Wildlife Health Australia

White-nose Syndrome Response Guidelines

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Contents

Preface

The policy recommendations in this document were developed by Wildlife Health Australia in consultation with stakeholder groups.

The consultation process included a workshop held by Wildlife Health Australia and Animal Health Australia in October 2016, which brought key stakeholders and response agencies together to consider the options for responding to white-nose syndrome in Australia. Participants included representatives from Commonwealth and State government agencies for agriculture and environment, Animal Health Australia, Wildlife Health Australia, biosecurity emergency management experts, bat ecology experts from the Australasian Bat Society, and university wildlife disease experts and epidemiologists.

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White-nose syndrome

Introduction

White-nose syndrome (WNS) is a fungal disease caused by *Pseudogymnoascus destructans*, which has caused significant mortalities of insectivorous bats in North America. It is estimated that over 5.7 million animals have died as a result of the disease, up to 90-100% in some roosts. Since WNS was first recognised in New York state in 2006, it has spread through eastern USA and Canada. It has caused widespread population declines and local extirpation in affected species, and may cause extinctions. As well as the severe ecological effects, researchers estimate that the loss of bats for insect control could result in losses to North American agriculture of more than $3 billion a year (Boyles *et al.* 2011).

The *P. destructans* fungus has been found across Europe and in north-east China, but without the mass mortalities observed in North America. It appears that *P. destructans* has been present in Europe for a long time, and was introduced into North America from Europe. *P. destructans* has not been identified in Australia.

WNS is a disease of hibernating insectivorous bats, as the fungus requires low body temperature in order to grow on the skin. Clinical signs of WNS include a white or grey powdery fungus on face or wing, wing membrane damage, aberrant behaviour e.g. day flying, and mass mortality. No other animals are known to be susceptible, and no human health risk from WNS has been identified.

P. destructans thrives at cold temperatures and can persist in the environment for long periods, even in the absence of bats. Transmission is through direct contact between bats, but fungal spores can be spread on fomites such as boots and caving equipment, and humans have been implicated in the spread of WNS in North America.

Risk assessment suggests that the most likely method of entry of *P. destructans* into Australia is via infected fomites such as clothing, footwear or equipment that has been used in affected caves in other countries e.g. by a caver, researcher or tourist (Holz *et al.* 2016). Cave-dwelling insectivorous bats in the colder southern parts of Australia, including the critically endangered southern bent-winged bat (*Miniopterus orianae bassanii*), are likely to be at risk of WNS if the fungus is introduced.

Disease status

The World Organisation for Animal Health (OIE) does not include WNS on its list of notifiable diseases, however it is included in the list of non OIE-listed diseases affecting wild animals, which are selected for monitoring by the OIE's Working Group on wildlife diseases.[1]

WNS is not currently a nationally notifiable disease in Australia.

A WNS outbreak could be considered under the *National Environmental Biosecurity Response Agreement* (NEBRA), which sets out emergency response arrangements, including cost-sharing arrangements, for

[1] http://www.oie.int/wahis_2/public/wahidwild.php#

responding to biosecurity incidents that primarily impact the environment and/or social amenity and where the response is for the public good.[2]

Nature of the disease

Aetiology

White-nose syndrome is caused by the fungus *Pseudogymnoascus destructans* (previously named *Geomyces destructans*). *P. destructans* is a psychrophilic (cold-growing) fungus that thrives at temperatures below 15 °C and ceases to grow above 20 °C. The genome sequence is available in Genbank.

P. destructans appears to have been present in Europe for a long time. It has been found in over 15 countries in Europe and in north-east China, where it causes skin pathology in bats but does not appear to cause mass mortalities as seen in the naïve bat populations in North America (Puechmaille *et al.* 2011; Hoyt *et al.* 2016). The reason for this difference has not been fully determined, but is likely to be due to species susceptibility, behaviour and/or environmental factors. Fungal isolates in North America are genetically identical, while genetic variability exists in samples within Europe (Leopardi *et al.* 2015). This, along with other evidence, suggests that *P. destructans* was imported from Europe to North America.

Susceptible species

Insectivorous bats

Seven bat species in North America and 13 species in Europe have been identified with WNS (as of November 2016), with fungus detected on additional bat species but without signs of disease.[3] The affected North American species are from the genera *Eptesicus, Myotis* and *Perimyotis,* and in Europe from *Miniopterus, Myotis, Eptesicus, Barbastella, Plecotus* and *Rhinolophus.*

There are a large number of insectivorous bat species (or microbats) in Australia, including some in the same genera as affected species in North America and Europe. These small bats are nocturnal, roost during the day and leave the roost around dusk to forage, using echolocation to navigate and find insect prey. A number of microbat species live in caves, which can range from small splits or crevices through to extensive caverns, as well as mines that are abandoned or irregularly used. During temperate winters bats enter periods of torpor or hibernation to conserve energy when insect prey is scarce, reducing their metabolic activity and lowering their body temperature to be close to the ambient temperature in the roost (Churchill 2009).

While the susceptibility of Australian bat species to WNS is not known, *P. destructans* is not species-specific. Therefore all Australian bat species inhabiting caves with a climate suitable for *P. destructans* growth should be considered potentially susceptible to the disease.

Seven species of cave-dwelling bats from southern Australia have been identified as most likely to be affected by WNS (Holz *et al.* 2016). These are: southern bent-winged bat (*Miniopterus orianae bassanii*),

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[2] http://webarchive.nla.gov.au/gov/20130329090427/http://www.coag.gov.au/node/74
[3] https://www.whitenosesyndrome.org/about/bats-affected-wns

eastern bent-winged bat (*Miniopterus orianae oceanensis*), eastern horseshoe bat (*Rhinolophus megaphyllus*), chocolate wattled bat (*Chalinolobus morio*), large-eared pied bat (*Chalinolobus dwyeri*), large-footed myotis (*Myotis macropus*) and Finlayson's cave bat (*Vespadelus finlaysoni*). Species most likely to be impacted are those that roost and hibernate in caves where the year-round temperature is maintained below 20 °C, in regions with severe winters with limited free water and/or prey availability, and in species that tend to cluster together in large numbers. The eastern bent-winged bat (*Miniopterus orianae oceanensis*) and the critically endangered southern bent-winged bat are considered to be most at risk from WNS in Australia (Holz *et al.* 2016).

Other animals

Australia's megabats including the flying-foxes (*Pteropus* spp.) do not hibernate and are not susceptible to WNS. No other animal species are known to be susceptible to WNS.

Humans

No human health risk from WNS has been identified. However there are other health and safety risks associated with working with bats (see *Workplace health and safety*).

World distribution and occurrence in Australia

White-nose syndrome was first recognised in North America in New York state in 2006. Since then it has spread through eastern USA and Canada, with WNS confirmed in 29 states and 5 Canadian provinces as of November 2016.[4] The fungus has been found in other states without the disease. In the USA, *P. destructans* was first found in a commercial tourist cave and may have been introduced by human movement. In March 2016, the fungus was detected for the first time in the western USA, in Washington State, more than 2,000 km from the westernmost detection prior to that time. While it is not known how this spread occurred, human activity is a possible explanation.

P. destructans has been found in over 15 countries in Europe and in north-east China, without the mass mortalities observed in North America (Puechmaille *et al.* 2011; Hoyt *et al.* 2015).

