Australian Government
Department of Agriculture, Water and the Environment

Conservation Advice for *Xeromys myoides* (Water Mouse)

In effect under the *Environment Protection and Biodiversity Conservation Act 1999* from 29 September 2021.

This document provides a foundation for conservation action and further planning.

Two Water Mouse *Xeromys myoides* individuals on their nest mound: © Copyright Nina Kaluza, University of Queensland

Conservation status

Xeromys myoides (Water Mouse; formerly False Water Rat) is listed in the Vulnerable category of the threatened species list under the *Environment Protection and Biodiversity Conservation Act 1999* (Cwth) (EPBC Act) effective from 16 July 2000. The species is eligible for listing because prior to the EPBC Act, it was listed as Vulnerable under the *Endangered Species Protection Act 1992* (Cwlth).

The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) lists *X. myoides* (as False Water Rat) on Appendix I. In 2016, the Water Mouse was assessed by Woinarski and Burbidge (2016) and listed on the IUCN Red List of Threatened Species as Vulnerable, having met Criterion 2:B2ab(ii,iii,v): Vulnerable.

Species can also be listed as threatened under state and territory legislation. For information on the current listing status of this species under relevant state or territory legislation, see the Species Profile and Threat Database.

Species information

Taxonomy

Conventionally accepted as *Xeromys myoides* Thomas (1889) (Rodentia: Muridae). The species is known by the common name Water Mouse and was formerly known as False Water Rat. It is the only member of the genus *Xeromys* (Thomas 1889). Phylogeography and population genetic analysis strongly support the current designation of *Xeromys myoides* as a single species (Benfer et al. 2014).

Description

The Water Mouse is a small rodent. Adults have a maximum head and body length of 126 mm and maximum weight of 64 g, with small eyes and rounded and small ears (Van Dyck & Gynther 2012; Gynther & Janetzki 2013). The species has a silky pelt that is water- and mud-resistant, with a characteristic white underbelly and steel grey upperparts (Redhead & McKean 1975). White flecking can be found on the dorsal fur of mature adult Water Mice (Gynther and Janetzki 2008) .

The Water Mouse can be distinguished from other species that may be encountered in similar habitat by its long and flattened head shape, slender, thinly haired and very finely ringed tail, and the presence of only two molars in each of the upper and lower rows of teeth (Gynther and Janetzki 2008). Unlike some other rodents that inhabit aquatic environments, such as the Water Rat or Rakali (*Hydromys chrysogaster*), the hind feet of Water Mice are not webbed (Thomas 1889). The species also has a strong, musty odour (Gynther and Janetzki 2008).

Distribution

The Water Mouse occurs across an extensive although almost linear range in coastal and near-coastal Queensland and the Northern Territory. However, the regions in which it occurs are widely separated. It is also known to occur in Papua New Guinea, where it was discovered on the Bensbach River floodplain (Hitchcock 1998).

In the Northern Territory, the Water Mouse is known to occur along the floodplains of the Glyde River and Tomkinson River in Arnhem Land, along the South Alligator and Daly Rivers in Kakadu National Park, and on Melville Island (Redhead and McKean 1975; Magnusson et al. 1976; Woinarski et al. 2000; Woinarski 2004; Woinarski et al. 2007).

In south-east Queensland, the Water Mouse is distributed from the Gold Coast and Moreton Bay area (Van Dyck 1997; Van Dyck & Gynther 2003; Gynther & Janetzki 2008; Kaluza 2019) to the Great Sandy Strait (Dwyer et al 1979; Burnham 2002; Kaluza et al. 2016; Kaluza 2019) and as far inland to the Beerwah State Forest (Dwyer et al. 1979).

