

THREATENED SPECIES SCIENTIFIC COMMITTEE

Established under the *Environment Protection and Biodiversity Conservation Act 1999*

The Minister approved this conservation advice on 02/05/2016 and included this species in the Vulnerable category, effective from 05/05/2016

Conservation Advice

Mastacomys fuscus mordicus

broad-toothed rat (mainland)

Note: The information contained in this Conservation Advice was primarily sourced from 'The Action Plan for Australian Mammals 2012' (Woinarski et al., 2014). Any substantive additions obtained during the consultation on the draft have been cited within the advice. Readers may note that Conservation Advices resulting from the Action Plan for Australian Mammals show minor differences in formatting relative to other Conservation Advices. These reflect the desire to efficiently prepare a large number of advices by adopting the presentation approach of the Action Plan for Australian Mammals, and do not reflect any difference in the evidence used to develop the recommendation.

Taxonomy

Conventionally accepted as *Mastacomys fuscus mordicus* (Thomas 1922).

Two subspecies are recognised. The other subspecies is *M. f. fuscus* (broad-toothed rat (Tasmania)).

Summary of assessment

Conservation status

Vulnerable: Criterion 1 A2(b)(c)(e), A3(b)(c)(e), A4(b)(c)(e) and Criterion 2 B2(a),(b)(i-v)

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

<http://www.environment.gov.au/cgi-bin/sprat/public/sprat.pl>.

Reason for conservation assessment by the Threatened Species Scientific Committee

This advice follows assessment of new information provided to the Committee to list *Mastacomys fuscus mordicus* (broad-toothed rat (mainland)).

Public Consultation

Notice of the proposed amendment and a consultation document was made available for public comment for 40 business days between 30 September 2015 and 25 November 2015. Any comments received that were relevant to the survival of the subspecies were considered by the Committee as part of the assessment process.

Species/Subspecies Information

Description

The broad-toothed rat has a broad face, short tail and stocky body. It has fine, dense fur which is brown tinged with rufous above, merging to a paler grey underneath. The fur may have a green tinge due to the presence of algae. The ears are small and round with tufts of hair inside. The feet are brown above and below. The tail is lightly haired, dark above and becoming slightly lighter underneath. It has characteristically large molars in a rounded head, with well developed

cheeks and large jaw muscles. It has a head and body length of 14–17 cm and a tail length of 10–13 cm (Happold 2008; Australian Museum 2014).

Distribution

The broad-toothed rat (mainland) has a highly fragmented distribution, with scattered records across the Great Dividing Range from near Warburton (Victoria) to the Brindabella Range (Australian Capital Territory) and around Barrington Tops (New South Wales), with at least one poorly-known subpopulation in coastal areas of far East Gippsland and south-eastern New South Wales (Seebeck & Menkhorst 2000; Green & Osborne 2003; C. Dickman pers. comm., cited in Woinarski et al., 2014).

Historically, the subspecies was far more widespread. Its distribution has declined significantly since European settlement (Seebeck 1971; Menkhorst 1995; Hocking & Driessen 2000; Bilney et al., 2010), with numerous sub-fossil deposits found in eastern and western Victoria, and some sub-fossil deposits found in South Australia, that lie well outside its current recognised distribution and habitat (Vic SAC 2012; Bilney pers. comm., cited in Vic SAC 2015; Fusco et al., 2015).

Its area of occupancy is probably continuing to decline (Seebeck & Menkhorst 2000; Green & Osborne 2003; Green et al., 2008; Menkhorst et al., 2008; Happold 2008). Menkhorst et al. (2008) reported that the last records from the Victorian Western District Plains and far East Gippsland are prior to 1900, from west Gippsland prior to 1950, and from Wilson's Promontory prior to 1980, and that it had not been recorded in the Otway Ranges 'for the last 30 years'. However, targeted surveys undertaken by Rowe and Shipway (2015) found that the subspecies persists at a small number of sites in the Otway Ranges, although populations at these sites are at high risk of local extinction, and it also persists at one outlier site in far East Gippsland.

