The Minister approved this conservation advice and transferred this species from the Vulnerable to Endangered category, effective from 07/12/2016

Conservation Advice

Pseudomys shortridgei

heath mouse

Taxonomy

Conventionally accepted as *Pseudomys shortridgei* (Thomas 1907).

Cooper et al. (2003) reported that there is only limited genetic difference between extant subpopulations from south-eastern and south-western Australia. A subsequent study using microsatellite and mitochondrial DNA identified differences, and proposed that the species comprises two highly-divergent lineages either side of the Nullarbor Plain that should be defined as separate Evolutionary Significant Units (Salinas et al., 2009). However, no subspecies have been formally described.

Summary of assessment

Conservation status

Endangered: Criterion 2 B2 (b)(ii,iii,iv,v),(c)(iv)

Pseudomys shortridgei was listed as Vulnerable under the predecessor to the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), the Endangered *Species Protection Act 1992* (ESP Act), and transferred to the EPBC Act in July 2000. For a species to be considered as Vulnerable under the ESP Act, the Minister must have been satisfied that the species was likely to become endangered within the next 25 years.

Following a formal review of the listing status of *Pseudomys shortridgei*, the Threatened Species Scientific Committee (the Committee) has determined that there is sufficient evidence to support a change of status of the species under the EPBC Act from Vulnerable to Endangered.

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 reassess the listing status of *Pseudomys shortridgei*.

Public consultation

Notice of the proposed amendment and a consultation document was made available for public comment for 32 business days between 29 February 2016 and 15 April 2016. Any comments received that were relevant to the survival of the species were considered by the Committee as part of the assessment process.

Species information

Description

The heath mouse is a small rodent native to Australia. It grows to a weight of 55–90 g and a head and body length of 95–120 mm. The tail is hairy, non-annulated and 85–100 mm in length,

with a distinct bicoloured pattern of dark above and white below. The body is quite stocky and the head is relatively large, with a blunt face, bulging eyes and relatively large, rounded ears. The coat has long black guard hairs and brown underfur, giving it a brindled appearance. The underparts are pale grey or white and the upper surfaces of the feet are covered with long grey hairs. Juveniles have a more sleek appearance than adults (Meulman 1997; Menkhorst & Knight 2010).

Distribution

The heath mouse is endemic to Australia. Sub-fossil records indicate the species historically occurred across the south-west of Western Australia to south-eastern Australia (Lee 1995; Cancilla & Johnson, 2006; Woinarski et al., 2014). In the south-west of Western Australia and South Australia, sub-fossils indicate the species was widespread from near Shark Bay to the southern edge of the Nullarbor Plain (Menkhorst et al., 2008); extending into South Australia including Eyre Peninsula (McDowell 1997; McDowell & Medlin 2010), Yorke Peninsula (McDowell et al., 2012), near Adelaide (Cooper et al., 2003) and Naracoorte Ranges (Kemper et al., 2010).

The population of the heath mouse is decreasing (Menkhorst & Morris 2008). The species is now restricted to a small number of locations in Western Australia, South Australia and Victoria (Lee 1995; Menkhorst et al., 2008).

In Western Australia, the first collection of the species was near Pingelly in the Western Australian wheatbelt (Woinarski et al., 2014). Since 1987, it has been trapped in low numbers in several localities in the southern parts of Western Australia including Reserve No. 31111 (6 km north of Burngup, near Lake Biddy), Dragon Rocks Nature Reserve, Lake Magenta Nature Reserve, Fitzgerald River National Park and the Ravensthorpe Range area (Sanders et al., 2012; WA TSSC 2015).

In Victoria, the Heath Mouse occurs in the Grampians Range and in the Lower Glenelg National Park (Menkhorst et al., 2008; Le Duff et al., 2009). The Grampians National Park is considered a stronghold for the species in Victoria (White pers. comm., 2016).

In South Australia, the species occurs in the Lower Glenelg River Conservation Park (managed by the South Australian Department of Environment, Water and Natural Resources and located adjacent to the Lower Glenelg National Park in Victoria), Dry Creek Native Forest Reserve and Honeysuckle Native Forest Reserve (both managed by ForestrySA) (Bachmann & Haywood 2016). One individual was found on Kangaroo Island in 1967. However, surveys in 1990 (Robinson & Armstrong, 1990) and in 2009 (Jones et al., 2010) did not locate the species. It should be noted that the survey was not directed specifically towards this species (Menkhorst & Morris 2008). The status of the species on Kangaroo Island is unknown.