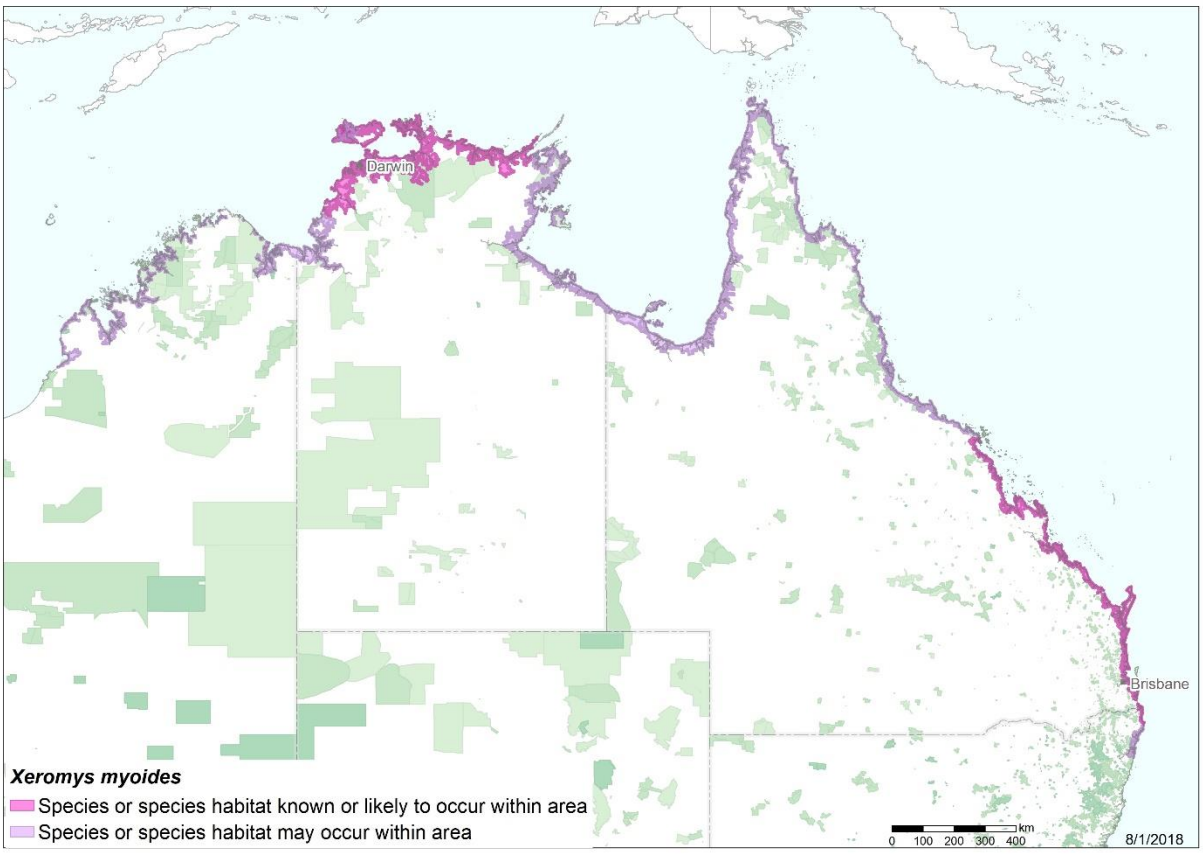
In central eastern Queensland, the Water Mouse is known to occur from Agnes Water to Mackay (Troughton 1943), and Cannonvale (Ball 2004). More recently, it has been recorded around Gladstone Harbour and on Curtis Island (QGC 2013).

The discovery of the species along the Jack Barnes Bicentennial Boardwalk, adjacent to Cairns Airport in 2017 (Ball & Mitchell 2018), represents the sole record of the Water Mouse from north Queensland, extending its known range in the state northwards by approximately 600 km (Ball & Mitchell 2018).

The Water Mouse may occur in the Kimberley region of Western Australia due to its close proximity to known records in the Northern Territory and the location of suitable habitat (Morris 2000). Furthermore, given the remoteness of habitat and risk to field workers posed by the presence of Saltwater Crocodiles (*Crocodylus porosus*), the species may occur, undetected, in suitable habitat between known locations in the northern parts of its range (DoE 2015).

All known Water Mouse locations are outlined in Appendix 1.

Map 1 Modelled distribution of Water Mouse



Source: Species distribution data Species of National Environmental Significance database, Base map Geoscience Australia.
Caveat: The information presented in this map has been provided by a range of groups and agencies. While every effort has been made to ensure accuracy and completeness, no guarantee is given, nor responsibility taken by the Commonwealth for errors or omissions, and the Commonwealth does not accept responsibility in respect of any information or advice given in relation to, or as a consequence of, anything containing herein.
Species distribution mapping: The species distribution mapping categories are indicative only and aim to capture (a) the specific habitat type or geographic feature that represents to recent observed locations of the species (known to occur) or preferred habitat occurring in close proximity to these locations (likely to occur); and (b) the broad environmental envelope or geographic region that encompasses all areas that could provide habitat for the species (may occur). These presence categories are created using an extensive database of species observations records, national and regional-scale environmental data, environmental modelling techniques and documented scientific research.

Population information

In Queensland, the population of the Water Mouse is estimated to be between 1001 and 10 000 individuals, occupying an area of approximately 101 to 1000 km^2 (Dickman et al. 2000). Woinarski & Burbidge (2016) estimated the national population to comprise 10,000 mature individuals (with low reliability) and to be declining.

Most parameters are poorly known for this species, especially for its range in Papua New Guinea and the Northern Territory. However, in spite of its large extent of occurrence, it is plausible that its area of occupancy is less than 2000 km^2 (Dickman et al. 2000). Within its range, it is patchily distributed and fragmented, with evidential decline and habitat degradation and loss well documented in the southern parts of its range in southeast Queensland (Van Dyck et al. 2006). There is a continuing decline of mature individuals in the estimated 10–30 known sites (Woinarski & Burbidge 2016).

Dickman et al. (2000) considered that its status was Endangered, stating that "its small and declining population and its range size suggest that it is more at risk in Queensland than previously believed". Since then, however, substantially more survey work has been conducted in Queensland, revealing a far more extensive distribution than previously known, with sizeable (but fewer than 1000 individuals) occupancy at some sites (Woinarski & Burbidge 2016).

In south-eastern Queensland, the highest density of the species is known to occur within the Great Sandy Strait (including Tin Can Bay, Kauri Creek, and the cattle station 'Tandora'), Maroochy River, Pumicestone Passage (Kaluza 2019), Quandamooka (Moreton Bay), and predominantly the western shores of Minjerribah (North Stradbroke Island) and South Stradbroke Island (Van Dyck & Gynther 2003).

A regional assessment of Water Mouse presence in the Great Sandy Strait was undertaken in 2014–2018 (Kaluza 2019). This aimed to validate the findings of Burnham (2002), who undertook regional surveys between 1999–2002. The re-assessment of the species in the Great Sandy Strait reported a decline in nest numbers and an increase in degradation to habitat (Kaluza 2019).