P. destructans has not been identified in Australia. WNS has been excluded in a small number of suspect cases in Australian bats. Some targeted surveillance has been conducted for *P. destructans* in Victoria (Holz *et al.* 2016), however as large scale surveillance has not been conducted, the presence of the pathogen in Australian cannot be entirely ruled out.

Manner and risk of introduction to Australia

Risk assessment for the introduction of WNS into Australia indicates that the most likely method of entry of *P. destructans* is via contaminated fomites such as clothing, footwear or equipment that has been used in affected caves overseas e.g. by a caver, researcher or tourist (Holz *et al.* 2016). Potential activities to prevent introduction of WNS into Australia are outlined in Appendix 1.

<u>Environmental impact</u>

WNS has had a significant impact on bat populations in North America, with mortality estimates of over

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[4] https://www.whitenosesyndrome.org/about/where-is-it-now

5.7 million bats. In 2014 the Commonwealth Department of Agriculture listed *P. destructans* as one of six invasive species of high concern as threats to Australia's environment.[5] While large scale mortalities are considered less likely in Australia due to the difference in climate, there is still a risk to southern cave-dwelling species. This is particularly the case for the critically endangered southern bent-winged bat, where the addition of a disease to the other threatening processes could be significant for its survival (Holz *et al.* 2016).

Insectivorous microbats perform an important ecological role. The loss of these bats would significantly affect other parts of the ecosystem such as invertebrates within cave environments.

<u>Economic impact</u>

Although not well defined, there are potential consequences for agriculture due to the loss of insect pest control. Losses to North American agriculture due to the reduction in insect control by bats have been estimated at US$22.9 billion a year (Boyles *et al.* 2011). The resulting increase in use of pesticides could have impacts on environmental and human health. There may also be a negative impact on tourism, for example for Naracoorte Caves World Heritage Area where tourists visit the Bat Observation Centre and view the southern bent-winged bat colony.

Epidemiology

Infection and transmission

WNS is a disease of hibernating bats, as it occurs when the body temperature drops low enough to allow the fungal pathogen to grow on the skin. In North America, the seasonal pattern starts with the first signs of skin lesions in autumn. However significant mortalities do not occur until mid-winter, approximately 120 days after bats enter hibernation, and peak in late winter (Lorch *et al.* 2011). By the end of winter, prevalence of *P. destructans* on bats at an affected site approaches 100%. As bats come out of hibernation their metabolic activity increases and their body temperature rises. Along with higher ambient temperature, this results in bats clearing the infection from the skin during summer (Langwig *et al.* 2015).

Transmission of WNS occurs via direct contact between bats. A number of Australian cave-dwelling species roost in very large colonies of thousands for at least part of the year, they move between multiple caves, and sharing roosts with other bat species is common. The southern bent-winged bat, for example, is an obligate cave-dwelling bat that spends the winter among a large number of caves and rock crevices, with over 50 known sites. During the breeding season the majority of the population congregates in two main breeding or maternity caves (Lumsden and Jemison 2015). Bats can also travel long distances from the roost site during foraging.

The environment is likely to play a critical role in the epidemiology and transmission of the disease. Infection of bats in autumn and early winter is most likely from contact with cave environments contaminated with the pathogen (Langwig *et al.* 2015). Humans may also facilitate the spread of the disease by transferring spores on clothing, equipment or other fomites.

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[5] Committee inquiry : Environmental biosecurity. Department of Agriculture, Questions Taken on Notice, 31 October 2014, Canberra
http://www.aph.gov.au/Parliamentary_Business/Committees/Senate/Environment_and_Communications/biosecurity/Additional_Documents

Persistence of the agent

The *P. destructans* fungus grows best in cold conditions, with optimal temperatures for growth between 12.5 and 15.8 °C and no growth above 20 °C (Verant *et al.* 2012). *P. destructans* can survive at 38 °C for more than three days, and to 30 °C for at least 15 days. It grows best at humidity levels above 90% but it can survive prolonged periods of low humidity (Hoyt *et al.* 2015). *P. destructans* is expected to be capable of growth on a range of substrates including invertebrate exoskeletons, feathers, hair, skin, moist plant material and guano (Holz *et al.* 2016).

P. destructans can persist in the environment for long periods in the absence of bats. Under laboratory conditions, *P. destructans* was cultured from dried agar plates kept at 5 °C and low humidity for over 5 years (Hoyt *et al.* 2015). In the field, live *P. destructans* was found in the sediment of a US mine that had been closed to bats for around two years (Lorch *et al.* 2013). The fungal spores are destroyed by submersion in hot water maintained at a temperature of 55 °C for a minimum of 20 minutes, or disinfectants such as ethanol 60%, isopropanol 60%, hydrogen peroxide 3%, chlorine bleach, chlorhexidine gluconate and Lysol®.[6,7]

Diagnostic criteria

Case definition

The definition of a case is a confirmed laboratory detection of *P. destructans,* either on a bat or in an environmental sample.

Any detection of *P. destructans* is sufficient to trigger a response as described in these guidelines, regardless of the presence or absence of clinical disease, or whether the fungus is detected on a bat or in an environmental sample such as a cave wall, sediment or soil. Clinical disease may not manifest immediately (see *Nature and extent of response*).

At the time of an outbreak, revised or subsequent case definitions may be developed. As a reference, particularly for a widespread outbreak, the case definition and diagnostic categories for WNS in the USA are available from the USGS National Wildlife Health Center website.[8]

Available tests for *P. destructans* include molecular assays such as real-time PCR (Muller *et al.* 2013; Shuey *et al.* 2014), sequencing and fungal culture. *P. destructans* must be distinguished from other fungal species in the same or closely related genera, which may occur in cave environments (Shuey *et al.* 2014). Testing for *P. destructans* can be conducted at the CSIRO Australian Animal Health Laboratory (CSIRO-AAHL) in Geelong. Ancillary tests such as UVA light on wing membranes have lower sensitivity and specificity and are not recommended for confirmation or exclusion of WNS.[9]

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[6] Lysol® IC Quaternary Disinfectant Cleaner (not available in Australia). EPA - 47371-129 http://www.reckittprofessional.com/customer_services/info_bulletins/5-27.pdf

[7] National White-Nose Syndrome Decontamination Protocol (USA) www.whitenosesyndrome.org/topics/decontamination

[8] https://www.nwhc.usgs.gov/disease_information/white-nose_syndrome/Case%20Defintions%20for%20WNS.pdf

[9] USGS National Wildlife Health Center Bat White-Nose Syndrome (WNS)/Pd Surveillance Submission Guidelines, Winter 2015/16 (November – May) http://www.nwhc.usgs.gov/disease_information/white-nose_syndrome/NWHC+Winter+2015.2016+Bat+submission+guidelines_FINAL.pdf

Clinical signs and pathology

Clinical signs of WNS include:

- Presence of white or grey powdery fungus on muzzle, face, wing membranes[10]
- Wing damage such as membrane thinning, depigmented areas, flaky appearance or non-traumatic holes
- Mass mortality
- Aberrant behaviour such as flying during the day or increased arousal/activity during a period of torpor or hibernation.

Histological changes in the skin include characteristic cup-like erosions of the epidermis or ulceration, with no or minimal evidence of inflammation, and branching septate fungal hyphae and distinctive asymmetrically curved conidia (Meteyer *et al.* 2009).