The subspecies historically occupied a much wider range of drier habitat types (<700mm rainfall) at lower elevations (<100m); but it is now considered locally extinct in most of these (Menkhorst 1995; Bilney et al., 2010; Fusco et al., 2015) and locally abundant only in a few alpine regions (Menkhorst 1995; Seebeck & Menkhorst 2000; Green & Osborne 2003; Menkhorst et al., 2008).

Relevant Biology/Ecology

Many aspects of the ecology and life history of the broad-toothed rat are relatively well known due to a series of intensive studies (e.g. Happold 1989b, 1998; Carron et al., 1990; Bubela et al., 1991; Bubela & Happold 1993), although these studies are not necessarily representative of the environmental range occupied by the species. The broad-toothed rat is a terrestrial and mostly nocturnal rodent. It is herbivorous, with grasses forming the major component of its diet (Carron et al., 1990). In summer it nests in burrows in the soil. In alpine areas in winter, it dens communally during the day in nests of shredded grass situated in dense undergrowth or under logs beneath the snow (Bubela & Happold 1993). In alpine and sub-alpine areas it is active in the vegetation layer under snow cover (Happold 1998).

Broad-toothed rats are now predominantly found on sites that have a cooler climate, significant annual rainfall, a plentiful food supply and adequate vegetative cover (Vic SAC 2012). Currently most such sites are at higher elevations, although the species is also found in some coastal and foothill areas (Vic SAC 2012). The species occupies a range of habitats across its range, but typically is highly selective in any region. Preferred habitats include alpine and subalpine heathlands, grassland adjacent to boulder outcrops, swamps, sedgeland, coastal grassy or shrubby dunes, and sometimes forests with grassy understories (Wallis et al., 1982; Seebeck et al., 2003; Green & Osborne 2003). Habitat suitability is largely determined by the availability of cover and grasses (Green & Osborne 2003; Menkhorst et al., 2008). Proximity to drainage lines, which are likely to support a higher density and complexity of vegetation, and a higher abundance of grasses (Carron et al., 1990), is also important with a decreasing likelihood of detecting the species with increasing distance from a drainage line (Milner et al., 2015). In mainland alpine areas its preferred habitats are those with rocks and shrubs (including

Phebalium and *Prostanthera* species; D. Happold pers. comm., cited in Woinarski et al., 2014). The Tasmanian subspecies is restricted to button-grass moorland or adjacent ecotones (Hocking & Driessen 2000), wet sedgeland and heathland (Green 2007), and isolated grassland on rocky mountains in alpine areas above the impact of grazing wallabies (Green 2011). Because of a requirement for dense ground cover, fire reduces the suitability of this habitat, and 'regrowth takes some years to mature to a stage suitable for re-colonisation' (Green, 2007).

In part, the habitat now occupied by the species is naturally discontinuous, prompting a fragmented distribution for this species. However, many areas of apparently suitable habitat are unoccupied (Green & Osborne 2003) and the species may have limited ability to disperse across unfavourable habitat; although where discrete habitat patches are relatively close together, there may be sufficient dispersal to treat these fragmented occurrences as a meta-population (O'Brien et al., 2008).

Home range size and social dispersion vary seasonally, from about 0.1 ha to 0.3 ha. Breeding is seasonal, with females giving birth to one or two litters (of 1–4 young) per season between October and March (Happold 1998; Green 2007). Sexual maturity is reached in 6–12 months (Happold 2008, 2011) and longevity is probably 2–3 years (Happold 2011). Generation length is assumed to be 1–2 years (Woinarski et al., 2014).

Threats

Threats to the broad-toothed rat (mainland) are outlined in the table below (Woinarski et al., 2014).