Relevant biology/ecology

Across its range the heath mouse frequently inhabits species-rich dry heathland, and open woodland and forest habitats with a heath understorey (Seebeck & Menkhorst 2000; Watson et al., 2003). In both the western and eastern subpopulations there appears to be a preference for a structurally complex heath (Cancilla & Johnson 2006).

In Western Australia, the heath mouse has been trapped mostly in species-rich heath but also in mixed scrub and mallee. The species has not been located in vegetation less than 10 years post-fire and it has been known to attain high densities in heath 30 years post-fire (DPAW 2012; Woinarski et al., 2014).

In South Australia, the heath mouse has been captured in open brown stringybark (*Eucalyptus baxteri*) woodland with an understorey dominated by grass tree (*Xanthorrhoea australis*) (Bachmann & Haywood 2016).

In Victoria, the heath mouse is most frequently found in species-rich dry heathland that has been burnt within the last 5−15 years, but it also occurs in dry brown stringybark (*Eucalyptus baxteri*) and desert stringybark (*E. arenacea)* open woodland and open forest with a heath understorey (Cockburn 1978; Meulman 1997). The species is able to exploit heathlands by colonising patches a few years after fire. However, where individuals occur in heathy woodland, they can inhabit much older vegetation, up to 25 years post-fire (Mitchell 2007; Di Stefano et al., 2011; Menkhorst et al., 2008).

The heath mouse is considered a generalist herbivore (Braithwaite et al., 1978). Dietary information is available for the heath mouse in Victoria (DPAW 2012). In late spring and summer, the species' diet consists of flowers, seeds and berries. At the end of summer, the species feeds on the stems, roots and leaves of grasses, sedges and lilies. Following autumn rains, the species feeds on truffle-like fungi (DPAW 2012).

The heath mouse is crepuscular, being active in the late afternoon and early evening, and again in the early morning. The home range of the heath mouse is likely to be associated with food productivity. Radio-tracking has indicated that the home range of the species may be as much as 5.5 ha. Trap monitoring has shown that home ranges are similar between males, females, adults and juveniles (Watson et al., 2003).

The species utilises well defined runways and establishes surface nests or shallow burrows amongst dense ground cover (Menkhorst 1995). Breeding takes place in late spring and summer. Adults form pairs that remain together for the four-month breeding season, producing one or two litters of three young. Longevity is unknown but is unlikely to exceed four years (Menkhorst et al., 2008), and may be less in the wild. Generation length is assumed to be approximately two years (Woinarski et al., 2014).

Studies in the Grampians National Park have shown there is a strong correlation between heath mouse abundance and rainfall. The species responds to rainfall in a 'boom and bust' dynamic. Abundance peaks in a lagged response to pulses of primary productivity associated with high rainfall events, and falls to very low densities during normal drought conditions (Senior 2014). In areas of high vegetation productivity, there is increased juvenile survival and decreased juvenile dispersal (DPAW 2012). Dispersing juveniles are more successful at finding suitable habitat if a mosaic of vegetation patches of differing maturity is available in the landscape (DPAW 2012).

Threats

Table 1 - Threats to the heath mouse.

Threat factor	Threat type	Threat status	Evidence base
Habitat loss, disturbance and modification			
Habitat clearing from agriculture and industry	known	current	There has been widespread clearing of heath mouse habitat across the species' range (Lee 1995; Watson et al., 2003; Menkhorst & Morris 2008). This clearing has resulted in extensive loss of habitat, as well as fragmentation and isolation of remaining habitat, thus limiting the potential for dispersal and genetic exchange. Habitat loss is a threat across a moderate extent of the species' range, and this has severe to catastrophic consequences as the species cannot occur outside natural bush and requires large areas of vegetation (Woinarski et al., 2014).