Cultural and community significance

The cultural and community significance of the Water Mouse is not known. In 1995, the Australian Nature Conservation Agency published an article on *Australian names for Australian rodents* which addressed two indigenous names for the Water Rat or Rakali: the Murrinh-Patha name *manngay*, and the Mayali and Gunwinjgu name *yirrku* (Braithwaite et al. 1995). These authors advocated that the latter name be accepted as the common name for the Water Mouse but with the orthography *yirrkoo*. Despite the well argued case by Braithwaite et al. (1995), this recommendation was not adopted.

The Water Mouse is a strong indicator of wetland health due to its specialised diet and reliance on sediment, bank structure, and tree hollows for nesting (Van Dyck & Gynther 2003; Ball 2004; Kaluza 2019). This provides a useful communication platform for engaging Traditional Owners and private land owners in managing country and better understanding this species.

A key information priority in this Conservation Advice is to better understand the cultural significance of the Water Mouse to Traditional Owners across its range, as well as improving knowledge of the species' occurrence on country. Achieving these things will assist to promote Traditional Owner engagement in monitoring of the species and their involvement in working

towards recovery of the Water Mouse. Implementation of any actions within this Conservation Advice should consider the role and interests of First Nations people.

Relevant biology and ecology

Behaviour and diet

Water Mice are nocturnal foragers and will search for prey between low and high tides along exposed tidal flats and around the water's edge (Van Dyck 1997). Foraging behaviour can be identified through leftover meal remains, otherwise known as middens. Prey remains can be located at the base of or on the external structure of nests and at feeding stations used by the Water Mouse within the intertidal zone (Van Dyck 1997; Kaluza 2019). Home range size ranges from 0.6 ha to 3.4 ha across sites in Queensland (Van Dyck 1997).

In south-east Queensland, the Water Mouse consumes a preferred diet of crustaceans (e.g. *Parasesarma erythodactyla*, *Helice leachi* and *Australoplax tridentata*), marine polyclads, marine pulmonates (e.g. *Salinator solida*, *Ophicardelus quoyi* and *Ochidina australis*) and marine bivalves (*Glauconome* sp.) found within intertidal systems (Van Dyck 1997).

In central eastern Queensland, the diet is similar and is known to include grapsid crabs (e.g. *Neoepisesarma mederi*) (Ball 2004). There is limited information on Water Mouse diet in its northern range, with only remains of grapsid crabs discovered on the outside of a mound nest on Melville Island (Woinarski 2006). Limited information exists on the nutritional value of its diet or water consumption by the species (DERM 2010).

Life cycle

Although the Water Mouse has been held in captivity (Low and Van Dyck 2000) little is known about its reproductive cycle and interaction with successive generations. It is assumed to be similar to other members of the family Muridae, producing a litter of several (2–4) offspring twice a year, with a presumed life expectancy of 2–3 years (Woinarski et al. 2014).

Nesting

The Water Mouse makes unique and varied mud-based nests for refuge and breeding. These nests are permanent and important features, contributing to the stability of Water Mouse populations (Van Dyck 1996; Gynther 2011; Kaluza et al. 2016). Van Dyck and Gynther (2003) examined the characteristics of Water Mouse nest structures in south-east Queensland, noting that the species has unique nesting behaviour, constructing mud or peat dwellings above the elevated high tide mark of suitable habitat in saltmarsh and mangrove environments. These structures vary between vegetation communities and are categorised into one of the following five broad types (Van Dyck & Gynther 2003):

- Freestanding mounds
- Island nests
- Supralittoral bank nests
- Tree trunk nests
- Spoil heap nests.

Typically, a nest will be used by the species for reproduction and a place of refuge (Van Dyck & Gynther 2003; Ball 2004; Kaluza 2019). Nest construction is a nocturnal activity and is time-consuming, requiring constant maintenance due to imposing factors such as tidal influence and seasonal storm events (Kaluza 2019). A distinctive mud-daubing method is used by the Water Mouse to construct and bind the nest (Van Dyck & Gynther 2003). Each nest consists of several internal chambers with external access holes that are elliptical with smooth edges with notable presence of fresh mud-daubing (Kaluza 2019). The positioning of these openings is possibly influenced by tidal occurrence and habitat (Kaluza 2019).

Habitat

The habitat of the Water Mouse is aquatic environments, including coastal saltmarsh, samphire shrublands, saline reed-beds and saline grasslands, mangroves, and coastal freshwater wetlands, and wet heathlands as demonstrated through occupancy by the species continuously, periodically or occasionally in the past or present (see Map 1).

The attributes of Water Mouse habitat providing for the species for various life cycle stages i.e breeding, nest construction, foraging, refuge and dispersal include but are not limited to:

- intact hydrology
- prey resources (crustaceans, polyclad worms, pulmonated snails and bivalves (see diet section)
- a defined supralittoral bank (enabling construction of nest burrows above the high tide level); and
- Structures (tidal pools, channels, crab holes, pneumatophores, crevices in bark and around roots, hollows in standing and fallen timber/mangroves, suspended drifts of twigs and leaves and driftwood).

Habitats and habitat attributes are contributed to Redhead and McKean (1975), Magnusson et al (1976), Dwyer et al (1979), Van Dyck (1997), Woinarski et al (2000), Van Dyck & Gynther (2003), Ball (2004), Woinarski et al (2000) and Kaluza (2019).