The physiological process by which WNS causes mortality is not fully known. It appears that wing damage caused by the fungus during hibernation results in increased evaporative water loss with subsequent dehydration and electrolyte imbalance, causing the bats to wake from hibernation more frequently, which depletes the fat reserves that are needed to survive over winter (Verant *et al.* 2014). Dead bats are found dehydrated and emaciated.

Diagnosis of clinical WNS in an individual bat requires both detection of *P. destructans* and characteristic histopathology of skin lesions. Differential diagnoses for WNS include other causes of mass mortality in cave-dwelling microbats. The overgrowth of saprophytic fungi on dead bats may appear as a white powdery material. Differential diagnoses for skin lesions on microbats include bacterial dermatitis, skin infection with other fungi, and mite infestation.

Samples for laboratory testing

Photographs should be taken before sample collection, as the attachment of the fungus to the bat is not robust and may be disrupted during sampling. Details to be recorded include location, bat colony status and observations, a description of the lesion(s), body condition, and who collected the samples.

To ensure the most appropriate samples are collected and are appropriately stored during transport, the state/territory WHA Coordinator[11] or state/territory diagnostic laboratory should be contacted prior to collecting or submitting any samples.

The whole carcass should be submitted where possible, to allow histopathology to be conducted and to maximise the opportunity for testing. Where this is not possible or preferable, non-lethal sampling techniques include biopsy of wing membrane or skin, and swab of affected area. For more detailed information, see the *WHA National Guidelines for Sample Submission – White-Nose Syndrome – Exclusion Testing*.[12] Samples should initially be sent to the state or territory diagnostic laboratory, from which they may be forwarded to CSIRO-AAHL for emergency disease testing.

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[10] For photos of affected bats, see: https://www.nwhc.usgs.gov/disease_information/white-nose_syndrome/gallery.jsp
[11] http://www.wildlifehealthaustralia.com.au/AboutUs/ContactDetails.aspx
[12] http://www.wildlifehealthaustralia.com.au/ProgramsProjects/BatHealthFocusGroup.aspx#WNS

Biosafety guidelines for working with *P. destructans* in the laboratory have been developed by the USGS National Wildlife Health Center.[13]

Resistance and immunity

Immune responses are suppressed during hibernation, which allows *P. destructans* to grow and invade the skin. Bats in Europe, where *P. destructans* is endemic, appear to be resistant to the disease in that the pathogen may invade the skin and cause pathology, but mass mortalities do not occur (Puechmaille *et al.* 2011). Species differences in susceptibility to WNS have been observed in North America and appear, at least in part, to be associated with differences in ecology and behaviour.

Research into the role of the host immune response in WNS is ongoing. Humoral and cell-mediated immune responses to *P. destructans* have been observed during hibernation. Antibodies to *P. destructans* do not appear to protect against or contribute to pathology (Johnson *et al.* 2015; Lilley *et al.* 2017).

Vaccination and/or treatment of infected animals

A vaccine or specific chemical or biological treatment for WNS is not currently available, however research is underway overseas and some treatments show early promise (see *Vaccination* and *Treatment of infected bats*).

Further reading

For further information on WNS, refer to the Wildlife Health Australia (WHA) fact sheet,[14] the Australian Government Department of Agriculture and Water Resources website,[15] the USGS National Wildlife Health Center website,[16] and the North American website *White-noseSyndrome.org - A Coordinated Response to the Devastating Bat Disease.*[17] See Holz *et al.* (2016) for a detailed summary of WNS as it relates to the Australian situation.

Principles of control and eradication

Critical factors for formulating response policy

Features of the disease

Features of WNS that have relevance for control are as follows:

- *P. destructans* is a fungus that thrives at temperatures below 15°C and ceases to grow above 20°C.
- *P. destructans* can grow on a range of substrates and persists in the environment for long periods in the absence of bats.

[13] https://www.nwhc.usgs.gov/disease_information/white-nose_syndrome/handling%20of%20pseudogymnoascus%20destructans.pdf
[14] http://www.wildlifehealthaustralia.com.au/FactSheets.aspx
[15] http://agriculture.gov.au/pests-diseases-weeds/animal/white-nose-syndrome
[16] https://www.nwhc.usgs.gov/disease_information/white-nose_syndrome/index.jsp
[17] https://www.whitenosesyndrome.org

- Transmission of WNS occurs via direct contact between bats. Bats may become infected through contact with contaminated cave environments.
- The disease may be spread by transfer of fungal spores on fomites. *P. destructans* persists on clothing, footwear and equipment despite normal cleaning; decontamination requires more rigorous treatment.
- WNS is a disease of hibernating bats, when the body temperature is low enough for the fungus to grow on the skin.
- WNS causes bats to wake from hibernation more frequently than normal, which depletes the fat reserves needed to survive over winter. Bats become infected with *P. destructans* in autumn but significant mortalities due to WNS do not occur until mid-winter. Surviving bats clear the infection in the warmer months, but are susceptible to re-infection the following autumn/winter.
- Clinical signs of WNS include the presence of white or grey powdery fungus, wing damage, mass mortality and aberrant behaviour e.g. increased activity during hibernation. WNS causes characteristic histopathological lesions in the skin.
- Signs of disease may not be observed at the time of detection of *P. destructans* due to the seasonal nature of WNS.
- Laboratory tests for *P. destructans* include molecular assays, sequencing and fungal culture.
- A vaccine or specific treatment for WNS is not currently available, however research is underway overseas.
- It should be noted that *P. destructans* could behave or present differently in Australia to what has been observed overseas.

Features of susceptible populations

Features of susceptible populations of relevance for control include the following:

- Cave-dwelling insectivorous bats in the colder southern parts of Australia are considered at risk of WNS. This includes a critically endangered species.
- Australian cave-dwelling species can roost in very large colonies, move between multiple caves and share roosts with other bat species. Individuals or colonies may roost in unknown locations or in areas that are difficult to reach due to remoteness or physical barriers.
- Bats are highly mobile and can travel large distances during foraging.
- Monitoring of insectivorous bats is difficult because they are small and nocturnal.
- Species differences in susceptibility of bats to WNS have been observed in North America.
- Insectivorous bats are the only animal known to be susceptible to WNS.
- No human health risk from WNS has been identified.

Options for control and eradication based on the critical factors

Management of wildlife diseases is inherently difficult. There are significant challenges in terms of detection of sick/dead animals, access to wildlife populations, obtaining diagnostic samples, disease surveillance and biosecurity, and lack of ecological data for wild populations. There are a number of challenges associated with a response to WNS, due to the nature of the bat host and the fungal pathogen, as described above.

The response will be a combination of strategies that involve assessment and reporting, prevention of WNS transmission by humans, active management of the host, management of the environment and supportive activities. Animal welfare must be considered in relation to all response activities.

Nature and extent of response

The aim of the response will differ depending on how widespread the disease is at the time of detection, and the area and species affected. Eradication may be feasible if the incursion is detected at an early stage, for example when only a single cave or site[18] is affected, however the outbreak may be well advanced by the time of detection. Mortalities of bats in caves can easily go undetected as human disturbance of hibernating bats is discouraged, and any carcasses may be decomposed or scavenged before they are observed. If multiple sites are affected, the focus will shift to containment i.e. prevention or slowing of spread of WNS into new areas, control of the disease within affected areas, and protection of high value populations such as threatened or high-risk species.

