

Threat abatement plan

For infection of amphibians with chytrid fungus
resulting in chytridiomycosis (2014)

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Introduction

This threat abatement plan (TAP) has been developed to address the key threatening process 'Infection of amphibians with chytrid fungus resulting in chytridiomycosis', which is listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

The TAP establishes a national framework to guide and coordinate Australia's response to chytrid fungus. It sets out the actions necessary to abate impacts of the listed key threatening process and was developed to comply with the requirements under the EPBC Act for the development of threat abatement plans. It identifies the research, management and other actions needed in Australia's response to this pathogen and replaces the threat abatement plan published in 2006 (Department of the Environment and Heritage, 2006).

The plan has been developed with the involvement and cooperation of a broad range of stakeholders, but the making or adoption of this plan does not necessarily indicate the commitment of individual stakeholders to undertaking any specific actions. Proposed actions may be subject to modification over the life of the plan due to developments in understanding of the organism and its impacts.

The Australian Government Department of the Environment (the Department) is responsible for preparing this TAP. Its development has been informed by:

- the current threat abatement plan (published in 2006)
- a review and evaluation of the 2006 TAP undertaken by the Australian Government (2012)
- information provided by key stakeholders between 2011 and 2014.

Chytridiomycosis is an infectious disease that affects amphibians worldwide. It is caused by the chytrid fungus (*Batrachochytrium dendrobatidis*), a fungus capable of causing sporadic deaths in some amphibian populations and 100 per cent mortality in others. The disease has been implicated in the mass die-offs and species extinctions of frogs since the 1990s. However, its origin and true impact on frog populations remains uncertain and continues to be investigated.

Since 2006, it has become clear that the eradication of this widespread and continuously present disease is not currently possible in wild amphibian populations. Given that the amphibian chytrid fungus has spread to almost all climatically suitable areas in eastern Australia, it has become increasingly important to better understand the impact on key affected species and monitor and mitigate the risk of spread and impact in high risk chytrid negative areas (e.g. Tasmanian Wilderness World Heritage Area) in eastern Australia.

This necessitates a new approach in dealing with the negative impacts of this disease on amphibians in Australia, one that involves identifying and reducing impacts on key environmental assets (threatened species) and requires national coordination.

The Department recognises that a number of the state and territory governments that own land impacted by chytrid have developed management plans and operational guides to abate this threat within their own jurisdictions. This TAP aims to complement state and territory approaches to managing chytrid.

Background – the previous threat abatement plan

'Infection of amphibians with chytrid fungus resulting in chytridiomycosis' was listed in July 2002 as a key threatening process. A key threatening process under the EPBC Act is defined as a process that 'threatens or may threaten the survival, abundance or evolutionary development of a native species or ecological community'. A TAP for infection of amphibians with chytrid fungus resulting in chytridiomycosis was prepared

in 2006 (DEH 2006) and was reviewed in 2012 as per requirements under section 279(2) of the EPBC Act.

The review of the 2006 TAP (DSEWPac 2012) was performed by the Department in consultation with key stakeholders and the members of the National Chytrid Working Group (convened by the Australian Government). It identified the progress against the plan's actions, objectives and goals over the period 2006–2012.

The review found that since 2006 some progress has been made in the implementation of the key actions identified in that TAP. For example: a national map of the distribution of chytridiomycosis is available; historical surveys have been completed; reliable diagnostic laboratory test protocols have been established; the biology of the pathogen has been investigated and is now much better understood; and many amphibian conservation managers in the state organisations are collaborating on captive breeding efforts. The Australian Government also funded other projects targeted specifically to implement key TAP actions, such as: the development of hygiene protocols; guidelines for captive husbandry; a rapid in-field diagnostic test; a national disease strategy; and the formation of the National Chytrid Working Group.

However, the two main goals of the TAP were only partially achieved. That is, the further spread of amphibian chytrid fungus within Australia has slowed to some extent but unfortunately surveys undertaken during the lifetime of the TAP revealed that the disease had already reached almost all climatically suitable areas in Australia by 2006. Furthermore, the impact of infection with amphibian chytrid fungus on populations that are currently infected has only been somewhat decreased.

As a result of the review the Minister decided in December 2012 that:

- a. the TAP should be revised to be a more realistic and targeted plan that will identify and prioritise the key actions and provide national leadership on multi-jurisdictional issues that cut across many species; and
- b. a threat abatement advice should be prepared to provide direction on specific actions and research that are required to abate the threat to biodiversity from chytrid fungus.

This threat abatement plan

This TAP has been developed to provide a new direction to refocus threat abatement actions, while building on the work of the previous TAP and retaining the actions from that plan that remain important to abating the threat. Considerable progress has been made in understanding the impact of chytrid fungus on Australia's native amphibians, and in the development of policies, tools and management procedures relating to them. Where appropriate, this TAP will use and adapt existing mechanisms to ensure efficient implementation and avoid duplication.

This TAP is considered to be a feasible, effective and efficient approach to abating the threat to Australia's biodiversity from the amphibian chytrid fungus. It provides a national framework to guide coordinated actions to minimise the impact of the fungus on biodiversity by protecting key environmental assets (threatened species and ecological communities listed under the EPBC Act and other matters of national environmental significance). The draft TAP is expected to maintain the profile of the issue of amphibian chytrid fungus, provide direction for priority setting of national funding programmes and guidance for state, territory and local governments to prioritise and support threat abatement actions in their management programmes. It also contains information on priorities for research to enable universities and other research facilities to target research projects towards addressing gaps in knowledge.