Areas with potential to be habitat

Areas with potential to be habitat include areas with one, some or all of known habitat attributes listed above which may be used for one or more of the species life cycle stages. Where these areas occur are best demonstrated by the known, likely and may occur indicative distribution mapping (see Map 1). The presence of a nest mound, active or not active or associated middens (see nesting section) is the most effective and straightforward way to confirm habitat where it is safe to do so.

Areas with potential to be habitat are expansive and linearly distributed between known locations through Far northern Queensland and across the coast and inland rivers and associated wetlands and vegetation communities of the Northern Territory and Western Australia. Confirmation of species presence and habitat attributes in these areas are important information needs and would contribute to a better understanding of this species, enabling a reassessment of its conservation status (see conservation actions). Some of these areas, particularly those in proximity to or connected to Water Mouse habitat (occupied areas) can become habitat through natural dispersal or with time, with the inclusion of, or development of

some attributes or investment in the area and its attributes (e.g. managing for feral animals or improving water quality). These areas may also already be habitat (occupied) without our knowledge due to lack of survey, remoteness and difficulty of accessing areas, lack of ecological knowledge and or the species low detectability.

Habitat condition and quality

Given the large extent of areas with potential to be habitat in Northern Queensland, the Northern Territory and Western Australia, the condition and quality as well as diversity and presence of certain attributes will vary across the species range. It will be the location of a particular action and the landscape context of that location which will determine the particular area's value and role in the life cycle and recovery of the Water Mouse. For example; the frequency of use of that area by the Water Mouse, that area's ability to become habitat for the Water Mouse (magntitide and intensity of threats and management cost effectiveness) or the area's ability to be habitat for the Water Mouse under a particular stress or event such as rising sea levels.

The context to consider in assessing an areas condition, quality and role in the Water Mouses long term recovery include the particular size of the area, the connectivity of the area, the presence of and magnitude or intensity of threats in the area, the history of and use of fire in the area and or, the proximity to particular ecological habitat attributes outlined above which provide for the life cycle stages of the Water Mouse. In addition to this and importantly for consideration is the species reproductive biology, life history, dispersal ability and home range, diet and vulnerability in the wild as demonstrated through the criteria for which it is eligible for listing.

Habitat critical to the survival

It is not considered practicable to describe habitat critical to the survival of the Water Mouse. Areas with potential to be habitat for this species are extensive and unsurveyed and newly identified threats to the species are ongoing and intensifying (i.e. predation by foxes (Kaluza et al. 2016) and mangrove die back (Duke et al. 2017)). The true extent and understanding of Water Mouse habitat can only be achieved through widespread detection-based presence /absence field surveys and or newly identified novel methods to sample remote /unsafe areas. In the absence of confirmed occupancy, the presence of habitat attributes can ascertain their importance and role in the recovery of the Water Mouse. The species eligibility for listing being a restricted area of occupancy and decline in habitat and quality suggests that all Water Mouse habitat as well as areas within areas with potential to be habitat, are important for the long term recovery of the Water Mouse.

Important populations

The Water Mouse is considered one single, nationally important population (Benfer et al. 2014). The study by Benfer et al. (2014) confirmed Water Mouse genetic diversity as being very low across its known range, suggesting the species may have experienced a recent range expansion.

Threats

Coastal wetlands are critical points of connectivity between terrestrial and marine ecosystems, and their environmental health is important for the proper functioning of both (Kaluza et al.

2016). These wetland systems are susceptible to a variety of factors, including land use change, increasing human presence, invasive species and climate change (Eslami-Andargoli et al. 2009).

The primary threat to the Water Mouse is the loss, degradation, and fragmentation of freshwater and intertidal wetland communities utilised by the species (DERM 2010; DoEE 2015). Drivers of this primary threat vary across the species 'range. In the Northern Territory, coastal habitat change is occurring due to saltwater intrusion, spread of exotic pasture grasses, and impacts of feral animals and livestock (especially associated with intensification of pastoral activities). In Queensland, changes in hydrology and expression of acid sulphate soils are causing loss, fragmentation and degradation of habitat.

The Water Mouse is also seriously threatened by feral predators, particularly in Queensland, where the Red Foxes (*Vulpes vulpes*) poses a severe threat to the species. In both Queensland and the Northern Territory, the Water Mouse may be at risk of predation by domestic and feral cats, though this has not been quantified (DERM 2010; DoE 2015).

Table 1 Threats impacting Water Mouse

Threat	Status and severity [a]	Evidence
Habitat loss, fragmentation and degradation		
Urban development and resource extraction (gas infrastructure development and sand mining).	• Status: current • Confidence: known • Consequence: major • Trend: increasing • Extent: across the known range	Areas of mangrove, saltmarsh and freshwater wetlands have been cleared and/or modified as a result of development in Queensland, primarily due to urbanisation, sand mining and construction of liquid natural gas facilities (Burnham 2002; Ball et al. 2006; Lee et al. 2006; Van Dyck et al. 2006; ABS 2007; Kaluza unpublished). These developments result in the disturbance of acid sulphate soils in coastal areas and changes in salinity and sedimentation due to increased stormwater runoff and changes in natural hydrology (Van Dyck & Gynther 2006; Ball et al. 2006; Lee et al. 2006). Sand mining on Minjerrabah (North Stradbroke Island) and historically on K'gari (Fraser Island), may have impacted Water Mouse habitat (Wardell-Johnson et al. 2015; Burgin 2020). In the Port of Gladstone and on Curtis Island, construction of gas infrastructure has caused loss and degradation of water mouse habitat (QGC 2013).
Recreational activity	• Status: current • Confidence: known • Consequence: moderate • Trend: increasing • Extent: across parts of its range (south east and central eastern Queensland)	Recreational use has led to habitat degradation at known water mouse locations. Site-specific impacts have reduced habitat quality or quantity and modified Water Mouse habitat (Van Dyck & Gynther 2003; Gynther 2011; Kaluza 2019).