Once established, the likely rate and extent of spread of WNS through caves in southern Australia is not known. However based on the North American experience, precautionary response activities should be considered for cave-dwelling bat populations likely to be at risk in other geographic areas, including in other jurisdictions (Holz *et al.* 2016).

Due to the seasonal aspects of this disease, the timing of first detection e.g. relative to the winter hibernation period will influence the assessment of the disease situation and the planning of the response.

The *P. destructans* pathogen could be detected in Australia without any evidence of clinical or histopathological disease in bats at that time e.g. on a skin swab from a live apparently healthy bat, or in an environmental sample. However disease could still occur at a later time or in another species, for the reasons outlined below. A response should therefore be implemented regardless of whether clinical disease is present.

1. <u>Timing:</u> WNS is a seasonal disease, only affecting bats during the winter hibernation period. Significant disease only manifests well into winter, with mortality occurring around 120 days after bats enter hibernation (Lorch *et al.* 2011) (see *Epidemiology*). If the pathogen is detected after a recent introduction, outside the hibernation period, or during the first three months of hibernation, the effects may not be seen until a later time.
2. <u>Species variability:</u> Variable species susceptibility has been seen in North America and appears to be associated with differences in ecology and behaviour (see *Susceptible species*). The pathogen may be first detected in a species with low susceptibility to the disease, but still pose a threat to other Australian bat species that may have higher susceptibility.

Roles and responsibilities

Lead agency

The lead agency for the response will be defined by the legislation in each state/territory.

[18] For the purpose of these guidelines, 'caves' also refers to mines where bats roost.

In the event that the response is managed under NEBRA, roles and responsibilities under the NEBRA are outlined in the Agreement. There is a requirement to report nationally within 24 hours to enact a NEBRA response.[19] Advice on reporting suspect cases of WNS is provided in Appendix 1.

Stakeholders

Any significant wildlife disease event will draw community and media attention, and may generate emotive responses. Stakeholders for a disease event like WNS are a diverse group with different perspectives, interests and concerns. Because of this, stakeholders should be identified and engaged as a preparedness and early response activity. Consultation with stakeholders is critical to ensure compliance with response measures such as closing caves to human access, and biosecurity and decontamination procedures. Experts in bat ecology, wildlife disease and epidemiology should be consulted for technical advice throughout a response. These experts may be situated within government agencies, universities or special interest groups such as the Australasian Bat Society.

Stakeholders will vary depending on the situation and location, but may include the following:

- Commonwealth agriculture and environment agencies, including the Threatened Species Commissioner
- State agriculture and environment agencies, including WHA State/Territory Coordinators and Environment Contacts
- Local government
- Wildlife Health Australia
- Species Recovery Teams (where appropriate)
- Australasian Bat Society[20]
- Australasian Cave and Karst Management Association[21]
- Australian Speleological Federation[22]
- Other/local caving groups
- Tourism Australia
- National Parks staff and volunteers
- Bat carers
- Universities/researchers
- Private landholders with caves on or near their land
- Mine owners and managers
- Local conservation groups
- Interested members of the public.

Wildlife Health Australia is a key stakeholder that can assist with communication and coordination where needed.

Workplace health and safety

No human health risk from WNS has been identified. However, there is a risk of exposure to other diseases such as Australian bat lyssavirus (ABLV) through handling bats. Bats should only be handled by

[19] http://webarchive.nla.gov.au/gov/20130329090427/http://www.coag.gov.au/node/74
[20] A non-profit organisation which aims to promote the conservation and study of bats in Australasia http://ausbats.org.au
[21] A professional association for all those responsible for, or interested in, planning and management of limestone landscapes and caves in the Australasian region http://www.ackma.org
[22] An Environmental Organisation with the primary objective of protecting the cave and karst environment of Australia; the national body that represents the interests of 28 caving clubs, over 700 members throughout Australia and represents Australia on the International Union of Speleology. http://www.caves.org.au

trained people who have current rabies immunity[23] and using appropriate personal protective equipment (PPE).

In the event of a bat bite, scratch or other significant contact, first aid should be applied immediately and urgent medical attention sought (even if the person is vaccinated as further booster doses of rabies vaccine may be required). This includes where contact has occurred between the saliva or neural tissue of a bat and the mucous membranes (eyes, nose and mouth) or non-intact skin of a person. For further information see public health and biosecurity guidelines.[24,25,26] Any communications to the public should include strong advice not to handle bats, but instead to contact a wildlife care organisation or local veterinarian if a sick, injured or orphaned bat is found.

Another infectious disease risk associated with visiting bat caves is histoplasmosis. This disease is caused by the fungus *Histoplasma capsulatum*, which is found in soil with high organic content and bird and bat droppings e.g. in bat caves.[27] Human infection occurs from inhaling fungal spores when contaminated soil, dust or guano is disturbed. People who are immunosuppressed are at increased risk of serious illness. Where exposure to *H. capsulatum* may occur, a properly fitted particulate respirator should be worn.[28]

There are also physical risks associated with accessing and working in cave environments. Cave safety guidelines are available from the Australian Speleological Federation.[29]

Health and safety risks associated with hazardous chemicals need to be managed. Refer to the safety data sheet of the product for more information.

Policy and rationale

Introduction

The consequence of WNS in Australian microbats is potentially serious. The disease has had a significant impact on bat populations in North America, with mortality estimates over 5.7 million bats. While the susceptibility of Australian bat populations is not known, the disease is of concern for southern cave-dwelling species, including the critically endangered southern bent-winged bat. Insectivorous microbats

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[23] Australian Technical Advisory Group on Immunisation (ATAGI). The Australian Immunisation Handbook 10th ed (2016 update). Canberra: Australian Government Department of Health, 2016 http://www.health.gov.au/internet/immunise/publishing.nsf/Content/Handbook10-home~handbook10part4~handbook10-4-16

[24] Department of Health. Rabies Virus and Other Lyssavirus (Including Australian Bat Lyssavirus) Exposures and Infections. CDNA National Guidelines for Public Health Units. Canberra. 2014 http://www.health.gov.au/internet/main/publishing.nsf/content/cdna-song-abvl-rabies.htm

[25] www.worksafe.qld.gov.au/agriculture/workplace-hazards/diseases-from-animals; www.worksafe.qld.gov.au/forms-and-resources/films/safe-bat-handling

[26] Australian Veterinary Association Guidelines for Veterinary Personal Biosecurity www.ava.com.au/biosecurity-guidelines

[27] http://conditions.health.qld.gov.au/HealthCondition/condition/14/92/76/Histoplasmosis

[28] US Department of Health and Human Services, CDC/NIOSH. Histoplasmosis: protecting workers at risk. Publication No. 2005–109. Cincinnati OH, 2004 https://www.cdc.gov/niosh/docs/2005-109/pdfs/2005-109.pdf

[29] ASF Cave Safety Guidelines April 2011Version http://www.caves.org.au/administration/codes-and-standards/send/8-codes-and-standards/15-safety-guidelines

perform an important ecological role, and economic consequences for agriculture could occur due to the loss of insect pest control.

