indicate the commitment of individual stakeholders to undertaking any specific actions. The attainment of objectives and the provision of funds may be subject to budgetary and other constraints. Proposed actions may be subject to modification over the life of the plan due to changes in knowledge.

The initial duration of the plan is five years, but the threat abatement process is likely to be ongoing, as there is no likelihood of nationally eradicating BFD in the foreseeable future. In addition, the costs of many of the actions will be determined by the level of resources that stakeholders commit to control of the disease. The total cost of the plan's implementation over its lifetime therefore cannot be quantified at the time of making this plan.

Section 279 of the EPBC Act provides for the plan's review at any time and requires that the plan be reviewed at intervals of no longer than five years (see Appendix B). If evidence is found that the practices recommended in the plan need to be updated or modified to prevent species becoming endangered or extinct, the Department will recommend to the Minister that the plan be revised sooner.

Before the end of the five-year period, the Department will commission an independent person to review the plan's implementation and the available technical information. The review will involve key stakeholders.

Recommendations from the review will be used to revise the plan for the next five-year phase.

Appendix A: Glossary

Adjuvants	A medication which is added to enhance the action of a vaccine
Aetiology	The study of the agents that cause disease processes
Antibody	Specific protein produced by the immune system in response to a specific antigen (e.g. a virus)
APV	Avian polyoma disease
BFD	Psittacine Beak and Feather Disease
Bursa (of Fabricius)	Part of the immune system of birds, located in the cloaca, where young lymphocytes released from the bone marrow mature into B-type lymphocytes (a type of white blood cell which produces antibodies)
CAV	Chicken anaemia virus
Critical habitat	As defined in and listed under the EPBC Act Habitat listed in the Register of Critical Habitat in relation to a species or ecological community is ***critical habitat*** for the species or ecological community
Ecological community	As defined in and listed under the EPBC Act Means an assemblage of native species that: (a) inhabits a particular area in nature *and* (b) meets the additional criteria specified in the regulations (if any) made for the purposes of this definition.
Endangered species	As defined in and listed under the EPBC Act A native species is eligible to be included in the endangered category at a particular time if, at that time: (a) it is not critically endangered *and* (b) it is facing a very high risk of extinction in the wild in the near future, as determined in accordance with the prescribed criteria.
Endemic	The continuous presence of an infectious disease-causing organism in a specific population of animals or in a particular geographical area
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Australian Government legislation)
Epidemic	The occurrence of a disease in numerous people (or animals) at the same time in the same geographical area. Literally the word epidemic refers to people, and the correct term for a disease outbreak in animals is epizootic
Epitheliotropic	Having an affinity for epithelium.
Epizootiology	The study of the frequency and distribution of infectious diseases among animals (as opposed to epidemiology which refers to people). This science attempts to define how an infectious agent interacts with host and external environmental factors to cause a disease process
Haemagglutination	The clumping of red blood cells

Haemagglutination-inhibition assay	A test used to detect antibodies to some viruses micro-organisms which cause clumping of red blood cells When antibodies to these viruses are incubated with the virus, the antibodies bind to the virus particles, inhibiting their ability to agglutinate the red blood cells
HI	Haemagglutination-inhibition
Incidence	The frequency with which a disease occurs within a specific population over a given period of time
Inclusion bodies	Visible accumulations of virus particles, proteins, viral components or damaged cellular debris in the nucleus or cytoplasm of some cells infected with certain viruses
Incubation period	The interval between exposure to an infectious agent and the first appearance of clinical signs
Intracytoplasmic	Located or occurring within the cytoplasm of a cell
IUCN	International Union for the Conservation of Nature
IUCN categories	Extinct, EX Extinct in the Wild, EW Critically Endangered, CR Endangered, EN Vulnerable, VU Near Threatened, NT Least Concern, LC Data Deficient, DD Not Evaluated, NE
Pathogenesis	The origination and development of a disease process
Pathognomonic	A change that is characteristic or peculiar to a specific disease
Pathology	Study of the changes in structure and function associated with disease
PCV	Packed cell volume, a measure of red blood cell numbers
PCR	Polymerase chain reaction
Prevalence	The number of cases of a particular disease present in a specific population at a specific point in time
Psittacine bird	Birds in the order Psittaciformes that includes family Psittacidae, the parrots including lorikeets, rosellas, budgerigars, and family Cacatuidae, the cockatoos
Seroconvert	The development of antibodies in response to an infection or vaccination
Seroprevalence	The number of birds in a study population that have antibodies to a particular organism
Threatened species	Refers to the Australian Government list of threatened native species divided into the following categories as per the EPBC Act: critically endangered; endangered; vulnerable; conservation dependent
Viremic period	Period when the presence of virus circulating in the blood can be detected