Threat	Status and severity [a]	Evidence
Pesticide application	• Status: current /future • Confidence: known • Consequence: moderate • Trend: increasing • Extent: across parts of its range (south east and central eastern Queensland)	Pesticide application can also affect prey items of the water mouse and contributed to the demise and local extinction of a population of the species at Coomera, southeast Queensland (Van Dyck & Gynther 2006).
Grazing	• Status: current • Confidence: known • Consequence: moderate • Trend: increasing • Extent: across part of its range	Water Mouse habitat is exposed to cattle grazing across large parts of its range, which can lead to habitat disturbance through trampling, overgrazing (reducing cover provided by saltmarsh vegetation, thereby exposing Water Mice to greater risk of predation), changing water quality and drainage patterns, and spreading invasive grasses and weeds (Traill et al 2011; DoE 2015; Kaluza 2019).
Climate change		
Saltwater intrusion	• Status: current/future • Confidence: known/inferred • Consequence: major • Trend: increasing • Extent: across the entire range, current in Top End part of range	Climate change is leading to rising sea levels causing habitat loss and degradation from saltwater intrusion. In northern Australia, floodplain wetlands are highly susceptible to change caused by rises in sea levels from global climate change, resulting in productive freshwater habitats being replaced by saline systems (DERM 2010; Traill et al. 2011). In Queensland, modelling under global sea level rise scenarios has predicted Water Mouse extirpation in approximately 50 years, assuming ongoing predation and habitat loss from urbanisation (Traill et al. 2011).
Increased extreme weather events i.e cyclonic events, storm surges and/or spring tides to impact on the Water Mouse and its habitat.	• Status: current/future • Confidence: known/inferred • Consequence: major • Trend: increasing • Extent: across entire range	Climate change is leading to an increase in frequency and intensity of wildfires causing habitat loss and degradation (Ward et al. 2020) and sudden and temporary drops in sea levels resulting in mass mangrove dieback (Duke et al. 2017). Wildfire is a major threat to Water Mouse habitat (Ward et al. 2020; State of Queensland 2021). Fire is known to directly impact Water Mouse mound nests and hollow-bearing trees along intertidal areas of saltmarsh and sedge grass communities (Van Dyck and Gynther 2003) and fire also exposes the Water Mouse population to increased predation by foxes and cats (Kaluza 2019).

Threat	Status and severity [a]	Evidence
Invasive species		
Predation and/or nest destruction by foxes, pigs or cats	• Status: current/future • Confidence: known • Consequence: major • Trend: increasing • Extent: across the entire range	Predation from foxes, cats and feral pigs, are major threats to the species' persistence (DERM 2010; DoE 2015). Kaluza ((2019) confirmed the threat of foxes, recording them raid and damage mound nests along the Maroochy River in south-east Qld. In south-east and central eastern Queensland, feral pig wallows prevent plant recovery and are known to compromise Water Mouse habitat (Burnham 2002; Kaluza 2019). Feral pigs are known to damage or destroy the permanent nest structures of the Water Mouse and possibly prey on the species. (Van Dyck and Gynther 2003).
Weed invasion	• Status: current • Confidence: known • Consequence: major • Trend: increasing • Extent: across part of its range	The spread of exotic pasture grasses poses a threat to the Water Mouse, modifying habitat and increasing fire intensity and risk to Water Mouse habitat (Woinarski et al. 2011). Most pastoralism relies on native grasses but, increasingly, non-native (mostly African) grass species have been introduced (and spread beyond pastoral lands which radically alter understorey composition and structure, produce biomass far in excess of that of native grasses, and hence fuel fires of far greater intensity, exacerbating habitat degradation (Rossiter et al. 2003).

Status—identifies the temporal nature of the threat;
Confidence—identifies the extent to which we have confidence about the impact of the threat on the species;
Consequence—identifies the severity of the threat;
Trend—identifies the extent to which it will continue to operate on the species;
Extent—identifies its spatial content in terms of the range of the species.

Each threat has been described in Table 1 in terms of the extent that it is operating on the species. The risk matrix (Table 2) provides a visual depiction of the level of risk being imposed by a threat and supports the prioritisation of subsequent management and conservation actions. In preparing a risk matrix, several factors have been taken into consideration. They are: the life stage they affect; the duration of the impact; and the efficacy of current management regimes, assuming that management will continue to be applied appropriately. The risk matrix and ranking of threats has been developed in consultation with experts and using available literature.

Table 2 Water Mouse risk matrix

Likelihood	Consequences				
	Not significant	**Minor**	**Moderate**	**Major**	**Catastrophic**
Almost certain	Low risk	Moderate risk	**Pesticide use** **Recreational activity** **Grazing**	**Urban development and resource extraction** **Pigs, Foxes and cats** **Weeds** **Salt water intrusion** **Wildfires and sudden sea level drops**	Very high risk
Likely	Low risk	Moderate risk	High risk	Very high risk	Very high risk
Possible	Low risk	Moderate risk	High risk	Very high risk	Very high risk
Unlikely	Low risk	Low risk	Moderate risk	High risk	Very high risk
Unknown	Low risk	Low risk	Moderate risk	High risk	Very high risk

Conservation and recovery actions

Primary conservation objectives

- Effective gene flow across the population has been maintained between 2021 and 2031.
- The area of occupancy in 2031 has not decreased compared to 2021.
- Increase in species knowledge and conservation action in areas identified in 2021 to have potential to be habitat.