While the Department initially developed separate draft TAP and draft threat abatement advice documents, it became evident during the process that there was a great deal of duplication between the two documents. Recent advances in the understanding of chytrid fungus has enabled longer term research priorities to be developed and included as part of the TAP, which resulted in the content originally proposed for the short-term

threat abatement advice becoming largely redundant. Also the proposal to have mandatory threat abatement advice for all key threatening processes was abandoned. Therefore, it was decided in consultation with the National Chytrid Working Group that the development of a threat abatement advice was no longer required.

Due to resource constraints and current priorities within the Department it is not proposed at this time to update and rewrite the scientifically detailed background document that accompanied the previous TAP. The preparation of a scientific background document for a TAP is not a requirement under the EPBC Act.

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1. Threat abatement plan for infection of amphibians with chytrid fungus resulting in chytridiomycosis

1.1 Threat abatement plans and implementation

The EPBC Act prescribes the process, content and consultation to be followed when making a TAP to address a listed key threatening process. Under Section 270(A) of the EPBC Act, the Australian Government:

- develops TAPs where the Minister agrees that the making of a TAP is a feasible, efficient and effective way to abate a key threatening process.

Under Section 269 of the EPBC Act, the Australian Government:

- implements TAPs to the extent they apply in areas under Australian Government control and responsibility. Australian Government agencies must not take any actions that contravene a TAP
- seeks the cooperation of the affected jurisdictions in situations where a TAP applies outside Australian Government areas in states or territories, with a view to jointly implementing the TAP.

The success of this TAP will depend on a high level of cooperation between all key stakeholders, including:

- Australian Government departments and agencies
- state and territory conservation and natural resource management agencies
- local governments
- research institutes
- the general community, including non-government environmental organisations and private conservation land management bodies, private landholders, Indigenous communities and natural resource management groups.

It will be important that land managers assess the threats and impacts of chytrid and allocate adequate resources towards effective on-ground prevention of spread and management of impacts, improving the effectiveness of prevention and management programmes, and measuring and assessing outcomes.

In order to successfully implement this TAP, the Department will:

- coordinate its implementation as it applies to Commonwealth land and act in accordance with the provisions of the TAP, as required under the EPBC Act
- seek stronger coordination of national action on chytrid
- draw on expertise from state and territory agencies and non-government organisations
- encourage involvement of key stakeholders and experts in chytrid related research and management.

The Australian Government will monitor the uptake and effectiveness of management actions by all parties as part of a review of the TAP under Section 279 of the EPBC Act. Where the Australian Government and state and territory governments have mutual obligations, negotiation of appropriate actions and funding of management actions will be undertaken.

1.2 The pathogen – history and spread

First discovered in dead and dying frogs in Queensland in 1993, chytridiomycosis is a highly infectious disease of amphibians, caused by the amphibian chytrid fungus *Batrachochytrium dendrobatidis* (*B. dendrobatidis*). Research since then has shown that the fungus is widespread across Australia and has been present in the country since the 1970s. The disease is also found in Africa, the Americas, Europe, New Zealand and Asia.

Chytridiomycosis has been found in all Australian states and in the Australian Capital Territory, but not in the Northern Territory. Currently, it appears to be confined to the relatively cool and wet areas of Australia, such as along the Great Dividing Range and adjacent coastal areas in the eastern mainland states of Queensland, New South Wales, Victoria, eastern and central Tasmania, southern South Australia, and south-western Western Australia.

Only a very few areas of suitable host environment remain uninfected in Australia—including the World Heritage Area in south-west Tasmania and the Iron Range on Cape York. There are also some pockets of disease-free areas existing within infected regions due to the isolated nature of these amphibian populations.

Chytridiomycosis/*B. dendrobatidis* is listed as a notifiable disease in Australia's National List of Reportable Diseases of Aquatic Animals and by the World Organisation for Animal Health (OIE, formerly Office International des Epizooties) in the Aquatic Animal Health Code.

1.3 Impacts of Chytrid

1.3.1 Ecological impacts

Chytrid fungi typically live in water or soil, although some are parasites of plants and insects. They reproduce asexually and have spores that 'swim' through the water. Only the amphibian chytrid fungus is known to infect vertebrate species. Individual frogs are thought to contract the disease when their skin comes into contact with water containing spores from infected animals.

Chytridiomycosis mostly affects amphibian species associated with permanent water, such as streams, moist bogs or soaks and ponds. The disease is strongly mitigated by high temperatures and disease outbreaks have been observed to occur seasonally. However, much is still unknown about the fungus and the disease in the wild, including reasons for the death of hosts, how the fungus survives in the absence of amphibian populations and how it spreads. Interactions between the fungus and environmental factors are known to be important. For example, Australian upland frog populations have suffered the greatest number of declines and extinctions, leading to the suggestion that environmental stress, perhaps from climate change or increased exposure to ultraviolet radiation, may be reducing resistance to infection.

The fungus invades the surface layers of the frog's skin, causing damage to the outer keratin layer. Amphibian skin is unique because it is physiologically active, allowing the skin to tightly regulate respiration, water, and electrolytes. It is not yet known exactly how the fungus kills amphibians but it is thought that it may cause mortality through disrupting the normal function of the skin resulting in electrolyte depletion and osmotic imbalance.

In some frog populations, the disease causes 100 per cent mortality, while only causing some deaths in other populations. Some amphibian species are highly susceptible and die quickly whilst others seem to be less susceptible. With antifungal and supportive treatment adult frogs and tadpoles can fully recover from the disease.

1.3.2. Impacts on matters of national environmental significance

EPBC Act listed threatened species or listed threatened ecological communities are matters of national environmental significance protected under the Act. 'Infection of amphibians with chytrid fungus resulting in chytridiomycosis' is listed as a key threatening process under the EPBC Act.