Threat factor	Consequence rating	Extent over which threat may operate	Evidence base
Predation by foxes	Severe	Entire	Many studies demonstrate predation by foxes, and Green (2002) demonstrated that foxes prefer to hunt broad-toothed rats over other large rodents (such as bush rats (<i>Rattus fuscipes</i>)). Such predation pressure may cause niche contraction and continued niche-denial (Bilney et al., 2010), likely exacerbated following fire and habitat removal or modification by feral herbivores (Vic SAC 2012).
Too frequent burning	Severe	Large	Major fires over the last decade have reduced habitat extent and suitability (Menkhorst et al., 2008; Happold 2008; Vic SAC 2012). Correlative studies demonstrate requirements for unburnt (>15 years post-fire) vegetation (Hocking & Driessen 2000; Green 2007).
Predation by feral cats	Severe	Entire	Some studies demonstrate predation (Menkhorst et al., 2008).

Global climate change	Severe	Large (magnifying in the near-medium future)	Direct impacts are likely due to reduced habitat suitability, but also through increases in pressure from predators and competitors (Green et al., 2008). There is direct evidence of detrimental impacts of early snow thaws in the Snowy Mountains subpopulations (K. Green pers. comm., cited in Woinarski et al., 2014).
Habitat loss and fragmentation	Severe	Minor	Some habitat destruction has been associated with ski resort development (Menkhorst et al., 2008).
Habitat change (and resource depletion) due to livestock and feral herbivores	Moderate	Large	There is habitat degradation due to feral horses, rabbits, deer, hares and pigs (Menkhorst et al., 2008). Some impact-control experiments demonstrate decline of the broad-toothed rat in areas with horse impact (K. Green pers. comm., cited in Woinarski et al., 2014). Scat surveys have demonstrated a negative relationship between the abundance of broad-toothed rats and habitat disturbance due to feral herbivores (Milner et al., 2015).
Competition with other native rodents	Moderate	Moderate	Some correlative evidence exists (Green & Osborne 2003).
Habitat change (and resource depletion) due to weeds	Minor	Minor	Weed invasion has been noted at some sites (Menkhorst et al., 2008).
Habitat change (and resource depletion) due to die-back	Minor	Localised	<i>Phytophthora cinnamomi</i> can affect habitats in some regions (NSW DEC 2007; Menkhorst et al., 2008).
Habitat change due to logging	Minor	Minor	A likely threat, but impacts are uncertain (Vic SAC 2012).

How judged by the Committee in relation to the EPBC Act Criteria and Regulations

Criterion 1. Population size reduction (reduction in total numbers)

Population reduction (measured over the longer of 10 years or 3 generations) based on any of A1 to A4

	Critically Endangered Very severe reduction	Endangered Severe reduction	Vulnerable Substantial reduction
A1	≥ 90%	≥ 70%	≥ 50%
A2, A3, A4	≥ 80%	≥ 50%	≥ 30%
<p>A1 Population reduction observed, estimated, inferred or suspected in the past and the causes of the reduction are clearly reversible AND understood AND ceased.</p> <p>A2 Population reduction observed, estimated, inferred or suspected in the past where the causes of the reduction may not have ceased OR may not be understood OR may not be reversible.</p> <p>A3 Population reduction, projected or suspected to be met in the future (up to a maximum of 100 years) [(a) cannot be used for A3]</p> <p>A4 An observed, estimated, inferred, projected or suspected population reduction where the time period must include both the past and the future (up to a max. of 100 years in future), and where the causes of reduction may not have ceased OR may not be understood OR may not be reversible.</p>	<p>based on any of the following:</p> <p>(a) direct observation [except A3]</p> <p>(b) an index of abundance appropriate to the taxon</p> <p>(c) a decline in area of occupancy, extent of occurrence and/or quality of habitat</p> <p>(d) actual or potential levels of exploitation</p> <p>(e) the effects of introduced taxa, hybridization, pathogens, pollutants, competitors or parasites</p>		

Evidence:

Eligible under Criterion 1 A2(b)(c)(e), A3(b)(c)(e), A4(b)(c)(e) for listing as Vulnerable

There is limited knowledge of the broad-toothed rat's (mainland) population size, population trends, and area of occupancy across its range. However, declines have been demonstrated at some sites and inferred at most other known locations. Available evidence suggests that the rate of decline may approach or exceed 30 percent over the past or future 10 year period.