Conservation and management priorities

Given the Water Mouse's large extent of occurrence, conservation management priorities differ across the species' range, and some actions may only be required in certain areas or have differing priorities in some areas compared to others.

Habitat loss, fragmentation and degradation

- Protect and prevent impacts to Water Mouse habitat in the planning, construction and post-construction phases of developments. Important components of this action are:
    - Implement rigorous environmental impact assessments to protect Water Mouse habitat.
    - Ensure that robust field surveys, which account for the species' detectability, are undertaken to identify Water Mouse habitat.
    - Maintain connectivity of Water Mouse habitat through appropriate positioning of infrastructure.

    - Educate stakeholders regarding the application of the assessment and approval process under the EPBC Act and their obligations under the Act to avoid significant impacts to the Water Mouse.

- Negotiate conservation covenants, management agreements or land purchases with owners of private land. Such covenants or agreements should include:
    - Stock exclusion fencing, with the aim of excluding cattle from Water Mouse habitat.
        - If not possible to exclude stock, promote sustainable grazing practices in Water Mouse habitat
    - Establishing terrestrial buffer zones to Water Mouse habitat.
    - Controlling invasive species, particularly foxes and pigs, in Water Mouse habitat.
- Support First Nations people to survey and manage Water Mouse habitat on country.

Climate change and extreme weather events

- Improve the resilience of Water Mouse habitats by removing or managing the impacts of local processes, such as feral pig damage, fires and weed invasions.
- Support Indigenous ranger groups to deliver life-sustaining watering when needed as part of an on-going program of regular maintenance of localised threats like feral pigs, weeds and fires
- Use predictive modelling to map Water Mouse habitat under scenarios involving sea-level rise.
- Identify Water mouse habitat at risk of loss or damage due to sea-level rise and determine time frames under which changes are likely to occur.
- Identify Water Mouse habitat or areas with potential to be habitat that could be artificially protected from sea-level rise
- Establish monitoring sites to enable early detection of the impacts of climate change on the Water Mouse and its habitat.

Fire

- Implement appropriate landscape-scale fire management strategies incorporating traditional patch burning (for fuel-reduction burning and to promote patchiness), wildfire control (to prevent large scale or frequent fire) and no-burn areas in and adjacent to Water Mouse habitat to reduce the risk of large-scale, uncontrolled bushfires.
- Implement 'right-way' ecological burning regimes, guided by further research, in order to protect and maintain Water Mouse habitat.
- Undertake predator control in Water Mouse habitat following ecological burns or after wildfires.
- In burnt areas of Water Mouse habitat, undertake manual weed control and restoration works to promote the natural regeneration of Water Mouse habitat. Caution should be used when applying herbicides within or near Water Mouse habitat.

Invasive species

- Develop and implement a long-term strategy to control numbers of foxes, cats and pigs in Water Mouse habitat.
- Implement local bylaws to forbid cat ownership in new developments adjacent to Water Mouse habitat or bylaws requiring domestic cats to be kept indoors in new and existing developments.

Stakeholder engagement/community engagement

- Involve and consult with First Nations people across the range of the Water Mouse when developing planning documents and management strategies and monitoring programs.
- Encourage community involvement in fox and pig control near Water Mouse habitat.

Survey and monitoring priorities

- Undertake widespread surveys for Water Mouse in areas with potential to be habitat, particularly in Far North Queensland and the Northern Territory.
- Design and implement a national monitoring program for the Water Mouse. This should include, but is not limited to:
    - Confirming population size, structure, reproductive status and trend.
    - Mapping area occupied by populations.
    - Monitoring condition of habitat and identifying associated threats.
    - Identifying thresholds at which management interventions, such as translocations, are required.
- Monitor progress of recovery, including the effectiveness of management actions and the need to adapt them if necessary.

Information and research priorities

- Gain an understanding of the cultural and community significance of the Water Mouse to better understand its ecology.
- Investigate the potential for 'right-way' Aboriginal cultural burning practices to be employed in terrestrial areas adjacent to Water Mouse habitat and the appropriates seasons to burn identified across its range.
- Investigate the potential to use novel methods (e.g. eDNA) to confirm presence of the species in areas with potential to be habitat.
- Investigate the reproductive biology of the species and identify any factors that potentially limit reproductive success..
- Evaluate current population status, longevity, fecundity and recruitment levels at one or more key sites in each of the regions across its range .
- Investigate the role of fire and other potential disturbance factors in the ecology of the Water Mouse.
- Measure the benefits of Blue Carbon sequestered by marine, coastal and estuarine ecosystems to Water Mouse habitat.

- Investigate nest usage, occupancy and movement between nests to improve knowledge of home range and population structure. This could include microchipping and monitoring individuals to track movements using fixed reading systems.

Links to relevant implementation documents

National Recovery plan for the water mouse (false water rat) Xeromys myoides (2010)

Threat abatement plan for predation by feral cats (2015)

Threat abatement plan for predation by the European red fox (2008)

Threat abatement plan for predation, habitat degradation, competition and disease transmission by feral pigs (Sus scrofa) (2017)

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Appendix 1

Table 1. Known Water Mouse locations as of July 2021 (from south-east Queensland to the Northern Territory).