The key threatening process is eligible for listing under the EPBC Act as it meets all criteria for listing:

- a. *it could cause a native species or an ecological community to become eligible for listing in any category, other than conservation dependent; or*
- b. *it could cause a listed threatened species or a listed threatened ecological community to become eligible to be listed in another category representing a higher degree of endangerment; or*
- c. *it adversely affects 2 or more listed threatened species (other than conservation dependent species) or 2 or more listed threatened ecological communities.*

In Australia, the fungus has been directly implicated in the extinction of at least four species and the dramatic decline of at least 10 others, including *Litoria nannotis* (waterfall frog), *Litoria rheocola* (common mistfrog), *Litoria spenceri* (spotted tree frog) and *Nycitmystes dayi* (lace-eyed tree frog). The four species listed as extinct are from Queensland and include *Rheobatrachus silus* (southern gastric-brooding frog, last seen 1981), *Rheobatrachus vitellinus* (northern gastric-brooding frog, 1985), *Taudactylus acutirostris* (sharp-snouted day frog, 1997) and *Taudactylus diurnus* (southern day frog, 1979). Many persisting species remain at lower abundance and smaller distributions than the levels recorded before the species were affected by chytridiomycosis, some are continuing to decline and significant mortality from the disease is ongoing even decades after introduction.

Table A provides a list of threatened species (under the EPBC Act) that are under immediate threat from the amphibian chytrid fungus and Table B lists the amphibian species that have gone extinct.

1.4. Managing the threat

While eradication of this widespread and continuously present disease is not currently possible in wild amphibians, an array of well-targeted actions, combined with well-developed management plans based on current knowledge, can assist in reducing the impact of the disease on threatened amphibian populations, particularly those presently in captive breeding programmes and for any future captive breeding of threatened species.

Currently there are no proven methods to control this endemic disease in the wild. For threatened frog species where the disease is endemic, emergency measures are needed to increase population sizes through strategies including captive insurance colonies and assisted colonisation. It is vital that these captive populations be established in a timely and strategic manner to avoid crisis situations and possible extinctions. Captive husbandry techniques for each at-risk species should be developed and documented.

The amphibian chytrid fungus is now established in most of the climatically suitable areas in Australia. Despite this, considerable efforts continue to protect the few remaining isolated uninfected amphibian populations, and some uninfected areas such as the Tasmanian Wilderness World Heritage Area. Some state governments have developed policy documents that contain strategies to limit the risk of spreading chytrid. However, there has been little coordination between the states in policy development, risk analysis, surveying efforts for the presence and spread of chytrid or limiting the impact of the disease once it has spread. Therefore, facilitation of coordination among jurisdictions would be of value in ensuring a consistent and high standard of threat abatement along with maximising cost efficiency. It would also help to identify if any high-risk areas have been overlooked to date.

Understanding the ecology and characteristics of the disease is important when developing effective management strategies. The mechanisms that underlie some amphibian species' resistance/ immunity to chytrid at species and individual levels and the role this apparent resistance plays in allowing populations to persist and even recover from the impact of chytrid should be investigated. This knowledge could be used to improve management strategies, which are important for ensuring successful reintroductions and long term threat abatement.

As chytrid strains vary in virulence, understanding the differences in strains, mapping their location and reducing the risk of spread between infected areas is also important. Developing a greater understanding of how the impact of amphibian chytrid fungus in infected wild populations can be better mitigated would help in controlling the threat of the disease.

Monitoring and surveillance is necessary to:

- determine the impact of the disease on frog populations;
- detect new outbreaks in currently uninfected populations or locations of unknown disease status; and
- monitor the progress and success of management strategies in order to provide the necessary feedback for adaptive management.

1.5. Climate Change

It is difficult to predict how changing climate parameters will impact the chytrid fungus, but it is likely that the distribution and virulence of chytrid disease will be somewhat altered because of climate change. With predicted average temperature increases of between 1°C and 5°C in Australia by the year 2070 (CSIRO and Bureau of Meteorology 2007-2012), it is possible that chytrid fungus will extend into areas that were previously unsuitable for the establishment of the pathogen. In contrast, some areas predicted to have higher temperatures and reduced rainfall could become less conducive to the disease. Some models suggest that higher temperatures associated with climate change may reduce the range suitable for chytrid impact, as some areas become too warm for chytrid development and transmission, although range expansion or shifts to higher altitudes may occur in the tropics (Rodder et al., 2010).

The effects of climate change are likely to be variable among species and sites; for example increases in cloud or canopy cover could tend to increase the effects of the disease on susceptible individuals but higher temperatures may tend to decrease the effects (Rowley and Alford, 2013). The impact that changes in hydrology may have on chytrid disease is even harder to predict than air temperature changes.

2. Objectives and actions

The overarching goal of this TAP is to minimise the adverse impacts of amphibian chytrid fungus on affected native species and ecological communities. To achieve this goal, the TAP has four main objectives that were developed in consultation with experts. These objectives are to:

1. improve understanding of the extent and impact of infection by amphibian chytrid fungus and reduce its spread to uninfected areas and populations
2. identify and prioritise key threatened amphibian species, populations and geographical areas and improve their level of protection by implementing coordinated, cost-effective on-ground management strategies
3. facilitate collaborative applied research that can be used to inform and support improved management of amphibian chytrid fungus
4. build scientific capacity and promote communication among stakeholders.

Each objective is accompanied by a set of actions that, when implemented, will help to achieve the goal of the TAP. Performance indicators (outcomes and outputs) have been established for each objective. Reports on progress against the objectives may be sought by the Department in years 3–5 for the purpose of assessing the effectiveness of the TAP.

Objective 1: Improve understanding of the extent and impact of infection by amphibian chytrid fungus and reduce its spread to uninfected areas and populations

Gaining information on the extent of infection and the location of uninfected populations and areas will help to inform the planning of control and surveillance activities.