Appendix B: EPBC Act Extracts – Threat Abatement Plans

The following extracts from the EPBC Act relate to the requirements for developing threat abatement plans.

Section 271 Content of threat abatement plans

(1) A threat abatement plan must provide for the research, management and other actions necessary to reduce the key threatening process concerned to an acceptable level in order to maximize the chances of the long-term survival in nature of native species and ecological communities affected by the process.

(2) In particular, a threat abatement plan must:

- (a) state the objectives to be achieved *and*
- (b) state the criteria against which achievement of the objectives is to be measured *and*
- (c) specify the actions needed to achieve the objectives *and*
- (d) state the estimated duration and cost of the threat abatement process *and*
- (e) identify organisations or persons who will be involved in evaluating the performance of the threat abatement plan *and*
- (f) specify the major ecological matters (other than the species or communities threatened by the key threatening process that is the subject of the plan) that will be affected by the plan's implementation *and*
- (g) meet prescribed criteria (if any) and contain provisions of a prescribed kind (if any).

(3) In making a threat abatement plan, regard must be had to:

- (a) the objects of this Act *and*
- (b) the most efficient and effective use of resources that are allocated for the conservation of species and ecological communities *and*
- (c) minimising any significant adverse social and economic impacts consistently with the principles of ecologically sustainable development *and*
- (d) meeting Australia's obligations under international agreements between Australia and one or more countries relevant to the species or ecological community threatened by the key threatening process that is the subject of the plan *and*
- (e) the role and interests of indigenous people in the conservation of Australia's biodiversity.

Section 274 Scientific Committee to advise on plans

(1) The Minister must obtain and consider the advice of the Scientific Committee on:

- (a) the content of recovery and threat abatement plans *and*
- (b) the times within which, and the order in which, such plans should be made.

(2) In giving advice about a recovery plan, the Scientific Committee must take into account the following matters:

- (a) the degree of threat to the survival in nature of the species or ecological community in question
- (b) the potential for the species or community to recover
- (c) the genetic distinctiveness of the species or community
- (d) the importance of the species or community to the ecosystem
- (e) the value to humanity of the species or community
- (f) the efficient and effective use of the resources allocated to the conservation of species and ecological communities.

(3) In giving advice about a threat abatement plan, the Scientific Committee must take into account the following matters:

(a) the degree of threat that the key threatening process in question poses to the survival in nature of species and ecological communities.
(b) the potential of species and ecological communities so threatened to recover.
(c) the efficient and effective use of the resources allocated to the conservation of species and ecological communities.

Section 279 Variation of plans by the Minister

(1) The Minister may, at any time, review a recovery plan or threat abatement plan that has been made or adopted under this Subdivision and consider whether a variation of it is necessary.

(2) Each plan must be reviewed by the Minister at intervals not longer than 5 years.

(3) If the Minister considers that a variation of a plan is necessary, the Minister may, subject to subsections (4), (5), (6) and (7), vary the plan.

(4) The Minister must not vary a plan, unless the plan, as so varied, continues to meet the requirements of section 270 or 271, as the case requires.