Menkhorst et al. (2008) noted a greater than 50 percent decline in the largest known and best-studied subpopulation (in the Mt Kosciuszko area) over the period 1999–2008 due to fox and cat predation, fire impacts, and some competition from other rodents. K. Green (pers. comm., cited in Woinarski et al., 2014) noted that, in the summer of 1999–2000, the population in the Snowy Mountains fell to about 34 percent of average values over the previous 13 years (associated with the earliest snow thaw on record), and has not increased above that point subsequently (in part due to subsequent extensive fire, and another early snow thaw in 2006). In Victoria, a high proportion of its range was burnt by major bushfires in 2003, 2006 and 2009 (Vic SAC 2012), which are likely to have severely impacted the distribution and availability of the subspecies' habitat and reduced populations (Hocking & Driessen 2000; Vic SAC 2012).

In 2014–2015, targeted scat surveys were undertaken at 68 historically occupied (prior to 1990) sites across Victoria, with six timed searches conducted at each site (Rowe & Shipway 2015). The subspecies was detected at only 32 of the sites, indicating a greater than 50 percent reduction in the number of sites occupied. The persistence of populations at historical sites was positively correlated with elevation and precipitation, and negatively correlated with temperature. The surveys also indicated that the subspecies' total distribution across Victoria has not appreciably changed, including the same range of elevation (0–2200 m above sea level) across the state.

Although the rate of decline is not well established across the subspecies' range, there is evidence of continuing decline in habitat suitability and extent, area of occupancy, number of subpopulations and population size. Woinarski et al. (2014) infer the overall population size

reduction to be greater than 30 percent over 10 years. Threats are ongoing and some appear to be increasing (e.g. the impact of feral herbivores, spread of weeds, *Phytophthora* die-back, effects of climate change, and possible increased fire frequency) (Vic SAC 2012).

The Committee considers that, although some of the data presented were obtained more than 10 years ago, many of the declines suggest that the subspecies has likely undergone a substantial reduction in numbers over the past 10 year period. Given the estimated 50 percent decline in the largest population between 1999 and 2008 (Menkhorst et al., 2008), the decline of the Snowy Mountains population between the late 1980s and 1999–2000 (Woinarski et al. 2014) and the apparent 50 percent reduction in site occupancy between the 1990s and 2014–15 (Rowe & Shipway 2015), the decline over the past 10 years is likely to be at least 30 percent, the reduction has not ceased, the cause has not ceased and is not understood. Given the ongoing threats, this rate of decline is likely to continue in the future. Therefore, the subspecies has met the relevant elements of Criterion 1 to make it eligible for listing as Vulnerable.

Criterion 2. Geographic distribution as indicators for either extent of occurrence AND/OR area of occupancy			
	Critically Endangered Very restricted	Endangered Restricted	Vulnerable Limited
B1. Extent of occurrence (EOO)	< 100 km ²	< 5,000 km ²	< 20,000 km ²
B2. Area of occupancy (AOO)	< 10 km ²	< 500 km ²	< 2,000 km ²
AND at least 2 of the following 3 conditions:			
(a) Severely fragmented OR Number of locations	= 1	≤ 5	≤ 10
(b) Continuing decline observed, estimated, inferred or projected in any of: (i) extent of occurrence; (ii) area of occupancy; (iii) area, extent and/or quality of habitat; (iv) number of locations or subpopulations; (v) number of mature individuals			
(c) Extreme fluctuations in any of: (i) extent of occurrence; (ii) area of occupancy; (iii) number of locations or subpopulations; (iv) number of mature individuals			

Evidence:

Eligible under Criterion 2 B2 (a),(b)(i-v) for listing as Vulnerable

The extent of occurrence is estimated at 159 706 km², and the area of occupancy estimated at 444 km². These figures are based on the mapping of point records from 1995 to 2015, obtained from state governments, museums and CSIRO. The EOO was calculated using a minimum convex hull, and the AOO calculated using a 2x2 km grid cell method, based on the IUCN Red List Guidelines 2014 (DotE 2015a). Mapped point records from 1965 to 1995, which give an EOO of 275 946 km² and an AOO of 1256 km² (DotE 2015a), show that the historical distribution was much larger assuming the survey effort and spatial pattern of search has not changed. Hence the EOO is likely to be within a plausible range of 160 000 to 276 000 km² and the AOO is likely to be no less than 444 km² and possibly as high as 1256 km². Woinarski et al. (2014) noted that their estimate of 428 km² for the AOO is likely to be a significant under-estimate due to limited sampling across the occupied range, and considered that the AOO is likely to be greater than 2000 km²; however, this is substantially greater than historical records suggest.

The EOO and AOO are continuing to decline, and there is also evidence of a continuing decline in population size and habitat quality (see Criterion 1). The broad-toothed rat (mainland) occurs at more than 10 locations, but the distribution is severely fragmented with isolated subpopulations in the Otway Ranges, Wilsons Promontory, Dandenong Ranges, far East Gippsland, Barrington Tops, south-eastern New South Wales, and scattered across the Great Dividing Range from near Warburton (Victoria) to the Brindabella Range (Australian Capital Territory)(Woinarski et al., 2014).

The Committee considers that the subspecies' area of occupancy is limited, and a decline in the extent of occurrence, area of occupancy, habitat, number of subpopulations and number of individuals may be inferred or projected. Therefore, the subspecies has met the relevant elements of Criterion 2 to make it eligible for listing as Vulnerable.

Criterion 3. Population size and decline			
	Critically Endangered Very low	Endangered Low	Vulnerable Limited
Estimated number of mature individuals	< 250	< 2,500	< 10,000
AND either (C1) or (C2) is true			
C1 An observed, estimated or projected continuing decline of at least (up to a max. of 100 years in future)	Very high rate 25% in 3 years or 1 generation (whichever is longer)	High rate 20% in 5 years or 2 generation (whichever is longer)	Substantial rate 10% in 10 years or 3 generations (whichever is longer)
C2 An observed, estimated, projected or inferred continuing decline AND its geographic distribution is precarious for its survival based on at least 1 of the following 3 conditions:			
(a) (i) Number of mature individuals in each subpopulation	≤ 50	≤ 250	≤ 1,000
(a) (ii) % of mature individuals in one subpopulation =	90 – 100%	95 – 100%	100%
(b) Extreme fluctuations in the number of mature individuals			

Evidence:

Insufficient data to determine eligibility

There are no robust estimates of total population size, nor that of most subpopulations, of the broad-toothed rat (mainland). In suitable habitat numbers may attain relatively high densities: the density of one subpopulation in Kosciusko National Park was 12.1 individuals per hectare (range 8–19/ha) during a 12 year period (Happold 1989, 1998). However, most sources consider the subspecies to be scarce and patchily distributed: Seebeck and Menkhorst (2000) noted that it was 'generally rare and localised, but may be locally common in appropriate habitat'; Happold (2008) considered it 'sparse to common'; and Menkhorst et al. (2008) considered it 'not a common species'. Woinarski et al. (2014) consider that the population size is 'probably substantially > 10 000 mature individuals.'

The Committee considers that there is insufficient information to determine the eligibility of the subspecies for listing in any category under this criterion.

Criterion 4. Number of mature individuals			
	Critically Endangered Extremely low	Endangered Very Low	Vulnerable Low
Number of mature individuals	< 50	< 250	< 1,000

Evidence:

Not eligible

There are no robust estimates of total population size, nor that of most subpopulations, of the broad-toothed rat (mainland). However, Woinarski et al. (2014) consider that the population size is 'probably substantially > 10 000 mature individuals.'

The Committee considers that the total number of mature individuals is not extremely low, very low or low. Therefore, the subspecies has not met this required element of this criterion.