Action	Priority/ timeframe	Outcome/output
<p>Action 1.1: Understand impacts of chytrid on priority species</p> <p>Stakeholders to undertake population monitoring of at risk species to determine impacts of chytrid on these species. Improved mapping and monitoring that incorporates changes in population distribution, density and impacts over time may also increase understanding of potential impact.</p> <p>Given that the amphibian chytrid fungus has spread to almost all climatically suitable areas in eastern Australia, it is important to better understand the impact on key affected species and monitor and mitigate the risk of spread and impact in high risk chytrid negative areas (e.g. Tasmanian Wilderness World Heritage Area) in eastern Australia.</p> <p>It is also important to consider the potential effects of climate change on the spread of chytrid and the impacts on priority species, which are likely to be variable among species and sites.</p>	<p>High priority</p> <p>Years 1–5</p>	<p>Monitoring of the impacts of chytrid on priority species is undertaken.</p>
<p>Action 1.2: Continue the mapping of the distribution of chytridiomycosis at a regional scale to inform appropriate planning and an adaptive management approach</p> <p>Stakeholders to continue their ongoing survey work and mapping the locations of chytrid-infected and chytrid-free areas (preferably at a regional scale). This would build on the work already done under the previous TAP (2006), such as the national distribution map developed in 2010 by Murray et al. (Attachment A) and the survey protocols developed by Skerratt et al. (2008, 2010).</p> <p>Regularly updating maps and reporting new infections (to the Australian Wildlife Health Network) would assist federal and state agencies to monitor the effectiveness of management programmes.</p> <p>The identification and mapping of different chytrid strains should also be undertaken to inform the distribution modelling and the risk of chytridiomycosis, and to identify where knowledge gaps exist.</p>	<p>Medium priority</p> <p>Years 1–5</p>	<p>Agreed survey protocols used by all affected jurisdictions to keep current the national map of the distribution of chytridiomycosis (at Attachment A) and develop regional scale maps.</p> <p>Identification and mapping of chytrid strains is undertaken</p>
<p>Action 1.3: Develop and implement amphibian translocation strategies to prevent the accidental spread of the fungus</p> <p>Ensure that measures to prevent the spread of chytrid fungus are included in amphibian translocation strategies developed for conservation purposes, such as:</p> <ol style="list-style-type: none"> the release of captive populations; reintroduction programmes; and relocation of populations to mitigate habitat loss. <p>The Department to support the development and implementation of translocation strategies (by the states) that are consistent with EPBC Act approved recovery plans and relevant policies. Strategies should</p>	<p>Medium priority</p> <p>Years 1–3</p>	<p>Translocation strategies agreed and implemented by all affected jurisdictions</p>

<p>include measures to prevent the introduction of amphibian chytrid fungus into naïve areas and populations.</p> <p>Although this action is particularly important in areas that are chytrid-free (such as the Tasmanian Wilderness World Heritage Area), it may also apply to widely separate infected areas of Australia where there is uncertainty about the levels of risk due to potential differences in strain virulence. A precautionary approach should be adopted for these areas i.e. no movement of infected amphibians between widely separate infected regions should occur until appropriately assessed under an approved translocation strategy.</p> <p>Information on how to manage accidentally translocated amphibians (such as in agricultural produce, e.g. bananas) needs to be made available to industry, wildlife professionals and the general community. This could be included in the Communication Strategy (see Action 4.1)</p>		
<p>Action 1.4: Ensure intra-state and inter-state implementation of hygiene protocols, focusing on high priority areas</p> <p>Preventing the spread of the chytrid fungus into chytrid-free high priority areas is vital to the continued existence of some particularly threatened amphibian species and populations. Implementing effective hygiene protocols will reduce the chances of the amphibian chytrid fungus spreading into these areas. Hygiene protocols and associated education programmes have been developed but have yet to be implemented in a coordinated manner across states. These protocols need to be included in management strategies at all levels.</p> <p>Government departments to ensure licences and permits for wildlife or flora studies, research or other activities that have the potential to transmit amphibian chytrid fungus into chytridiomycosis-free areas, include conditions that require the use of appropriate disinfection strategies between sites.</p> <p>Community access to information about best-practice hygiene and spread-prevention techniques should be included in the Communication Strategy (see Action 4.1).</p>	<p>Low priority Years 1–4</p>	<p>Agreed hygiene protocols implemented by all states and provided to land managers, contractors and affected communities for implementation</p>

Objective 2: Identify and prioritise key threatened amphibian species, populations and geographical areas and improve their level of protection by implementing coordinated, cost-effective on-ground management strategies

The purpose of this TAP is to address the key threatening process; that is, to reduce the impacts to native amphibians from infection with chytrid fungus resulting in chytridiomycosis. It is therefore necessary to identify priority amphibian species and populations that may need protecting. The Australian Government has a responsibility to manage the impacts of chytrid fungus on Commonwealth land and to protect matters of national environmental significance, such as EPBC Act listed threatened amphibian species. There may also be state, regional and/or local species/populations that should be identified to help prioritise management activities. Particularly sensitive areas and populations need to be prioritised for protection; and monitoring and management activities coordinated in order to make best use of limited resources.

To achieve improvements and maximum efficiency in management activities, it is accepted that sharing information and coordinating activities across jurisdictions will result in the greatest gains. Applying coordinated, scientifically-based management to high-priority areas that contain key threatened species is vitally important to protect these amphibian species.

A number of guidelines and protocols are required for the successful coordinated management of amphibian chytrid fungus. Many of the state governments have developed different policy documents that contain management strategies but there is a lack of coordination between states in their application and implementation. Linking chytrid management strategies to threatened species recovery plans would help to coordinate conservation efforts and maintain awareness of any listed species or ecological communities potentially affected by management actions.