Summary of policy

The policy is to:

1. eradicate WNS if a single site or area is affected, unless other factors suggest this is not feasible; or
2. contain the disease if multiple sites are affected or eradication is not feasible i.e. prevent or slow the spread of WNS into new areas, control the disease within affected areas, and protect high value populations such as threatened or high-risk species.

The policy will be achieved by a combination of strategies including *(high priority activities in bold)*:

1. **Identification and engagement of stakeholders**
2. Epidemiological assessment
3. **Disease surveillance**
4. **Quarantine: closure of caves to human access**
5. **Biosecurity and decontamination**
6. Education and communication
7. Depopulation (culling) *(only in specific circumstances)*
8. Supportive treatment of infected bats
9. Environmental modification
10. **Conservation activities**
11. Listing of WNS as a nationally notifiable disease

Other management options are not currently available but may eventuate from overseas research:

12. Chemical or biological treatment of infected bats
13. Vaccination
14. Environmental treatment to reduce fungal load

Strategies for control and eradication

1. Identification and engagement of stakeholders

Engagement with stakeholders at all stages of the response is a high priority.

It is crucial that stakeholders be involved as early as possible in a response (See *Roles and responsibilities*). As well as providing technical advice, this group may be a source of experienced, vaccinated volunteers to assist with surveillance and response activities. Engagement with stakeholders such as bat researchers, carers and cavers will facilitate cooperation with controls such as cave closures and adherence to biosecurity protocols. They may also be a good source of local information.

2. Epidemiological assessment

An immediate assessment of the epidemiological situation should be undertaken, including aspects such as seasonality, species, ecology, geographical range, human access and activity, transmission pathways, etc. Ongoing monitoring of the epidemiological situation will help to determine whether the response is effective or if a change of approach is required.

3. Disease surveillance

Surveillance to determine the extent of the disease is a high priority.

Surveillance will:

- Provide information to assist with the epidemiological assessment
- Monitor disease spread including tracing back and forward
- Determine the susceptibility of Australian microbats to WNS
- Identify potentially susceptible species and populations.

Surveillance will assist with decision-making for management activities, and monitor the effectiveness of the response.

General surveillance networks can be established and existing networks utilised or strengthened to detect new cases and locations. However relying on opportunistic observation of sick or dead bats is unlikely to be sufficient, as small numbers of bat deaths are not uncommon under normal conditions, rats in caves remove carcasses, many bats hibernate in unknown locations, and disturbance of hibernating bats by people entering caves is discouraged.

A coordinated and consistent targeted disease surveillance program should be established in affected and non-affected areas, guided by the findings of the epidemiological assessment. Monitoring for sick and dead bats will be most useful from mid to late winter, but monitoring of surrounding caves to determine the extent of spread of the pathogen can occur at any time of year through environmental sampling and sampling of bats (trapping at the mouth of the cave or sampling bats on walls). Standardised protocols for sampling of bats and the environment are recommended,[30] as well as coordinated collection and management of surveillance data. Sampling techniques may need to be modified to prevent transmission of disease e.g. through physical contact of bats within harp traps. While non-destructive sampling techniques are useful, it may be necessary to euthanase a small number of bats to confirm the diagnosis (with the necessary approvals as required for the jurisdiction).

Rapid diagnosis and processing of samples will be critical for surveillance activities. Depending on the extent of the outbreak, it may be necessary to develop capacity at laboratories other than CSIRO-AAHL, such as state/territory government laboratories.

Some of the other unique challenges associated with WNS surveillance include:

- Resourcing - people who are vaccinated and experienced in bat handling, and sufficient equipment to prevent contamination of uninfected sites. Stakeholder groups (see list above) may be a source of volunteers and/or equipment
- Health and safety issues - working in caves and with bats

[30] USGS National Wildlife Health Center Bat White-Nose Syndrome (WNS)/Pd Surveillance Submission Guidelines, Winter 2015/16 (November – May) http://www.nwhc.usgs.gov/disease_information/white-nose_syndrome/NWHC+Winter+2015.2016+Bat+submission+guidelines_FINAL.pdf

- Biosecurity – fungal spores are spread by fomites, and rigorous decontamination procedures are required.

4. *Closure of caves to human access* (Quarantine)

Restricting human access to caves is a high priority given that fungal spores can be spread on fomites. Humans have been implicated in the spread of WNS in North America.

Closing caves (and mines) to human access is a key step in preventing human spread of WNS. Closures may be temporary or permanent, depending on the situation and likely impact. Widespread temporary closure of all caves in a region may also be considered at the time of first detection, until the situation is better understood, analogous to a standstill imposed during an outbreak of livestock disease. As well as preventing disease spread, closing caves protects diseased bats from further disturbance by human visitors. An alternative to full closure is to restrict access through a permit or approval process. Where a decision is made not to close a cave, a biosecurity plan should be developed (see *Biosecurity and decontamination*).

Different approaches and approvals for cave closures may be required depending on the type of land e.g. public, private, National Park, Commonwealth etc. Closure of popular caves to human access may not be readily accepted by the public, cavers or cave managers and there is a potential loss of income from tourism for some caves, so consultation with stakeholders will be critical in ensuring compliance.

Officially closing a cave to deter people from entering can be done using signs, tape, fencing, etc (see also *Education and communication*). Physical closure methods that prevent human access but allow continued access by bats have been used for various purposes overseas, but are unlikely to be feasible for most at-risk Australian bat species.

If the *P. destructans* pathogen is detected in a cave where no bats are dwelling, the cave could be sealed off and surveillance conducted in the surrounding area to monitor the situation.

5. *Biosecurity and decontamination*

Biosecurity is a high priority given that fungal spores can be spread on fomites and humans have been implicated in the spread of WNS in North America.

Biosecurity is critical to prevent inadvertent transfer of *P. destructans* on clothes, equipment, vehicles and other fomites. Protocols should provide recommendations on PPE, movement between sites and decontamination. Training in the use of PPE, biosecurity principles and decontamination procedures should be provided to people visiting sites. Biosecurity and decontamination will be particularly critical for surveillance teams.

Decontamination protocols developed by government agencies in North America are publicly available and updated regularly based on new research. The preferred treatment, after cleaning to remove dirt and debris, is submersion in hot water maintaining a temperature of at least 55 °C for a minimum of 20 minutes. Equipment that cannot be immersed in water can be treated by disinfection. The US *National White-Nose Syndrome Decontamination Protocol*[31] details specific, effective disinfectants, including ethanol 60%, isopropanol 60%, hydrogen peroxide 3%, chlorine bleach, chlorhexidine gluconate and

[31] www.whitenosesyndrome.org/topics/decontamination

Lysol.[32] Equipment that can be effectively decontaminated should be selected wherever possible. There may be particular challenges with appropriate PPE for cavers, and the potential for disinfection to reduce the performance of caving and safety equipment will need to be assessed.