Fragmentation	known	current	The distribution of the heath mouse is highly fragmented, predominantly due to historic land clearance (Harley et al., 2005). The Western Australia and South Australia subpopulations are separated by the Nullarbor Plain (Salinas et al., 2009) and the South Australia subpopulations are largely isolated from Victorian subpopulations (Bachmann & Haywood 2016). Habitat in Western Australia and Victoria is fragmented and habitat in South Australia is severely fragmented (Bachmann & Haywood 2016). There is very limited dispersal between subpopulations as a result of fragmentation. Other threats, such as weed incursion, exacerbate the threat of fragmentation, making the species is prone to localised extinction (Bachmann & Haywood 2016).
Fire			
Increased fire frequency and intensity	known	current	The heath mouse preferentially inhabits vegetation of certain post-fire ages (5−30 years) (Woinarski et al., 2014). Altered fire regimes are a threat across the entire extent of the species' range (Woinarski et al., 2014), however, future fire regimes are uncertain. It is considered that multiple high-intensity fires within several years during a drought period would severely impact the ability of the heath mouse to recover and persist (Senior 2014). Large-scale and frequent bushfires can also result in increased predation by introduced species due to loss of dense vegetation cover (Russel et al., 2003). A catastrophic bushfire in a long unburnt site is likely to cause a significant loss of habitat for a subpopulation, decrease habitat patchiness and limit areas for dispersal (Bachmann & Haywood 2016).
Invasive species			
Predation by cats (*Felis catus*)	suspected	current	It is likely that predation by cats is a current threat to the species across the entire extent of the species' range, however the extent of the threat is unknown (Lee 1995; Watson et al., 2003).
Predation by foxes (*Vulpes vulpes*)	suspected	current	It is likely that predation by foxes is a current threat to the species across a large extent of the species' range, however the extent of the threat is unknown (Lee 1995; Watson et al., 2003). Fox control can lead to increased cat abundance, which may threaten the heath mouse through increased predation by cats (Bachmann & Haywood 2016). Fox control has been found to lead to increased brushtail possum abundance and altered behaviour (increased time on ground) in the Lower Glenelg National Park which may increase competition with the heath mouse (Bachmann & Haywood 2016).

Habitat degradation by *Phytophthora cinnamomi*	suspected	current	*Phytophthora* is a threat across some of the species' range (Woinarski et al., 2014). *Phytophthora cinnamomi* may have a significant impact on the heath mouse as it is dependent upon species-rich and structurally complex heath communities, and most sites where the heath mouse occurs are dominated by plants susceptible to *Phytophthora* (Menkhorst 2012). Infection could potentially lead to dieback of heathland flora (Watson et al., 2003). *Phytophthora cinnamomi* in the area surrounding Kentbruck Heath in Victoria may have contributed to the loss of the heath mouse in that area (Watson et al., 2003).
Habitat degradation by invasive plant species	known	current	Incursion of species such as golden wattle (*Acacia longifolia* species), radiata pine (*Pinus radiata),* bluebell creeper *(Billardiera heterophylla),* bitou bush *(Chrysanthemoides monilifera)* and bridal creeper (*Asparagus asparagoides)* alters the composition of heath mouse habitat by simplifying understorey structure and altering soil nutrient characteristics, making it unsuitable for the species (Bachmann & Haywood 2016).
Native species			
Competition with brushtail possums (*Trichosurus vulpecula*)	potential	current	In response to fox control, brushtail possums have been found to increase in abundance and increase terrestrial foraging. Competition for resources with brushtail possums may threaten the heath mouse by causing a contraction in occupancy (Bachmann 2013; Bachmann & Haywood 2016). The threat of competition with native species on the heath mouse is suspected but has not been demonstrated. Further research is required to resolve the uncertainty.
Climate change			
Drying climate (increased occurrence and longevity of drought)	known	current / future	Climate change is a key threat to the heath mouse because the species' abundance is related to rainfall (Senior 2014). Annual rainfall has declined in south-west Western Australia and western Victoria and is predicted to decline further (Hughes 2003). Western Victoria is currently in a 'drought cycle' and heath mouse abundance is currently declining and expected to continue to decline (Senior 2014). Drought events have caused a contraction in the range of the heath mouse (White pers. comm., 2016). An increased frequency of drought events will reduce the ability of the heath mouse and its habitat to recover from wildfire events (Senior 2014). A drying climate is likely to drive population density down with predation exerting a greater pressure on the species during such periods (White pers. comm., 2016).

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%**

A1 Population reduction observed, estimated, inferred or suspected in the past and the causes of the reduction are clearly reversible AND understood AND ceased.

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.