Location	Tenure	Stakeholder management	Nest quantity	Survey timeline (year located and revisited)
South-east Queensland				
Coomera River	Gold Coast City Council	Department of Environment and Science, Gold Coast City Council	22 0	1993–1994 2006
McCoy Creek (Pimpama River)	Gold Coast City Council	Department of Environment and Science, Gold Coast City Council	6	2015
Jacobs Well	Gold Coast City Council	Department of Environment and Science, Gold Coast City Council	1	1993
Steiglitz	Gold Coast City Council	Department of Environment and Science, Gold Coast City Council	4	1996
South Stradbroke Island (Browns Bay)	Native Title Moreton Bay Marine Park	Quandamooka Yoolooburrabee Aboriginal Corporation, Department of Environment and Science, Gold Coast City Council	19	1997
Minjerribah (North Stradbroke Island)	Native Title Moreton Bay Marine Park	Quandamooka Yoolooburrabee Aboriginal Corporation, Department of Environment and Science, Redland City Council	17 Unknown Unknown	1981 1992–1993 1997
Myora Springs	Native Title Moreton Bay Marine Park		1 1 1 6	1979 1992 1993 2013
Russell Island	Native Title Moreton Bay Marine Park	Quandamooka Yoolooburrabee Aboriginal Corporation, Department of Environment and Science, Redland City Council	8	2015 (possibly earlier records)
Caboolture River	Moreton Bay Regional Council	Department of Environment and Science, Moreton Bay Regional Council	1	2015
Bribie Island (Gallagher Point)	National Park Moreton Bay Marine Park	Department of Environment and Science, Moreton Bay Regional Council, Quandamooka Yoolooburrabee Aboriginal Corporation	5 6	1996 2009 (records in between thought to exist
Bribie Island (White Patch and Second Lagoon)	National Park Moreton Bay Marine Park	Department of Environment and Science, Moreton Bay Regional Council, Quandamooka Yoolooburrabee Aboriginal Corporation	1	Uunknown
Bullock Creek	Conservation Park Moreton Bay Marine Park	Department of Environment and Science	3	1996
Donnybrook	Moreton Bay Regional Council Ramsar Area	Department of Environment and Science, Moreton Bay Regional Council	17	1996

Location	Tenure	Stakeholder management	Nest quantity	Survey timeline (year located and revisited)
Glass Mountain Creek	State Forest Sunshine Coast Council	Department of Environment and Science, Sunshine Coast Council, Hancock Plantations.	51	2012
Hussey Creek	State Forest Sunshine Coast Council Ramsar Area	Department of Environment and Science, Sunshine Coast Council	30	2012
Halls Creek	State Forest Sunshine Coast Council Ramsar Area	Department of Environment and Science, Sunshine Coast Council	18	2013
Bells Creek	State Forest Sunshine Coast Council Ramsar Area	Department of Environment and Science, Sunshine Coast Council	3	2012
Beerwah State Forest (Beerwah Scientific Area 1 and Coochin Creek)	State Forest Sunshine Coast Council	Department of Environment and Science, Sunshine Coast Council	Unknown Unknown 1 Unknown	1975 1994
Mooloola River	National Park	Department of Environment and Science, Sunshine Coast Council, Gubbi Gubbi Traditional Owners	5	2013
Maroochy River	Conservation Park and Sunshine Coast Council	Department of Environment and Science, Sunshine Coast Council, Gubbi Gubbi Traditional Owners	1 185	1997 2011–2015
Noosa River (including Cooloola)	National Park Conservation Park Noosa Council	Department of Environment and Science, Noosa Council, Gubbi Gubbi Traditional Owners	1 6 5	1975 1997 2013
Wide Bay Region, Queensland				
Tuan State Forest (Poona Creek, Big Tuan Creek, Mosquito Creek, Buttha Creek and Kauri Creek)	State Forest	Unknown	Unknown	Unknown
Poona	National Park	Department of Environment and Science, Butchulla Aboriginal Corporation, Fraser Coast Regional Council	Unknown	Unknown
Cowra Point	National Park	Department of Environment and Science, Butchulla Aboriginal Corporation, Fraser Coast Regional Council	8	2000
Kauri Creek	National Park Ramsar Area	Department of Environment and Science, Butchulla Aboriginal Corporation, Fraser Coast Regional Council	29 11	2000–2002 2014–2017
Inskip & Bullock Creek	National Park Ramsar Area	Department of Environment and Science, Butchulla Aboriginal Corporation, Fraser Coast Regional Council	8 0	2000 2014–2017