Criterion 5. Quantitative Analysis			
	Critically Endangered Immediate future	Endangered Near future	Vulnerable Medium-term future
Indicating the probability of extinction in the wild to be:	≥ 50% in 10 years or 3 generations, whichever is longer (100 years max.)	≥ 20% in 20 years or 5 generations, whichever is longer (100 years max.)	≥ 10% in 100 years

Evidence:

Not eligible

Population viability analysis has not been undertaken.

Conservation Actions

Recovery Plan

The Committee recommends that there should not be a recovery plan for *Mastacomys fuscus mordicus* (broad-toothed rat (mainland)), as approved Conservation Advice provides sufficient direction to implement priority actions and mitigate against key threats.

Primary Conservation Actions

1. Implement predator control programs.
2. Maintain and protect habitat, including reducing the frequency of extensive and intense fires, and reducing the impacts of livestock and feral herbivores.

Conservation and Management Actions

There are no species-specific management actions in place for the broad-toothed rat (mainland). However, much of its current range lies within conservation reserves, including Kosciuszko National Park, Barrington Tops National Park, Victoria's Alpine National Park, Wilsons Promontory National Park and Great Otway National Park (Menkorst et al., 2008). Management plans have been developed for these reserves, and some include intensive and extensive management of threats to the subspecies such as predator control programs (Menkorst et al., 2008). This subspecies has also been the subject of a series of intensive research studies and some monitoring.

Other plans that will benefit the broad-toothed rat (mainland) include:

- the Threat Abatement Plan and background document for predation by the European red fox (DEWHA 2008a,b).
- the Threat Abatement Plan and background document for predation by feral cats (DotE 2015b,c).

Recommended management actions are outlined in the table below (Woinarski et al., 2014).

Theme	Specific actions	Priority
Active mitigation of threats	Implement control mechanisms for non-native predators, that minimise adverse impacts on this subspecies.	High
	Undertake landscape-scale fire management, including ignition surveillance and rapid response on extreme fire-weather days, to decrease the incidence of extensive and intense fire.	High
	Constrain grazing by livestock and feral herbivores to within acceptable limits in and around important subpopulations.	Medium-high
	Control or eradicate woody weeds in and around important subpopulations.	Low-medium
Captive breeding	Maintain a captive breeding colony.	Low
Quarantining isolated populations	N/a	
Translocation	Reintroduce to parts of its former range, once threat management is effective.	Low
Community engagement	Seek conservation covenants on private land holding important subpopulations.	Low-medium

Survey and monitoring priorities

Theme	Specific actions	Priority
Survey to better define distribution	Assess population size (or relative abundance) of all subpopulations, and then prioritise subpopulations for management.	High
	Undertake a targeted survey of all suitable habitat within the subspecies' range.	Low-medium
Establish or enhance monitoring program	Design an integrated monitoring program across subpopulations, linked to an assessment of management effectiveness.	Medium-high
	Monitor the abundance of feral predators at key subpopulations, in response to management actions.	Medium-high
	Monitor the incidence of fire, and vegetation response, at key subpopulations.	Medium-high

Information and research priorities

Theme	Specific actions	Priority
Assess relative impacts of threats	Assess the impacts of feral predators (under different densities and seasonal conditions).	High
	Assess the impacts of livestock and feral herbivores, and develop thresholds for safe grazing pressure.	High
	Assess the impacts of fire, and identify fire regimes that are compatible with persistence of populations.	Medium
	Assess the impacts of competition with other native rodents.	Medium (in Barrington Tops area; K. Green pers. comm., cited in Woinarski et al., 2014)

Assess relative effectiveness of threat mitigation options	Assess the efficacy of a range of management regimes for non-native predators.	High
	Assess the efficacy of a range of management regimes for weeds.	Medium
	Identify options for management control of other native rodents, if necessary.	Low
Resolve taxonomic uncertainties	N/a	
Assess habitat requirements	N/a	
Assess diet, life history	N/a	
Undertake research to develop new, or enhance existing, management mechanisms	Develop broad-scale, targeted feral cat control methods.	High

Recommendations

- (i) The Committee recommends that the list referred to in section 178 of the EPBC Act be amended by **including** in the list in the Vulnerable category:
- Mastacomys fuscus mordicus*
- (ii) The Committee recommends that there not be a recovery plan for this subspecies.