A protocol will need to be developed by the responding agency for management of equipment, vehicles and waste material. This includes field equipment such as clothing, footwear, caving equipment (harnesses, ropes, helmets, backpacks), trapping and sampling equipment, gloves, cameras and other electronics, torches, containers, bags and vehicles (inside and out). Off-site areas such as laboratories, hospitals, office or home also need to be considered. For general information, refer to the *AUSVETPLAN Operational Procedures Manual on Decontamination*.[33]

Careful planning of site visits for surveillance and other activities is required. Ideally, site-dedicated equipment (clothing, footwear, research and caving equipment) will be used. Where this is not feasible, separate sets of equipment may be maintained for known infected and other 'clean' sites. 'Clean' equipment must be stored separately, without any contact with potentially contaminated equipment, and infected sites should only be visited after those which are believed to be uninfected. For a detailed example of decision-making for biosecurity including a flow chart for movement of equipment, see the US *National White-Nose Syndrome Decontamination Protocol*.[31]

Individual response plans may be developed for some caves. Examples from North America show a range of approaches to biosecurity where caves have remained open, from decontamination of visitor's shoes through to a full change of clothes before entry. Some American states have developed flow charts to assist in decision making, and certification documents for cave visitors (e.g. *White-Nose Syndrome Response Plan - Mammoth Cave National Park, Appendix C p21*).[34]

As well as the prevention of human spread of disease between sites, biosecurity protocols should be developed to prevent bat-to-bat spread during capture and handling in the field. Trapping of bats (e.g. harp traps) often results in individuals from different species coming into contact. A moratorium on trapping of bats for research may be considered to help prevent disease transmission through this method. Detailed biosecurity protocols will also be needed for off-site situations such as veterinary care, bat rehabilitation, captive facilities, research facilities and laboratories. This would include appropriate isolation and management of individual bats, and the use of hygiene, PPE and disinfection to prevent any spread of the pathogen.

Education and communication through stakeholder groups and the media will be critical to ensure that biosecurity messages reach people working with bats, cavers, and members of the public (see *Education and Communication*).

[32] Lysol® IC Quaternary Disinfectant Cleaner (not available in Australia). EPA - 47371-129 http://www.reckittprofessional.com/customer_services/info_bulletins/5-27.pdf
[33] Animal Health Australia (2007). Operational procedures manual: Decontamination (Version 3.0). Australian Veterinary Emergency Plan (AUSVETPLAN), Edition 3, Primary Industries Ministerial Council, Canberra, ACT https://www.animalhealthaustralia.com.au/our-publications/ausvetplan-manuals-and-documents/
[34] https://www.whitenosesyndrome.org/sites/default/files/http___www.nps_.gov_maca_parkmgmt_loader.pdf

6. *Education and communication*

The aim of education and communication is to promote early detection by encouraging rapid reporting of suspect cases, prevent further spread of the disease, and support affected bat populations by avoiding disturbance during hibernation.

Effective communication to the public will: inform them of the situation, the potential significance to biodiversity and planned response actions; provide advice on what to look for and how to report;[35] and ask for their assistance in complying with response measures such as cave closures. Human health messages should be included to allay fears of a potential human health risk from WNS, but to remind the public that bats should not be handled due to the risk of other diseases. Messages may be shared through media releases, social media, on websites (e.g. government agencies, parks, special interest groups - see *Stakeholders*), at park entrances, through permit application processes, and directly to private landholders. Tailored messages can be prepared to target particular stakeholder groups e.g. educating cavers on the importance of decontamination procedures and the reason for cave closures; raising awareness of the signs of WNS among people who come in contact with bats; informing landholders with caves or mines on their land. Messages should also highlight the risk of spreading *P. destructans* from Australia to other parts of the world where this pathogen has not been found.

7. *Depopulation (Culling)*

Culling of bats is only considered an appropriate response in very specific circumstances, and must be conducted humanely. It presents logistic challenges.

Culling is only considered an appropriate response in very specific circumstances, where eradication is considered feasible e.g. where WNS is detected soon after introduction and it is certain that only one site is infected. In this case generalised culling (total culling of the bat colony) and physical sealing of the cave could be considered, however total culling of a colony is likely to be logistically difficult as bats rouse periodically and fly during hibernation and are known to move between adjacent sites. Approval for culling would need to be obtained, including an exemption under the EPBC Act if it is a listed threatened species.[36] If culling is to be undertaken, animal welfare must be considered and only best-practice, humane methods used. Selection of the best method will depend on the particular circumstances, and must take into account current recommendations for euthanasia of animals.[37]

In all other situations culling is not recommended. Depopulation of wild animals for disease control has generally not been found to be effective, and in some cases may even exacerbate the disease by encouraging dispersal of surviving animals and creating vacant niches for other animals to enter. Culling may also impact threatened species or populations, and result in significant negative reaction by stakeholders and the public.

Targeted culling to remove infected individuals is generally not recommended for management of WNS for a variety of reasons, including that bats are highly mobile animals, there are high contact rates within colonies, individuals with resistance to the disease may be removed, and there is already a high

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[35] WHA How to Report a Suspect Case of White-Nose Syndrome http://www.wildlifehealthaustralia.com.au/ProgramsProjects/BatHealthFocusGroup.aspx#WNS

[36] http://www.environment.gov.au/epbc/what-is-protected; http://www.environment.gov.au/cgi-bin/sprat/public/publicthreatenedlist.pl

[37] AVMA Guidelines for the Euthanasia of Animals https://www.avma.org/KB/Policies/Pages/Euthanasia-Guidelines.aspx

prevalence of infection early in the hibernation period (Foley *et al.* 2011; Hallam and McCracken 2011; Meyer *et al.* 2016). Culling has no impact on *P. destructans* in the environment as the fungus can persist in the absence of bats, and modelling has shown that generalised culling does not improve the long term survival of a colony (Meyer *et al.* 2016).

An alternative to culling where only one or two locations are infected and a relatively small number of bats are affected, is to bring the bats into captivity to recover, and physically close the cave (see *Supportive* t*reatment of infected bats*).

8. Supportive treatment of infected bats

Specific chemical or biological treatments are currently not available (see *Chemical or Biological Treatment of Infected bats*). An alternative is to provide supportive therapy to assist bats to recover from the disease and clear the fungus by bringing bats into captivity, raising their body temperature and providing food (Langwig *et al.* 2015; see *Infection and transmission*). Recovered bats could then be released after winter. This is unlikely to be feasible for large numbers of bats but may still be a useful option. After bringing the bats into captivity, the infected cave could be physically closed to any access by bats, humans or other animals to prevent re-infection from the environment. Environmental treatment of the cave to remove the fungus may be considered, if a suitable method becomes available (see *Environmental Treatment*).

9. Environmental modification

Environmental modification is directed at reducing growth and/or transmission of *P. destructans*, or supporting infected bats to reduce the impact of disease.

<u>Temperature and humidity</u>

Environmental modification of temperature and humidity is considered to have potential as a long-term solution, and these methods have been used in some instances in the USA. Options include manipulation of the temperature and/or humidity around hibernating bats by physically altering the cave entrance, restricting access of bats to some areas of a cave, or by creating ‘thermal refugia’ or localised warm areas where bats can retreat during periods of arousal from hibernation.

Modelling has indicated that environmental modification can improve survival of infected bats (Langwig *et al.* 2016), however its effectiveness is yet to be proven and it will not be feasible for all sites. There are also possible unintended consequences on other species within caves, unknown impacts on hibernation patterns, and the risk of deterring bats from the site.

<u>Food and water</u>

Provision of supplemental food and water during winter has been suggested to reduce starvation and dehydration due to the effects of WNS, however bats may not learn to take supplemental food and feeding bats during hibernation may result in physiological problems (Foley *et al.* 2011).