Location	Tenure	Stakeholder management	Nest quantity	Survey timeline (year located and revisited)
Little Stoney Creek & Mort Creek	National Park	Department of Environment and Science, Butchulla Aboriginal Corporation, Fraser Coast Regional Council	11	2000
Middle Creek & Cooloola Creek	National Park	Department of Environment and Science, Butchulla Aboriginal Corporation, Fraser Coast Regional Council	11	2000
Poverty Point	National Park	Department of Environment and Science, Butchulla Aboriginal Corporation, Fraser Coast Regional Council	8	2000
Carlo Point	National Park Ramsar Areas	Department of Environment and Science, Butchulla Aboriginal Corporation, Fraser Coast Regional Council	3 0	2000 2014–2016
Searys Creek	National Park Ramsar Areas	Department of Environment and Science, Butchulla Aboriginal Corporation, Fraser Coast Regional Council	16	2000
Carlo Creek	National Park Ramsar Areas	Department of Environment and Science, Butchulla Aboriginal Corporation, Fraser Coast Regional Council	8	2000
Boronia	National Park Ramsar Areas	Department of Environment and Science, Butchulla Aboriginal Corporation, Fraser Coast Regional Council	10	2000
Mosquito Creek, Kala Creek & Big Tuan Creek	National Park Ramsar Areas	Department of Environment and Science, Butchulla Aboriginal Corporation, Fraser Coast Regional Council	25	2000
Teebar Creek			33	2000
Camp Kerr (Tin Can Bay)	Commonwealth of Australia	Department of Defence	7 7	2000 2014–2017
Tandora cattle station	Private Property	Lindsay Titmarsh (property owner), Department of Environment and Science	29	2013–2017
River Heads	Fraser Coast Regional Council	Fraser Coast Regional Council, Butchulla Aboriginal Corporation, Department of Environment and Science	3 1	2014 2014
Turtle Cove				
Booral	Fraser Coast Regional Council	Fraser Coast Regional Council, Butchulla Aboriginal Corporation, Department of Environment and Science	5 0	2000 2014–2017
Wanggoolba Creek, K'gari (Fraser Island)	Native Title World Heritage Area	Butchulla Aboriginal Corporation, Department of Environment and Science, Fraser Coast Regional Council	8	2015

Location	Tenure	Stakeholder management	Nest quantity	Survey timeline (year located and revisited)
Garys' Anchorage, K'gari (Fraser Island)	Native Title, National Park, World Heritage Area	Butchulla Aboriginal Corporation, Department of Environment and Science, Fraser Coast Regional Council	Unknown	1995
Burrum Heads	National Park	Department of Environment and Science, Fraser Coast Regional Council, Butchulla Aboriginal Corporation	11	2015
Moore Park	National Park	Department of Environment and Science, Bundaberg Regional Council	4	2017
Elliot Heads	National Park	Department of Environment and Science, Bundaberg Regional Council	4	2017
Central Eastern Queensland				
Roundhill Creek (Agnes Waters)	National Park and Bustard Bay HCVAE	Department of Environment and Science, Gladstone Regional Council	10 9	2000 2015
Eurimbula (Agnes Water)	National Park and Bustard Bay HCVAE	Department of Environment and Science, Gladstone Regional Council	3 1	2000 2011
Gladstone Harbour (Humpy Creek and Targinie Creeks)	Private Property	Gladstone Regional Council	Unknown	2013
Laird Point (Curtis Point)	Private Property	Gladstone Regional Council	Unknown	2013
Shoalwater Bay	Defence Land	Commonwealth of Australia	1	2009
Cape Palmerston (Mackay)	National Park	Department of Environment and Science, Mackay Regional Council, Reef Catchments, Pioneer Catchment Landcare	3	2011
Cape Hillsborough	National Park	Department of Environment and Science, Mackay Regional Council, Reef Catchments, Pioneer Catchment Landcare	1	2013
Sandringham Bay	Conservation Park	Department of Environment and Science, Mackay Regional Council, Reef Catchments, Pioneer Catchment Landcare	14 9	2011 2012
Bakers Creek	Conservation Park	Department of Environment and Science, Mackay Regional Council, Pioneer Catchment Landcare	1	2000
Skull Knob	Conservation Park	Department of Environment and Science, Mackay Regional Council, Pioneer Catchment Landcare	Unknown	Unknown
Bucasia (Mackay)	Reserve	Reserve manager, Department of Resources, Mackay Regional Council	2	2011
Freshwater Point (Mackay)	Reserve	Reserve manager, Department of Resources, Mackay Regional Council	1	2011
Eimeo (Mackay)	Unallocated State Land	Department of Resources, Mackay Regional Council	Unknown	Unknown

Location	Tenure	Stakeholder management	Nest quantity	Survey timeline (year located and revisited)
Pioneer Bay, Waite Creek (Cannonvale)	Unallocated State Land	Department ofResources, Whitsunday Regional Council	Unknown	2017
Proserpine River (Flying Fox Island)	Unallocated State Land	Department of Resources, Whitsunday Regional Council	Unknown	1982
Far North Queensland				
Jack Barnes Bicentennial Boardwalk,Cairns	Cairns Regional Council	Cairns Regional Council, North Queensland Land Council	Unknown	2017
Northern Territory				
Glyde River and Tomkinson River (Maningrida to Ramingining)	Indigenous Protected Area Northern Territory Government	Northern Land Council, Territory Natural Resource Management, Crocodile Island Rangers, Gumurr Marthakal Rangers, Djelk Rangers, Wanga Djakamirr Rangers, Marldbalk Marine Rangers, Garngi Rangers, Thamarrurr Rangers (Linked to Marri Jabin south west of Darwin)	Unknown Unknown	1975 2000
South Alligator River	Kakadu National Park	Parks Australia	unknown	unknown
Daly River	Northern Land Council	Northern Territory Government, Northern Land Council, Bulgul Land and Sea Rangers, Kenbi Rangers	Unknown	1976
Melville Island (Tiwi Islands)	Northern Land Council	Northern Territory Government, Northern Land Council, Tiwi Islands Land Council, Tiwi Islands Land and Sea Management	Unknown	1975

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