Threatened Species Scientific Committee

2/3/2016

References cited in the advice

Australian Museum (2014). Animal species: broad-toothed rat. Viewed: 20 February 2014. Available on the Internet at: <http://australianmuseum.net.au/broad-toothed-rat>

Bilney, R. J., Cooke, R., & White, J. G. (2010). Underestimated and severe: small mammal decline from the forests of south-eastern Australia since European settlement, as revealed by a top order predator. *Biological Conservation* 143, 52-59.

Bubela, T. M., & Happold, D. C. D. (1993). The social organisation and mating system of an Australian sub-alpine rodent, the Broad-toothed Rat *Mastacomys fuscus* (Thomas). *Wildlife Research* 20, 405-417.

Bubela, T. M., Happold, D. C. D., & Broome, L. S. (1991). Home range and activity in the Broad-toothed Rat *Mastacomys fuscus*, in subalpine heathland. *Wildlife Research* 18, 39-48.

Carron, P. L., Happold, D. C. D., & Bubela, T. M. (1990). Diet of two sympatric subalpine rodents, *Mastacomys fuscus* and *Rattus fuscipes*. *Australian Wildlife Research* 17, 479-489.

Department of the Environment (DotE) (2015a). Area of Occupancy and Extent of Occurrence for *Mastacomys fuscus mordicus*. Unpublished report, Australian Government Department of the Environment, Canberra.

- Department of the Environment (DotE) (2015b). Threat abatement plan for predation by feral cats. Canberra: DotE. Available on the Internet at: <http://www.environment.gov.au/biodiversity/threatened/publications/tap/threat-abatement-plan-feral-cats>
- Department of the Environment (DotE) (2015c). Background document for the threat abatement plan for predation by feral cats. Canberra: DotE. Available on the Internet at: <http://www.environment.gov.au/biodiversity/threatened/publications/tap/threat-abatement-plan-feral-cats>
- Department of the Environment, Water, Heritage and the Arts (DEWHA) (2008a). Threat abatement plan for predation by the European red fox. Canberra: DEWHA. Available on the Internet at: <http://www.environment.gov.au/biodiversity/threatened/publications/tap/predation-european-red-fox>
- Department of the Environment, Water, Heritage and the Arts (DEWHA) (2008b). Background document for the threat abatement plan for predation by the European red fox. Canberra: DEWHA. Available on the Internet at: <http://www.environment.gov.au/biodiversity/threatened/publications/tap/predation-european-red-fox>
- Fusco D. A., McDowell, M. C. & Prideaux, G. J. (2015). Late-Holocene mammal fauna from southern Australia reveals rapid species declines post-European settlement: Implications for conservation biology. *The Holocene*. December 18, 2015, DOI: 10.1177/0959683615618261. Available online at: <http://hol.sagepub.com>.
- Green, K. (2002). Selective predation on the broad-toothed rat *Mastacomys fuscus* (Rodentia: Muridae) by the introduced red fox *Vulpes vulpes* (Carnivora: Canidae) in the Snowy Mountains. *Austral Ecology* 27, 353-359.
- Green, K. (2011). Is the altitudinal distribution of the Broad-toothed rat in Tasmania a result of the effects of Bennett's Wallaby? *Australian Zoologist* 35, 770-773.
- Green, K., & Osborne, W. S. (2003). The distribution and status of the Broad-toothed Rat *Mastacomys fuscus* (Rodentia: Muridae) in New South Wales and the Australian Capital Territory. *Australian Zoologist* 32, 229-237.
- Green, K., Stein, J. A., & Driessen, M. M. (2008). The projected distribution of *Mastacomys fuscus* and *Rattus lutreolus* in south-eastern Australia under a scenario of climate change: potential for increased competition? *Wildlife Research* 35, 113-119.
- Green, R. H. (2007). *The Fauna of Tasmania: Mammals*. Potoroo Publishing, Launceston.
- Happold D. C. D. (1989a). The value of faecal pellets for ascertaining the presence of *Mastacomys fuscus* in field surveys. *Victorian Naturalist* 106, 41-43.
- Happold, D. C. D. (1989b). Small mammals of the Australian Alps. In *The Scientific Significance of the Australian Alps* (ed. R. Good), pp. 221-239. Australian Academy of Science, Canberra.
- Happold, D. C. D. (1998). The subalpine climate at Smiggin Holes, Kosciusko National Park, Australia, and its influence on the biology of small mammals. *Arctic and Alpine Research* 30, 241-251.
- Happold, D. C. D. (2008). Broad-toothed Rat *Mastacomys fuscus*. In *The Mammals of Australia*. Third edition. (Eds S. Van Dyck & R. Strahan), pp. 589-591. Reed New Holland, Sydney.