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*]

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.

based on any of the following:

(a) direct observation [*except A3*]

(b) an index of abundance appropriate to the taxon

(c) a decline in area of occupancy, extent of occurrence and/or quality of habitat

(d) actual or potential levels of exploitation

(e) the effects of introduced taxa, hybridization, pathogens, pollutants, competitors or parasites

Evidence:

Insufficient data to determine eligibility

Monitoring and survey data in Western Australia, South Australia and Victoria indicate that the heath mouse population is undergoing population decline and range retraction. This decline is demonstrated through substantial reductions in recapture rate and lack of captures in previously occupied habitat.

For example, in Western Australia, the Lake Magenta subpopulation was monitored during 2004−2009, and a steady decline in abundance and distribution was observed (WA TSSC 2015). In South Australia, monitoring at Dry Creek Native Forest Reserve and Lower Glenelg River Conservation Park in 2013 and 2015 did not record the heath mouse, despite these sites being previously occupied by the species in 2004 (Bachmann 2016). Similarly, in Victoria, Hill (2005) surveyed 16 historic sites in the Wimmera but the species was not recorded. Morris (2007) only trapped 13 individuals in woodland west of Casterton over 5000 trap nights targeting the species, despite the species being recorded as common in the 1970s.

Woinarski et al. (2014) consider that the reduction in population size for the species is likely to be less than 30 percent over a ten year period.

Although the available information suggests there is decline, the data are insufficient to estimate population size or the rate of decline. Therefore, the Committee considers that there is insufficient information to determine the eligibility of the species for listing in any category under this criterion.

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 (b)(ii,iii,iv,v),(c)(iv) for listing as Endangered

Based on the mapping of point records from 1996 to 2016, obtained from state governments, museums and CSIRO, the extent of occurrence is estimated at 337 570 km^2, and the area of occupancy estimated at 328 km^2. The extent of occurrence was calculated using a minimum convex hull, and the area of occupancy calculated using a 2x2 km grid cell method, based on the IUCN Red List Guidelines 2014 (DotE 2015). Similarly, Woinarski et al. (2014) estimated the area of occupancy to be 316 km^2.

There is evidence demonstrating that the heath mouse is continuing to decline in area of occupancy, quality of habitat, number of subpopulations and number of mature individuals (see Criterion 1).

The species is considered severely fragmented in Western Australia (WA TSSC 2015) and South Australia (DEWNR 2016), but may not be in Victoria.

Woinarski et al. (2014) assessed the number of locations to be greater than 10, but WA TSSC (2015) assessed this number to be 8. However, given that the effects of climate change (which are predicted to be severe for this species: Senior 2014; White pers. comm., 2016) are likely to affect the entire Western Australian part of the distribution at the same time, and/or the entire eastern (South Australia and Victoria) part of the distribution at the same time, the number of locations could be two. Given the range of possibilities, the Committee considers that the number of locations is very likely less than 10, and possibly less than 5.

Woinarski et al. (2014) considers that the species does not undergo extreme fluctuations. However, other authors have noted that the heath mouse is a 'boom and bust' species and numbers fluctuate with rainfall and productivity (Senior 2014). Monitoring of the heath mouse in the Grampians National Park found that there was a greater than ten-fold increase in heath mouse abundance between 2008 and 2012 (with 2010/11 being a high rainfall period) followed by a five-fold decrease between 2012 and 2014 (Senior 2014). From this information, it may be inferred that extreme fluctuations do occur in this species in response to variation in fire impacts and rainfall.

The Committee considers that the species' area of occupancy is restricted, the geographic distribution is precarious for the survival of the species because its area of occupancy, quality of habitat, number of subpopulations and number of mature individuals are continuing to decline, the species is severely fragmented across at least part of its range, it may occur in fewer than 5 locations, and the population can undergo extreme fluctuations. Therefore, the species has

been demonstrated to have met the relevant elements of Criterion 2 to make it eligible for listing as Endangered.

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**
	(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 overall population size, and as such, the rate of population decline cannot be estimated. In 2008, Menkhorst & Morris (2008) estimated that there were approximately 4000 individuals at the Lake Magenta Nature Reserve, and considered the heath mouse to be common in limited habitat in Victoria. By extrapolation, it was inferred that there were more than 10 000 mature individuals at the time. However, given there is evidence of decline, the current population may be smaller. It is considered that some subpopulations are likely to exceed 1000 mature individuals, based on earlier survey results. The species is likely to undergo extreme fluctuations.