An alternative is to alter the environment to provide water and food around caves in vulnerable areas e.g. establish crops to accumulate insects and establish wetlands. This could be done proactively to support at-risk populations ahead of a disease front.

10. Conservation activities

Conservation activities are a high priority, to protect bat populations affected by WNS, particularly for threatened species.

Activities to mitigate the impact of WNS on bat populations include:

- Captive management e.g. captive breeding for insurance populations, maintaining bats in captivity during winter. Captive breeding provides an opportunity to re-establish wild populations, however is only likely to be useful if the disease situation changes i.e. if suitable disease-free sites are identified and can be maintained, if the disease can be eradicated, or if vaccines become available
- Mitigation of other sources of morbidity and mortality that could compound the impact of WNS
- Reducing stress to hibernating bats e.g. closing caves to visitor access and reducing disturbance by researchers
- Protection and restoration of bat habitat to support bat populations
- Assessing the risk to bat species from WNS and listing species as threatened, as necessary.

11. Listing of WNS as a nationally notifiable disease

Listing of WNS as a nationally notifiable disease should be considered if this has not already occurred (see *Appendix 1*). Listing WNS will help to raise awareness of the disease and encourage reporting of suspect cases, which may lead to early detection of new sites of infection and thereby improve the effectiveness of the response.

Management options in development

The management options listed below are not currently available, however the situation may change as research progresses and these options can then be incorporated into a response.

12. Chemical or biological treatment of infected bats

Treatment of infected bats with chemical or biological agents is not currently available, however research is underway overseas and some agents show early promise. Delivery of the treatment on a broad scale presents a challenge, particularly if repeated treatments are necessary. Options could include fogging, with the disadvantage of potentially affecting other microbial cave flora, or hand delivery, which would only be feasible for a small number of bats. Treatment of individual bats may be a more viable option for bats in care or captivity, or for genetically valuable animals.

There are a number of challenges in achieving effective treatment for WNS:

- Treatment of bats leaves the environment infected, so if treatment offers only short-term protection, re-infection is likely.
- The proportion of the population that needs to be treated to achieve success may not be known.
- The disturbance associated with treatment (or the treatment itself) may have an impact on hibernating bats.
- The effects of the treatment on other species and cave ecology may not be known.

13. Vaccination

A vaccine for WNS is not currently available.

Vaccination against WNS and other methods of increasing immunity are the subject of research in North America, despite the challenge of weakened immune response during hibernation. Challenges of administering a vaccine are similar to those outlined above for treatment. If a safe, effective and practical vaccine can be developed, it could be used to establish immune populations, reduce susceptibility to infection and disease, and reduce or prevent transmission.

14. Environmental treatment to reduce fungal load

Environmental treatment for P. destructans *is not currently available.*

Research is underway overseas to find suitable chemical treatments that can be applied to the surfaces or interior of a cave or mine to kill the fungus causing WNS, but an accepted environmental treatment option is not currently available.

Challenges of environmental treatment include:

- Treatment may affect the health of bats and other cave-dwelling species.
- Treatment is likely to affect the cave microflora, with potential ecological impacts.
- Not all hibernation sites may be known, access to caves and mines may be restricted, and the size and complexity of many caves and mines will make coverage difficult.
- Bat-to-bat transmission will not be affected.

Despite these challenges, environmental treatment could be useful in particular situations e.g. for hibernation sites for significant populations, for single sites in conjunction with treatment of bats (see *Supportive treatment of infected bats*), or where only one site is affected and eradication is possible, such that the benefit outweighs the potential ecological effects.

Appendix 1: Prevention and preparedness

Preparedness and prevention activities

A number of activities can be undertaken prior to an incursion of WNS to reduce the risk of introduction of the disease and to better prepare the country for an effective response.

1. Prevention of introduction

Pre- and post-border activities to prevent entry of WNS into Australia could include: border activities such as alerts to quarantine staff, development of Australia-specific information for decontamination, and an education campaign for overseas visitors and Australians returning from overseas.[38]

2. Development of laboratory diagnostic capacity

Testing for *P. destructans* is available at CSIRO-AAHL. It is important to maintain laboratory capacity to confirm and respond to an event, including ongoing development of laboratory tests and monitoring overseas developments in diagnostics. Exclusion testing of suspect cases will assist in maintaining diagnostic capacity.

3. Enhancing the likelihood of detection

The likelihood of early detection of a WNS incursion can be improved by:

- Implementing an awareness campaign for recognising and reporting suspect cases[39]
- Advising veterinarians on appropriate sample submission for suspect cases[40]
- Provision of swab sample kits, protocols and training to field researchers, rangers and others likely to encounter bats in caves.

4. Listing of WNS as a nationally notifiable disease

The listing of WNS as a nationally notifiable disease would help to raise awareness about the disease in Australia and encourage reporting of suspect cases, thereby improving the chance of early detection.

5. Stakeholder engagement and communication

Stakeholders for a disease event such as WNS involving bats and caves will be a diverse group, and wildlife issues in general can draw significant attention from the media and the public. Identifying and engaging with stakeholders prior to any outbreak of WNS will help prevent introduction of the disease and improve the chance of early detection of an outbreak. Established relationships will also assist with an effective response (see *Stakeholders*). A communication plan can be developed in consultation with stakeholders, ready for deployment at the start of a response.

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[38] http://agriculture.gov.au/pests-diseases-weeds/animal/white-nose-syndrome
[39] WHA How to Report a Suspect Case of White-Nose Syndrome http://www.wildlifehealthaustralia.com.au/ProgramsProjects/BatHealthFocusGroup.aspx#WNS
[40] WHA National Guidelines for Sample Submission – White-Nose Syndrome – Exclusion Testing http://www.wildlifehealthaustralia.com.au/ProgramsProjects/BatHealthFocusGroup.aspx#WNS

6. Research to inform risk and response

Identification of key knowledge gaps and facilitation of research are considered a high priority to inform prevention and management actions. Areas of interest are outlined in *Research* below.

7. Conservation initiatives

Activities supporting vulnerable bat populations may help reduce the impact of WNS if it is introduced. Where appropriate, WNS should be included as a potential threat in recovery plans for threatened bat species.

Reporting suspect cases of WNS

Targeted education and training will help ensure that suspect WNS cases are reported and receive an appropriate response. The initial observation of a suspect case could be from a range of sources. The visible presence of the fungus or clinical disease e.g. skin lesions, sick/dead bats could be detected and reported by a bat ecology or disease researcher, environmental manager, cave manager or staff, caver, bat carer, veterinarian, landowner or other member of the public. Advice on recognition and reporting of suspect WNS cases is provided in *WHA How to Report a Suspect Case of White-Nose Syndrome.*[12] Recommended reporting is through one of the following: the state/territory WHA Coordinator,[41] the Emergency Animal Disease (EAD) Watch Hotline, a local veterinarian, or WHA. Events may not be reported through these channels however; other routes could include a park ranger, state/territory Environment agency, veterinary hospital or university. As reports may be made to the EAD Watch Hotline, information on the significance of WNS, how it might present and what response is required should be provided to those taking hotline calls.

Reporting requirements will change if the status of the disease changes e.g. if WNS is listed as a nationally notifiable disease.