Action	Priority/ timeframe	Outcome/output
<p>Action 2.1: Identify species at high risk from chytrid for priority management (this links to Action 1.1 Understand impacts of chytrid on priority species and 2.3 below)</p> <p>Identify key native amphibian species that are threatened or particularly vulnerable to amphibian chytrid fungus (most are found in Table A). This should include species assessed as having the potential to become threatened due to the impacts of chytrid fungus such as the Tasmanian Tree Frog <i>Litoria burrowsae</i>.</p> <p>State environment departments, biodiversity conservation managers and researchers to lead in monitoring and surveillance of the identified high priority species of amphibians to inform risk assessments and subsequent management decisions.</p>	High priority Years 1–2	Key species identified and prioritised for protection
<p>Action 2.2: Implement biosecurity measures around high priority areas and identify any additional chytrid-free areas for protection</p> <p>The state environment departments, biodiversity conservation managers and researchers to develop and implement effective biosecurity measures to protect areas that are known to be of high biodiversity value and are ranked high priority for amphibian chytrid fungus exclusion, such as the Tasmanian Wilderness World Heritage Area. This action has high priority but applicability in only a few regions.</p> <p>The state environment departments, biodiversity conservation managers and researchers to identify any additional areas that are of high biodiversity value and are ranked high priority for amphibian chytrid fungus exclusion.</p>	High priority Years 1–2	Key areas identified and effective biosecurity measures implemented.
<p>Action 2.3: Protect at risk species by establishing insurance populations of key threatened species</p> <p>Expand knowledge of husbandry practices, and infrastructure, for captive breeding of amphibians, particularly with respect to species that are threatened or particularly vulnerable to chytridiomycosis (as identified in Action 3.1). This work should be done in a strategic manner, based on risk assessments, in order to avoid potential crisis situations (i.e. few individuals of a species remaining resulting in non-sustainable population levels).</p> <p>Establish captive breeding, captive husbandry and/or translocation programmes across states and territories. Conservation managers to coordinate these activities where possible in order to maximise the outcomes and share knowledge.</p>	High priority Years 1–5	Insurance populations of key threatened species established. Husbandry protocols developed for all species that are vulnerable to chytridiomycosis. No additional amphibian species go extinct due to chytrid.

<p>Action 2.4: Genome banking and cryopreservation of high priority species</p> <p>Genome banks for threatened Australian amphibian species to be developed at appropriate cryopreservation facilities by state environment departments, biodiversity conservation managers and researchers, with priority on the key at risk species identified in Action 2.1.</p> <p>This action supports Action 2.3 for captive husbandry purposes in that it can be used to expand the gene pool of captive populations.</p> <p>This action may be required as a last line of defence to prevent the extinction of critically endangered native amphibian species.</p>	<p>High priority</p> <p>Years 1–3</p>	<p>Genome banks established at approved cryopreservation facilities.</p>
<p>Action 2.5: Include chytrid management strategies in frog recovery plans to achieve better coordination of conservation efforts. Ensure recovery plans are enacted for all high priority species threatened by chytrid</p> <p>The Department to ensure, as new recovery plans are developed, that strategies to manage chytridiomycosis are addressed in the appropriate EPBC Act listed frog recovery plans. The recovery plans should include: assessing species vulnerability to chytridiomycosis; monitoring, detection and determining impact of chytridiomycosis; and identifying actions to address the arrival of the chytrid fungus in the case of chytridiomycosis-free populations or population decline for chytridiomycosis-positive populations.</p> <p>The states to ensure that strategies to manage chytridiomycosis are addressed in state listed frog recovery plans where appropriate.</p> <p>All recovery plans should aim to achieve improved coordination of conservation efforts for amphibians impacted by amphibian chytrid fungus across populations, regions and species.</p> <p>Develop and enact recovery programmes for all high priority species threatened by chytrid.</p>	<p>High priority</p> <p>Years 1–5</p>	<p>Frog recovery plans enacted for threatened species and include strategies to manage chytridiomycosis and improve coordination across regions.</p>
<p>Action 2.6: Develop regional management plans and reporting framework</p> <p>The Department to support the states to develop and implement management programmes for EPBC Act listed threatened amphibian species.</p> <p>States to develop a process to report on and evaluate the implementation of management actions. This would help to maintain momentum, motivation and direction. Regular reporting on the implementation of management programmes will help to identify effective methodologies and prioritise any key areas requiring greater management effort.</p> <p>Agreement on monitoring and evaluation methods will assist with the implementation of procedures and processes. This could include appropriate reporting at national, state, territory and regional levels and the use of existing frameworks such as MERI (monitoring, evaluation, reporting and improvement).</p>	<p>Medium priority</p> <p>Years 1–2</p>	<p>Regional management plans prepared and implemented by jurisdictions.</p> <p>Reporting and evaluation process implemented by states</p>

Objective 3: Facilitate collaborative applied research that can be used to inform and support improved management of amphibian chytrid fungus

To develop the most effective management strategies for abating the threat from amphibian chytrid fungus and ensure the continued existence of sustainable populations of at-risk amphibians in Australia, it is important that joint/collaborative research be used to inform and update knowledge of the key aspects of the disease. Despite improved understanding of the disease through ongoing research efforts there are still significant gaps in knowledge that are hampering the success of management programmes, such as: the different strains of the fungus; levels of virulence; mechanisms for resistance to the disease; treatment options; husbandry methods for individual species, and the potential of other species acting as reservoirs or vectors for transmission of the fungus.

Without this information, there is a risk that management efforts will be misdirected or ineffective.