(5) Before varying a plan, the Minister must obtain and consider advice from the Scientific Committee on the content of the variation.

(6) If the Minister has made a plan jointly with, or adopted a plan that has been made by, a state or self-governing territory, or an agency of a state or self-governing territory, the Minister must seek the cooperation of that state or territory, or that agency, with a view to varying the plan.

(7) Sections 275, 276 and 278 apply to the variation of a plan in the same way that those sections apply to the making of a recovery plan or threat abatement plan.

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2000 NO. 181 - REG 7.12 Content of threat abatement plans

For paragraph 271 (2) (g) of the Act, a threat abatement plan must state:

(a) any of the following that may be adversely affected by the key threatening process concerned:

(i) listed threatened species or listed threatened ecological communities
(ii) areas of habitat listed in the register of critical habitat kept under section 207A of the Act
(iii) any other native species or ecological community that is likely to become threatened if the process continues *and*

(b) in what areas the actions specified in the plan most need to be taken for threat abatement.

Appendix C: Threatened Parrots in Australia

The following table lists the conservation status of threatened parrots under the EPBC Act.

Common name	Taxonomic name	EPBC Act status
Paradise Parrot	*Psephotus pulcherrimus*	Extinct
Red-crowned Parakeet (Lord Howe Island)	*Cyanoramphus novaezelandiae subflavescens*	Extinct
Red-crowned Parakeet (Macquarie Island)	*Cyanoramphus novaezelandiae erythrotis*	Extinct
Norfolk Island Kaka	*Nestor productus*	Extinct
Coxen's Fig-Parrot	*Cyclopsitta diophtalma coxeni*	Endangered
Orange-bellied Parrot	*Neophema chrysogaster*	Endangered
Night Parrot	*Pezoporus occidentalis*	Endangered
Red-tailed Black-Cockatoo (south-eastern)	*Calyptorhynchus banksii graptogyne*	Endangered
Glossy Black-Cockatoo (Kangaroo Island)	*Calyptorhynchus lathami halmaturinus*	Endangered
Carnaby's Black-Cockatoo or Short-billed Black-Cockatoo	*Calyptorhynchus latirostris*	Endangered
Swift Parrot	*Lathamus discolor*	Endangered
Golden-shouldered Parrot	*Psephotus chrysopterygius*	Endangered
Norfolk Island Green Parrot or Red-crowned Parakeet (Norfolk Island)	*Cyanoramphus novaezelandiae cookii*	Endangered
Western Ground Parrot	*Pezoporus wallicus flaviventris*	Endangered
Superb Parrot	*Polytelis swainsonii*	Vulnerable
Muir's Corella (southern) or Western Long-billed Corella (southern)	*Cacatua pastinator pastinator*	Vulnerable
Regent Parrot (eastern)	*Polytelis anthopeplus monarchoides*	Vulnerable
Baudin's Black-Cockatoo or Long-billed Black-Cockatoo	*Calyptorhynchus baudinii*	Vulnerable
Princess Parrot or Alexandra's Parrot	*Polytelis alexandrae*	Vulnerable

Appendix D: Parrot species affected by beak and feather disease

The following table lists examples of parrot species worldwide in which lesions suggestive of BFD have been identified. This list is not comprehensive, but indicates the range of species that are at risk. Birds are listed in alphabetical order by common name. (Modified from Ritchie (1995).)