- Happold, D. C. D. (2011). Reproduction and ontogeny of *Mastacomys fuscus* (Rodentia, Muridae) in the Australian Alps and comparisons with other mammals living in alpine communities. *Mammalian Biology* 76, 540-548.
- Hocking, G. J., & Driessen, M. M. (2000). Status and conservation of the rodents of Tasmania. *Wildlife Research* 27, 371-377.
- Menkhorst, P. W. (1995). Broad-toothed Rat. In *Mammals of Victoria* (ed. P. W. Menkhorst), pp. 208-210. Oxford University Press, Melbourne.
- Menkhorst, P., Denny, M., Ellis, M., Driessen, M., Broome, L., & Dickman, C. (2008). *Mastacomys fuscus*. In 'IUCN red list of threatened species.' Version 2012.1. Viewed 4 July 2012. Available on the Internet at: <http://www.iucnredlist.org>.
- Milner, R. N. C., Starrs, D., Hayes, G. & Evans, M. C. (2015). Distribution and habitat preference of the broad-toothed rat (*Mastacomys fuscus*) in the Australian Capital Territory, Australia. *Australian Mammalogy* 37, 125-131.
- NSW Department of Environment and Conservation (NSW DEC) (2007). Draft Recovery Plan for the Barrington Tops Broad-toothed Rat Endangered Population. Sydney.
- O'Brien, C. M., Crowther, M. S., Dickman, C. R., & Keating, J. (2008). Metapopulation dynamics and threatened species management: why does the broad-toothed rat (*Mastacomys fuscus*) persist? *Biological Conservation* 141, 1962-1971.
- Seebeck, J. H. (1971). Distribution and habitat of the broad-toothed rat *Mastacomys fuscus* Thomas (Rodentia, Muridae) in Victoria. *Victorian Naturalist* 88, 310-323.
- Seebeck, J. H., & Menkhorst, P. W. (2000). Status and conservation of the rodents of Victoria. *Wildlife Research* 27, 357-369.
- Victorian Scientific Advisory Committee (Vic SAC) (2012). Final Recommendation on a nomination for listing: Broad-toothed Rat *Mastacomys fuscus* (Nomination no. 829). Flora and Fauna Guarantee Scientific Advisory Committee. Department of Sustainability & Environment, Melbourne.
- Wallis, R. L., Brunner, H., & Menkhorst, P. W. (1982). Victorian field studies on the broad-toothed rat (*Mastacomys fuscus* Thomas). *Victorian Naturalist* 99, 12-21.
- Woinarski, J. C. Z., Burbidge, A. A., & Harrison, P. L. (2014). *The Action Plan for Australian Mammals 2012*. CSIRO Publishing, Collingwood.

Other sources cited in the advice

- Rowe & Shipway (2015). Evidence for the listing eligibility of *Mastacomys fuscus mordicus* (broad-toothed rat (mainland)). Submission to the Department of the Environment. Received 25 November 2015.
- Victoria Flora and Fauna Guarantee – Scientific Advisory Committee (Vic SAC) (2015). Submission on the EPBC Act assessment of the broad-toothed rat. Received 25 November 2015.