Action	Priority/ timeframe	Outcome/output
<p>Action 3.1: Assisted colonisation to aid recovery of amphibian populations impacted by chytrid fungus</p> <p>Assisted colonisation is an effective and relatively low cost management option to potentially improve numbers of at-risk priority amphibian species (identified in Actions 1.1 and 2.1).</p> <p>Research is needed to develop assisted colonisation strategies for priority species. Consideration should be given to the identification of the most advantageous low risk sites based on appropriate environment conditions for the target amphibian species, environmental unsuitability for the disease and the potential role of reservoir hosts.</p>	High priority 1–5 years	Assisted colonisation to improve numbers of at-risk priority amphibian species is evaluated for success and broad applicability.
<p>Action 3.2: Investigate and select/modify individual's resistance to abate the threat of chytridiomycosis</p> <ul style="list-style-type: none"> • Understand mechanisms for resistance • Select/modify for resistance based on understanding <p>The mechanisms underlying individual resistance to chytrid are not understood and should be investigated across species including their role in allowing populations to persist and even recover from the impact of chytrid.</p>	High priority 1–5 years	Mechanisms for resistance to chytridiomycosis are understood and potential for targeted selection of individuals or modification are determined.
<p>Action 3.3: Investigate the virulence of the pathogen and potential for pathogen modification/selection</p> <p>Research to improve the understanding of the differences between the various strains of chytrid is urgently required. The virulence of the pathogen varies between strains and therefore the level of risk posed by each strain is variable. It is important to understand what affects virulence and whether the pathogen can be modified or selected to be less virulent.</p>	High priority 1–5 years	The risk posed by various strains of the fungus is determined. The potential for pathogen virulence being selected for or modified (including biocontrol)

<p>The potential role for biocontrol agents such as fungus viruses and predators needs exploration.</p> <p>The virulence of the pathogen varies between species and this aspect should also be investigated.</p>		<p>sufficiently to lead to recovery of species is determined.</p>
<p>Action 3.4: Further development of treatment protocols for infected amphibians and areas</p> <p>Continued research to determine the best treatments for individual species and whether the environment can be treated to abate the threat of chytridiomycosis, such as by spraying with already widely used fungicides.</p> <p>This action complements some of the actions included in the recovery plans for each amphibian species listed under the EPBC Act. Recovery plans set out the research and management actions necessary to stop the decline of, and support the recovery of, listed threatened species. Further information on recovery plans can be found at http://www.environment.gov.au/topics/biodiversity/threatened-species-ecological-communities/recovery-plans</p>	<p>High priority</p> <p>1–3 years</p>	<p>Optimal treatments for priority species are identified. Treatment of the environment is evaluated for feasibility and effectiveness in abating the threat of chytridiomycosis.</p>
<p>Action 3.5: Research to develop husbandry protocols for captive bred populations of priority species</p> <p>Husbandry methods for establishing captive insurance populations of at-risk priority species need to be researched and developed in a timely and strategic manner. This work will support Action 3.3 and priorities should be decided based on the risk assessment process in Action 3.1 and the population impact assessments in Action 1.1.</p> <p>This action complements some of the actions included in the recovery plans for each amphibian species listed under the EPBC Act. Recovery plans set out the research and management actions necessary to stop the decline of, and support the recovery of, listed threatened species. Further information on recovery plans can be found at http://www.environment.gov.au/topics/biodiversity/threatened-species-ecological-communities/recovery-plans</p>	<p>High priority</p> <p>1–3 years</p>	<p>Optimal husbandry for establishing captive insurance colonies for priority species is determined.</p>
<p>Action 3.6: Determine the trigger points required to cause extinction of a population</p> <p>Investigate why apparently "secure" populations occur within infected areas, and whether they may become vulnerable due to shifts in environmental conditions.</p> <p>Investigate vulnerable populations on the current "edge of range" and assess the risks to these populations under climate change scenarios</p>	<p>High priority</p> <p>1–5 years</p>	<p>Trigger points for extinction for vulnerable populations and species are determined.</p>

<p>Action 3.7: Understanding the chytrid fungus in the environment and environment/habitat modification</p> <p>Continue research to improve diagnostic capability, including further testing of the Loop-Mediated Isothermal Amplification (LAMP) test to verify its application as a rapid diagnostic in-field test for detecting the presence of the chytrid fungus in environmental water samples.</p> <p>Research is required to provide further insight into pathogenesis including the factors affecting the virulence of chytrid under various environmental conditions. Research to see whether these factors can be readily manipulated to abate the threat.</p> <p>Undertake research to answer high priority questions about chytrid fungus in the environment, particularly relating to transmission, possible amphibian and non-amphibian vectors, and amphibian and non-amphibian carriers/hosts (e.g. crayfish).</p>	<p>Med priority</p> <p>1–5 years</p>	<p>Diagnostic capability is furthered and the field application of LAMP test is determined.</p> <p>Environmental factors affecting chytridiomycosis are identified and their manipulation is evaluated for feasibility and effectiveness in abating the threat of chytridiomycosis.</p>
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Objective 4: Build scientific capacity and promote communication among stakeholders

Building coordination and communication between key stakeholders and researchers is expected to improve the likelihood of the success of this TAP by facilitating access to data and alerting stakeholders to new sites of infection as well as encouraging increased support for implementing management actions. For researchers it would allow greater collaboration, build capacity and reduce unintentional duplication of efforts.

To achieve improvements and maximum efficiency in management activities, it is accepted that sharing information and coordinating activities across jurisdictions will result in the greatest conservation gains. Applying coordinated, scientifically-based management to high-priority areas that contain key threatened species is vitally important to protect these amphibian species.