Family	Common name	Taxonomic name
Cacatuidae	Black Palm Cockatoo*	*Probosciger aterrimus*
	Citron Cockatoo	*Cacatua citrinocristata*
	Cockatiel*	*Nymphicus hollandicus*
	Galah*	*Cacatua roseicapillus*
	Gang-gang Cockatoo*	*Callocephalon fimbriatum*
	Glossy Black-Cockatoo*	*Calyptorhynchus lathami*
	Goffin's Cockatoo*	*Cacatua goffini*
	Little Corella*	*Cacatua sanguinea*
	Long-billed Corella*	*Cacatua tenuirostris*
	Major Mitchell's Cockatoo*	*Cacatua leadbeateri*
	Moluccan Cockatoo	*Cacatua moluccensis*
	Red Tailed Black-Cockatoo*	*Calyptorhynchus banksii*
	Red-vented Cockatoo	*Cacatua haematuropygia*
	Sulphur-crested Cockatoo*	*Cacatua galerita*
	Triton Cockatoo	*Cacatua triton*
	Umbrella Cockatoo	*Cacatua alba*
	Yellow Tailed Black-Cockatoo*	*Calyptorhynchus funereus*
Loridae	Blue-streaked Lory	*Eos reticulata*
Psittacidae	African Grey Parrot	*Psittacus erithacus*
	Australian King Parrot*	*Alisterus scapularis*
	Australian Ringneck*	*Barnardius zonarius*
	Black Parrot	*Coracopsis nigra*
	Blue and Gold Macaw	*Ara ararauna*
	Blue-fronted Amazon Parrot	*Amazona aestiva*
	Bourke's Parrot*	*Neopsephotus bourkii*
	Budgerigar*	*Melopsittacus undulatus*
	Cape Parrot	*Poicephalus robustus*
	Crimson Rosella*	*Platycercus elegans*
	Eastern Rosella*	*Platycercus eximius*
	Eclectus Parrot*	*Eclectus roratus*
	Golden-shouldered Parrot*	*Psephotus chrysopterygius*
	Green-winged Macaw	*Ara chloroptera*
	Hooded Parrot*	*Psephotis dissimilis*
	Indian Ring-necked Parakeet	*Psittacula manillensis*
	Jandaya Conure	*Aratinga auricapilla*
	Meyer's Parrot	*Poicephalus meyeri*
	Northern Rosella*	*Platycercus venustus*
	Orange-bellied Parrot*	*Neophema chrysogaster*
	Pale-headed Rosella*	*Platycercus adscitus*
	Princess Parrot*	*Polytelis alexandrae*
	Rainbow Lorikeet*	*Trichoglossus haematodus*
	Red-bellied Parrot	*Poicephalus rufiventris*
	Red-lored Amazon	*Amazona autumnalis*
	Red-rumped Parrot*	*Psephotus haematonotus*

	Regent Parrot*	*Polytelis anthopeplus*
	Rose-ringed Parakeet	*Psittacula krameri*
	Scaley-headed Parrot	*Pionus maximiliani*
	Scaly-breasted Lorikeet*	*Trichoglossus chlorolepidotus*
	Scarlet Macaw	*Ara macao*
	Senegal Parrot	*Poicephalus senegalus*
	Superb Parrot*	*Polytelis swainsonii*
	Swift Parrot*	*Lathamus discolor*
	Vasa Parrot	*Coracopsis vasa*
	Western Rosella*	*Platycercus icterotis*
Genus Agapornis	Black-cheeked Lovebird	*Agapornis nigrigenis*
	Fisher's Lovebird	*Agapornis fisheri*
	Masked Lovebird	*Agapornis personatus*
	Nyassa Lovebird	*Agapornis lilianae*
	Peach-faced Lovebird	*Agapornis roseicollis*

** Parrot species native to Australia*

Appendix E: Bibliography

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Appendix F: Acknowledgments

Many people and organisations representing community and industry groups and all levels of government have contributed to the development of this threat abatement plan. Rosemary Booth drafted the plan with input from David Buckley (AQIS), Mark Holdsworth (DPIWE, Tas.), Sue Leelawardana (AQIS), Shane Raidal (Murdoch University), Miranda Shirley (RSPCA), Ian Smales (Healesville Sanctuary, ZPGBV) and Michael Weston (Birds Australia).

Officers of the Department of the Environment and Heritage have also contributed to the preparation of the plan, in particular Anne Brady, Andrew Copp, Narelle Freestone, Robert Moore, Amanda Ozolins, Belinda Parkes and Susan Wright.