The Committee considers that there is insufficient information to determine the eligibility of the species 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:

Insufficient data to determine eligibility

There are no robust estimates of population size for the heath mouse.

The Committee considers that there is insufficient information to determine the eligibility of the species for listing in any category under 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:

Insufficient data to determine eligibility

Population viability analysis has not been undertaken for the heath mouse.

Conservation actions

Recovery plan

There is no national recovery plan or monitoring program currently in place for the species. The majority of land on which the heath mouse is known to occur is within conservation estate, which is managed by state conservation agencies. Management and research activities are being undertaken at state and local levels.

The Committee recommends that there should not be a recovery plan for *Pseudomys shortridgei* (heath mouse), as approved Conservation Advice provides sufficient direction to implement priority actions, mitigate key threats and enable recovery.

Primary conservation actions

1. Prevent further loss and degradation of habitat.
2. Maintain and increase habitat connectivity between subpopulations.

Conservation and management priorities

Habitat loss, disturbance and modifications

- Establish biodiversity corridors between habitat patches of known subpopulations and/or suitable habitat by undertaking habitat restoration, where appropriate, to increase connectivity and dispersal.

- Develop and implement appropriate methods for increasing the amount of suitable habitat for the heath mouse to disperse through.

Fire

- Fires must be managed to ensure that prevailing fire regimes do not disrupt the life cycle of the heath mouse, that they support rather than degrade the habitat necessary to the heath mouse, that they do not promote invasive species, and that they do not increase predation or disease (for example, *Phytophthora*).
- Ensure that a high proportion of habitat is maintained with a post-fire age sufficient to provide adequate cover for the heath mouse.
- Physical and chemical damage (such as use of fire retardants) to habitat and individuals of the heath mouse must be avoided during and after fire operations.
- Fire management authorities and land management agencies should use suitable maps and install fire markers to avoid damage to threatened species and their habitat.
- Ensure immediate and ongoing post-fire predator control within known habitat when fire events occur.

Invasive species

- Undertake weed control at infested sites, occupied or potentially occupied by the heath mouse, using appropriate methods.
- Implement an integrated control program for foxes and cats, using baiting methods, to control predator abundance at known sites.

Stakeholder Engagement

- Liaise with organisations which have undertaken, or are currently undertaking, research for the heath mouse including the Nature Glenelg Trust and Deakin University.
- Liaise with co-regulators to ensure appropriate management activities are undertaken within state government jurisdictions to manage threats to heath mouse subpopulations, including:
  - Victoria Government Department of Environment, Land, Water and Planning
  - Parks Victoria
  - South Australian Government Department of Environment, Water and Natural Resources
  - ForestrySA
  - Western Australian Government Department of Parks and Wildlife.
- Engage with local communities to promote conservation of habitat for the heath mouse.

Survey and monitoring priorities

- Survey across the species' range to establish current distributional status of the heath mouse in Western Australia, South Australia and Victoria.
- Monitor a representative sample of subpopulations to assess subpopulation size and population trends.
- Monitor the progress of conservation actions, including the effectiveness of management actions and adapt them if necessary to contribute to the species' recovery.

Information and research priorities

- Determine the causes of the recent declines in Western Australia and South Australia, including impacts of fire, rainfall variation, and predation by foxes and cats.

- Investigate the response of the heath mouse to different fire regimes, including wildfire, and identify appropriate fire regimes for conserving heath mouse subpopulations.
- Assess the relative impact of threats associated with fox control at known sites, including increased abundance of cats and brushtail possums, to inform management actions.
- Assess effectiveness for heath mouse subpopulations and cost-benefits of alternative methods for controlling invasive species.
- Investigate population fluctuations in relation to climatic variation and fire in different parts of the species' range.
- Investigate responses of the heath mouse to habitat fragmentation at different spatial scales.
- Assess options for increasing area of suitable habitat at known sites.
- Investigate options for linking and enhancing current subpopulations and/or establishing additional populations (e.g. captive breeding and translocation).

Recommendations

(i) The Committee recommends that the list referred to in section 178 of the EPBC Act be amended by **transferring** from the Vulnerable category to the Endangered category:

Pseudomys shortridgei

(ii) The Committee recommends that there not be a recovery plan for this species.

Threatened Species Scientific Committee

06/09/2016

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