Action	Priority/ timeframe	Outcome/output
<p>Action 4.1: Develop a communication strategy that will contribute to abating the threat of amphibian chytrid fungus</p> <p>The Department to promote information exchange between researchers/key stakeholders and coordinate the development of a communication strategy on abating the threat of amphibian chytrid fungus.</p> <p>Key stakeholders to lead on developing and implementing the communication strategy. This communication strategy should include:</p> <ul style="list-style-type: none"> techniques to encourage collaborative research on chytridiomycosis and its impact on amphibian populations across disciplines and institutions methods to disseminate information to stakeholders, including detection of outbreaks, to assist in the coordination of responses to outbreaks particularly in key chytridiomycosis- 	<p>High priority</p> <p>Years 1–3</p>	<p>Communication Strategy developed and implemented</p>

<p>free areas</p> <ul style="list-style-type: none"> methods to educate and inform the community (including key groups such as wildlife carers, veterinarians, bushwalkers and frog naturalists) about existing legislation and regulations regarding chytrid, basic disease management and the risks of transporting potentially infected amphibians, water and other transmitting agents. The Australian Registry of Wildlife Health has an existing public website that could be utilised to provide publicly available information. The content of the Amphibian Disease Home Page could be moved across to this site and updated as required guidelines on appropriate information and signage to be placed at entrances to national parks, forestry reserves, and other areas containing water bodies – particularly identified key areas. 		
<p>Action 4.2: Support the development/provision of a central information storage site where government, stakeholders and researchers can upload and access data (part of communication strategy Action 4.1)</p> <p>Stakeholders to lead on the provision of an agreed central information/data storage site that allows researchers and stakeholders to upload relevant information such as research data and papers that can be shared with other researchers and key stakeholders. This should also act as a coordinated national database for chytrid survey results that could inform reporting processes at all levels of government.</p>	<p>Med priority Years 1–5</p>	<p>Central database developed and relevant data provided to stakeholders</p>
<p>Action 4.3: Support the capacity of stakeholders to participate in the management of amphibian chytrid fungus through the National Chytrid Working Group</p> <p>The Department to support the 'National Chytrid Working Group' whose members are amphibian managers working to abate the threat from amphibian chytrid fungus.</p> <p>The members of this group have technical and practical knowledge in chytrid and amphibian management and include key stakeholders from states and territories where chytrid is recognised as a threat to amphibians. This group is to provide advice and recommendations on resources and priorities for actions to abate the threat of amphibian chytrid fungus in Australia and also provide key contact points to improve information flow and communication between states, regions and local groups.</p>	<p>High priority Years 1–5</p>	<p>National Chytrid Working Group meet annually and provide advice on progress and actions to abate the threat of chytrid.</p>

3. Duration, Review, Funding and Implementation

3.1. Duration and review of the plan

Section 279 of the EPBC Act provides for the review of this TAP at any time and requires that it be reviewed by the Minister at intervals of no longer than five years. During the life of the TAP, the Minister's scientific advisory committee (the Threatened Species Scientific Committee), will be provided with updates of actions taken under this TAP to aid them in advising the Minister on the effectiveness of the TAP in abating the key threatening process.

3.2. Funding and implementation

It is important to note that TAPs are not linked directly to any Australian Government funding programmes. Each financial year, the Australian Government funds TAP development and implementation as part of a broader budget outcome related to biodiversity conservation (www.environment.gov.au/about/publications/budget/index.html). The Department allocates its annual budget to a range of competing biodiversity conservation priorities. The budget provided by the Department for the implementation of individual TAPs may vary from year to year as a range of biodiversity conservation priorities are addressed.

The total cost of implementing this TAP cannot be quantified at the time of its writing. Projects that are to be undertaken by the Australian Government will need to be procured in accordance with the Commonwealth Procurement Rules. The cost of individual projects will not be accurately known until a process to test the market (for example to obtain quotes or tenders for those projects) has been undertaken.

The Australian Government recognises that the capacity of each state or territory government to implement this TAP will be dependent on the resources of that state or territory and the methods of implementation they choose to adopt.

This TAP provides guidance to identify priority areas and undertake actions targeted at these areas. Budgetary and other constraints may affect the achievement of the objectives of this TAP and, as knowledge changes, proposed actions may be modified over the ten-year life of the TAP. Australian Government funds may be available to implement key national environmental priorities, such as relevant actions listed in this TAP and actions identified in regional natural resource management plans that are consistent with this TAP. Achievement of the overarching goal of the TAP will require ongoing management beyond the life of the TAP. Ongoing support by all partners is therefore essential.

Table A: Threatened species listed under the EPBC Act that are under immediate threat from the impacts of amphibian chytrid fungus

Scientific name	Common name	EPBC Act status
Amphibians		
<i>Litoria lorica</i>	armoured mistfrog	CE
<i>Litoria nyakalensis</i>	mountain mistfrog	CE
<i>Pseudophryne corroboree</i>	southern corroboree frog	CE
<i>Pseudophryne pengilleyi</i>	northern corroboree frog	CE
<i>Taudactylus pleione</i>	Kroombit tinker frog/ Pleione's torrent frog	CE