Research

A formal process to identify research priorities has not been undertaken, however significant knowledge gaps were identified during the risk assessment process. These include: identification of fungal species present in Australian cave environments; confirmation of the presence or absence of *P. destructans* in Australia; temperature and humidity in Australian caves; body temperature of Australian bats during torpor/hibernation; susceptibility of Australian microbats to WNS; population and ecology of at-risk bat species; and the ecosystem services attributable to insectivorous bats, and their economic importance to agriculture in Australia.

These response guidelines should be reviewed regularly to take account of new findings from research in Australia and overseas.

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[41] http://www.wildlifehealthaustralia.com.au/AboutUs/ContactDetails.aspx

Definitions

Term	Definition
Captive breeding	Bringing wild animals into captivity e.g. to rear animals for reintroduction into the wild for the purpose of conservation. *See also* Insurance population.
Decontamination	Includes all stages of cleaning and disinfection.
Depopulation	The removal of a host population from a particular area to control or prevent the spread of disease.
Disease Watch Hotline	24-hour freecall service for reporting suspected incidences of exotic diseases — **1800 675 888**.
Disinfectant	A chemical used to destroy disease agents outside a living animal.
Emergency animal disease	A disease that is (a) exotic to Australia or (b) a variant of an endemic disease or (c) a serious infectious disease of unknown or uncertain cause or (d) a severe outbreak of a known endemic disease, and that is considered to be of national significance with serious social or trade implications. *See also* Endemic animal disease, Exotic animal disease.
Endemic animal disease	A disease affecting animals (which may include humans) that is known to occur in Australia. *See also* Emergency animal disease, Exotic animal disease.
Epidemiological investigation	An investigation to identify and qualify the risk factors associated with the disease.
Epidemiology	The study of disease in populations and of factors that determine its occurrence.
Ex situ	Away from the original site
Exotic animal disease	A disease affecting animals (which may include humans) that does not normally occur in Australia. *See also* Emergency animal disease, Endemic animal disease.
Fomites	Inanimate objects (eg boots, clothing, equipment, instruments, vehicles, crates, packaging) that can carry an infectious disease agent and may spread the disease through mechanical transmission.
Hibernation or torpor	Reduction in metabolic activity and lowering of body temperature by an animal in order to conserve energy e.g. during winter when food is scarce.
Insurance population	A captive population of a wild species, designed to ensure the survival of the species. *See also* Captive breeding.
Microbats	Small bats (Order Chiroptera) that are insectivorous and use echolocation to navigate and forage.
Microflora	Collective microorganisms (bacteria, fungi) in a location or ecosystem.
Monitoring	Routine collection of data for assessing the health status of a population or the level of contamination of a site for remediation purposes. *See also* Surveillance.
Polymerase chain reaction (PCR)	A method of amplifying and analysing DNA sequences that can be used to detect the presence of viral DNA.
Prevalence	The proportion (or percentage) of animals in a particular population affected by a particular disease (or infection or positive antibody titre) at a given point in time.
Sensitivity	The proportion of truly positive units that are correctly identified as positive by a test. *See also* Specificity.
Specificity	The proportion of truly negative units that are correctly identified as negative by a test. *See also* Sensitivity.
Surveillance	A systematic program of investigation designed to establish the presence, extent or absence of a disease, or of infection or

	contamination with the causative organism. It includes the examination of animals for clinical signs, antibodies or the causative organism.
Susceptible animals	Animals that can be infected with a particular disease.
Vaccination	Inoculation of individuals with a vaccine to provide active immunity.
Vaccine	A substance used to stimulate immunity against one or several disease-causing agents to provide protection or to reduce the effects of the disease. A vaccine is prepared from the causative agent of a disease, its products, or a synthetic substitute, which is treated to act as an antigen without inducing the disease.
Wild animals - Native wildlife - Feral animals - Exotic fauna	 - Animals that are indigenous to Australia and may be susceptible to emergency animal diseases (eg bats, dingoes, marsupials). - Animals of domestic species that are not confined or under control (eg cats, horses, pigs). - Nondomestic animal species that are not indigenous to Australia (eg foxes).
Zoonosis	A disease of animals that can be transmitted to humans.

Abbreviations

Abbreviation	**Full title**
AAHL	Australian Animal Health Laboratory
EAD	Emergency Animal Disease
NEBRA	National Environmental Biosecurity Response Agreement
OIE	World Organisation for Animal Health
PCR	Polymerase chain reaction
PPE	Personal protective equipment
UVA	Ultraviolet A
WHA	Wildlife Health Australia
WNS	White-nose syndrome

References

<u>Documents and guidelines</u>

Wildlife Health Australia fact sheet http://www.wildlifehealthaustralia.com.au/FactSheets.aspx

Wildlife Health Australia How to Report a Suspect Case of White-Nose Syndrome http://www.wildlifehealthaustralia.com.au/ProgramsProjects/BatHealthFocusGroup.aspx#WNS

Wildlife Health Australia National Guidelines for Sample Submission – White-Nose Syndrome – Exclusion Testing http://www.wildlifehealthaustralia.com.au/ProgramsProjects/BatHealthFocusGroup.aspx#WNS

USGS National Wildlife Health Center Diagnostic Categories for Reporting Cases of Bat White-Nose Syndrome (WNS) Including a Summary of revisions to WNS case definitions for the 2015-2015 season https://www.nwhc.usgs.gov/disease_information/white-nose_syndrome/Case%20Defintions%20for%20WNS.pdf

USGS National Wildlife Health Center Bat White-Nose Syndrome (WNS)/Pd Surveillance Submission Guidelines, Winter 2015/16 (November – May) http://www.nwhc.usgs.gov/disease_information/white-nose_syndrome/NWHC+Winter+2015.2016+Bat+submission+guidelines_FINAL.pdf

National White-Nose Syndrome Decontamination Protocol (USA) www.whitenosesyndrome.org/topics/decontamination

Animal Health Australia (2007). Operational procedures manual: Decontamination (Version 3.0). Australian Veterinary Emergency Plan (AUSVETPLAN), Edition 3, Primary Industries Ministerial Council, Canberra, ACT https://www.animalhealthaustralia.com.au/our-publications/ausvetplan-manuals-and-documents/

USGS National Wildlife Health Center Biosafety Measures for Working with *Pseudogymnoascus destructans* in the Laboratory and Use or Storage of Potentially Contaminated Materials https://www.nwhc.usgs.gov/disease_information/white-nose_syndrome/handling%20of%20pseudogymnoascus%20destructans.pdf

<u>Response plans – USA and Canada</u>

US and Canadian national, federal and state response plans for WNS, available from https://www.whitenosesyndrome.org/white-nose-syndrome-response-plans, with particular reference to:

U.S. Fish and Wildlife Service (2011) A National Plan for Assisting States, Federal Agencies, and Tribes in Managing White-Nose Syndrome in Bats. Available from https://www.whitenosesyndrome.org/sites/default/files/white-nose_syndrome_national_plan_may_2011_0.pdf

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Kentucky Department of Fish and Wildlife Resources (2014) Kentucky WNS Response Plan. Available from https://www.whitenosesyndrome.org/sites/default/files/resource/ky_wns_response_plan_040814_final-webversion_0.pdf

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Hallam, TG, McCracken, GF (2011) Management of the panzootic white-nose syndrome through culling of bats. *Conservation Biology* **25**, 189-94.

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