<i>Geocrinia alba</i>	white-bellied frog/ creek frog	E
<i>Litoria booroolongensis</i>	Booroolong frog	E
<i>Litoria castanea</i>	yellow-spotted tree frog/ yellow-spotted bell frog	E
<i>Litoria myola</i>	Kuranda tree frog	E
<i>Litoria nannotis</i>	waterfall frog/ torrent tree frog	E
<i>Litoria rheocola</i>	common mistfrog	E
<i>Litoria spenceri</i>	spotted tree frog	E
<i>Mixophyes fleayi</i>	Fleay's frog	E
<i>Mixophyes iteratus</i>	giant barred frog/ southern barred frog	E
<i>Nyctimystes dayi</i>	lace-eyed tree frog/ Australian lacelid	E
<i>Philoria frosti</i>	Baw Baw Frog	E
<i>Spicospina flammocaerulea</i>	sunset frog	E
<i>Taudactylus eungellensis</i>	Eungella day frog	E
<i>Taudactylus rheophilus</i>	Tinkling frog	E
<i>Geocrinia vitellina</i>	orange-bellied frog	V
<i>Heleioporus australiacus</i>	giant burrowing frog	V
<i>Litoria aurea</i>	green and golden bell frog	V
<i>Litoria littlejohni</i>	Littlejohn's tree frog/ Heath frog	V
<i>Litoria olongburensis</i>	Wallum Sedge frog	V
<i>Litoria piperata</i>	peppered tree frog	V
<i>Litoria raniformis</i>	growling grass frog/southern bell frog/ green and golden frog/ warty swamp frog	V
<i>Litoria verreauxii alpina</i>	Alpine tree frog/ Verreaux's Alpine tree frog	V
<i>Mixophyes balbus</i>	stuttering frog/ southern barred frog (In Vic. only)	V
<i>Pseudophryne covacevichae</i>	magnificent brood frog	V

CE = critically endangered; E = endangered; V = vulnerable

Table B: Amphibian species listed under the EPBC Act as having gone extinct from the impacts of amphibian chytrid fungus

Scientific name	Common name	EPBC Act status
<i>Rheobatrachus silus</i>	southern gastric- brooding frog	EX
<i>Rheobatrachus vitellinus</i>	northern gastric- brooding frog/Eungella gastric – brooding frog	EX
<i>Taudactylus acutirostris</i>	sharp-snouted day frog/ sharp- snouted torrent frog	EX
<i>Taudactylus diurnus</i>	southern day frog/ Mt Glorious torrent frog	EX

Glossary

Assisted colonisation	Helping species colonise areas within or immediately adjacent to their current or former ranges that appear to be suitable habitats for that species
<i>B. dendrobatidis</i>	<i>Batrachochytrium dendrobatidis</i>
Chytridiomycosis	The state of being infected with <i>Batrachochytrium dendrobatidis</i> .
CSIRO	Commonwealth Scientific and Industrial Research Organisation
EPBC Act	The <i>Environment Protection and Biodiversity Conservation Act 1999</i> , the Australian Government's environment legislation.
Key threatening process	<p>A threatening process listed under the EPBC Act that meets any of the following criteria:</p> <ul style="list-style-type: none">• could cause a native species or an ecological community to become eligible for listing in any category, other than conservation dependent• could cause a listed threatened species or a listed threatened ecological community to become eligible to be listed in another category representing a higher degree of endangerment• adversely affects two or more listed threatened species (other than conservation dependent species) or two or more listed threatened ecological communities.
Matter of national environmental significance	<p>A matter defined and protected under the EPBC Act. In 2013 there were eight:</p> <ul style="list-style-type: none">• World Heritage properties• National Heritage places• wetlands of international importance (listed under the Ramsar Convention)• listed threatened species and ecological communities• migratory species protected under international agreements• Commonwealth marine areas• the Great Barrier Reef Marine Park• nuclear actions (including uranium mines).

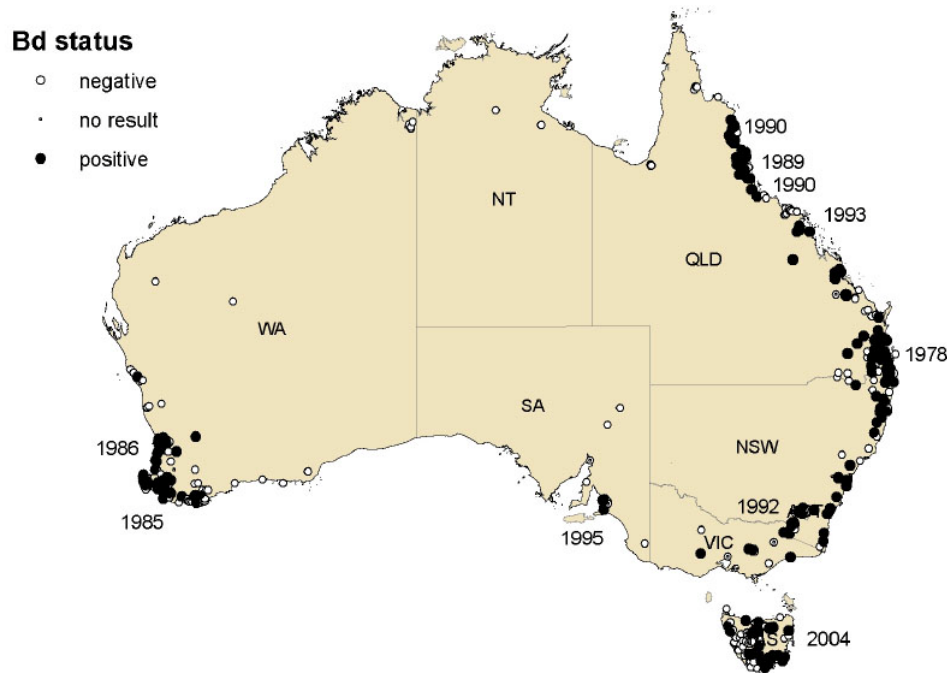
TAP	Threat abatement plan.
Threat abatement plan	A plan made or adopted under section 270B of the EPBC Act that establishes a national framework to guide and coordinate Australia's response to the impacts of a key threatening process.
Threatened species	A species listed under the EPBC Act as being critically endangered, endangered, vulnerable or conservation dependent.
Threatening process	A process listed under the EPBC Act that threatens or may threaten the survival, abundance or evolutionary development of a native species or ecological community.

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Attachment A: Map of the distribution of chytridiomycosis (with dates of first detection)



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