The Distribution and Status of the Broad-toothed Rat *Mastacomys fuscus* (*Rodentia: Muridae*) in New South Wales and the Australian Capital Territory

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ABSTRACT

Evidence of viable populations of *Mastacomys fuscus* was found in two areas, the Snowy Mountains region in southern New South Wales (including the higher parts of the Australian Capital Territory), and at Barrington Tops in the north. Evidence of *M. fuscus* was found at 196 of 231 sites at which searches were conducted for faecal remains within the Snowy Mountains region, and at 14 of 27 sites at Barrington Tops. Sites could be classified in six broad habitat types, all having two major components, protection from predators, and grass or sedge to provide food. All sites at which the species was detected were characterised by a mean annual precipitation of >1000mm, a mean annual temperature of <10^{O}C and altitudes >1000m. The presence of *M. fuscus* could not be confirmed at sites at lower elevations. Only populations in the Snowy Mountains region, specifically those above the winter snowline (>1500m), may be considered secure in the short term.

Key words: *Mastacomys*, mountains, alpine, habitat, scats

Introduction

The broad-toothed rat (*Mastacomys fuscus* Thomas, 1882) is strictly herbivorous, feeding primarily on grass at all times of the year (Carron *et al.* 1990). *Mastacomys fuscus* is considered to be a southern hemisphere ecological equivalent of northern hemisphere voles such as *Clethrionomys* and *Microtus* (Calaby and Wimbush 1964; Happold 1989a). Diets are similar, they occupy a seasonally snow-covered environment (though not in all parts of their distribution) and they have a similar home range, but *M. fuscus* is heavier and does not exhibit cyclical population changes (Bubela and Happold 1993). The species was first described from a specimen (at the British Museum) collected in Tasmania. *Mastacomys fuscus* is the only extant member of the genus but, although Baverstock *et al.* (1981) regarded *Mastacomys* as being a valid and distinct genus, others consider it to be a member of the genus *Pseudomys* (Watts *et al.* 1992); later publications have not accepted the synonymy (Menkhorst 1995; Happold 1995).

Mainland records obtained prior to the 1930s were mainly of subfossil skeletal material, with locations ranging from Mount Gambier in South Australia (Thomas 1922), Gippsland in Victoria (Thomas 1922), and the Wellington Caves in New South Wales (Lydekker 1885). Until 1933, only five specimens from living animals were known. In addition to the type specimen from Tasmania there were four specimens from Victoria, one collected in 1892 (Troughton 1973) and three collected in 1918 (Brazenor 1934). However, a partial specimen (a juvenile skin without a skull) from Spencers Creek near Mt. Kosciuszko had been registered with the Australian Museum by A. S. Le Souef in 1923 (Calaby and Wimbush, 1964). Fears were expressed that the species had become extinct until a total of five live specimens was collected at Cradle Valley in Tasmania (Finlayson 1933) and in Gippsland (Brazenor 1934). The species was later found in the Otway Ranges (Seebeck 1976) and Whites River in Kosciuszko National Park (Troughton 1973). Further extensions to its known range were to the Australian Capital Territory (Eberhard and Schulz 1973) and Barrington Tops in northern NSW (Dickman and McKechnie 1985).

Fossil evidence suggests that *M. fuscus* occupied a continuous range throughout south-eastern Australia at the height of the last Pleistocene glacial period, *ca.* 10,000 years ago (Ride 1956) and probably occurred in areas now submerged beneath Bass Strait. Fossil remains have been found in areas that were tussock grassland during the Pleistocene glacial period. Since that time, the range of *M. fuscus* has contracted to its current restricted distribution with the general drying of the Australian environment (Calaby and Wimbush 1964; Watts and Aslin 1981).

The question of the current distribution of *M. fuscus* is important because of the status of this species in southeastern Australia and because it is one species identified as most at risk due to habitat changes resulting from global warming (Busby 1988; Brereton *et al.* 1995). Additionally, *M. fuscus* is preyed upon by the red fox (*Vulpes vulpes* Linnaeus 1758) in seeming preference to the bush rat (*Rattus fuscipes* (Waterhouse 1839)) (Green and Osborne 1981, Green 2002). Green and Osborne (1981) expressed concern that foxes may be reducing the numbers of *M. fuscus*. In Victoria, the species is classified as Lower risk – near Threatened (Natural Resources and Environment 2000) and in New South Wales as Vulnerable, with one of two known populations (at Barrington Tops) under severe threat (Green 2000) and now classified as Endangered. In the ACT, the species has no specially protected status. The present study therefore set out to investigate the range of *M. fuscus* in NSW and the ACT and to determine its status.

Methods

Sixty three sites that provided potential habitat (native grassland and heath) for *M. fuscus* in and adjacent to the ACT were identified from aerial photographs. These sites were each searched for up to 15 minutes for evidence of *M. fuscus* from 1988-1990.

The Atlas of New South Wales Wildlife was examined to determine the general spread of known locations of *M. fuscus* in NSW. All records were investigated and used as a basis for determining locations for detailed searches.

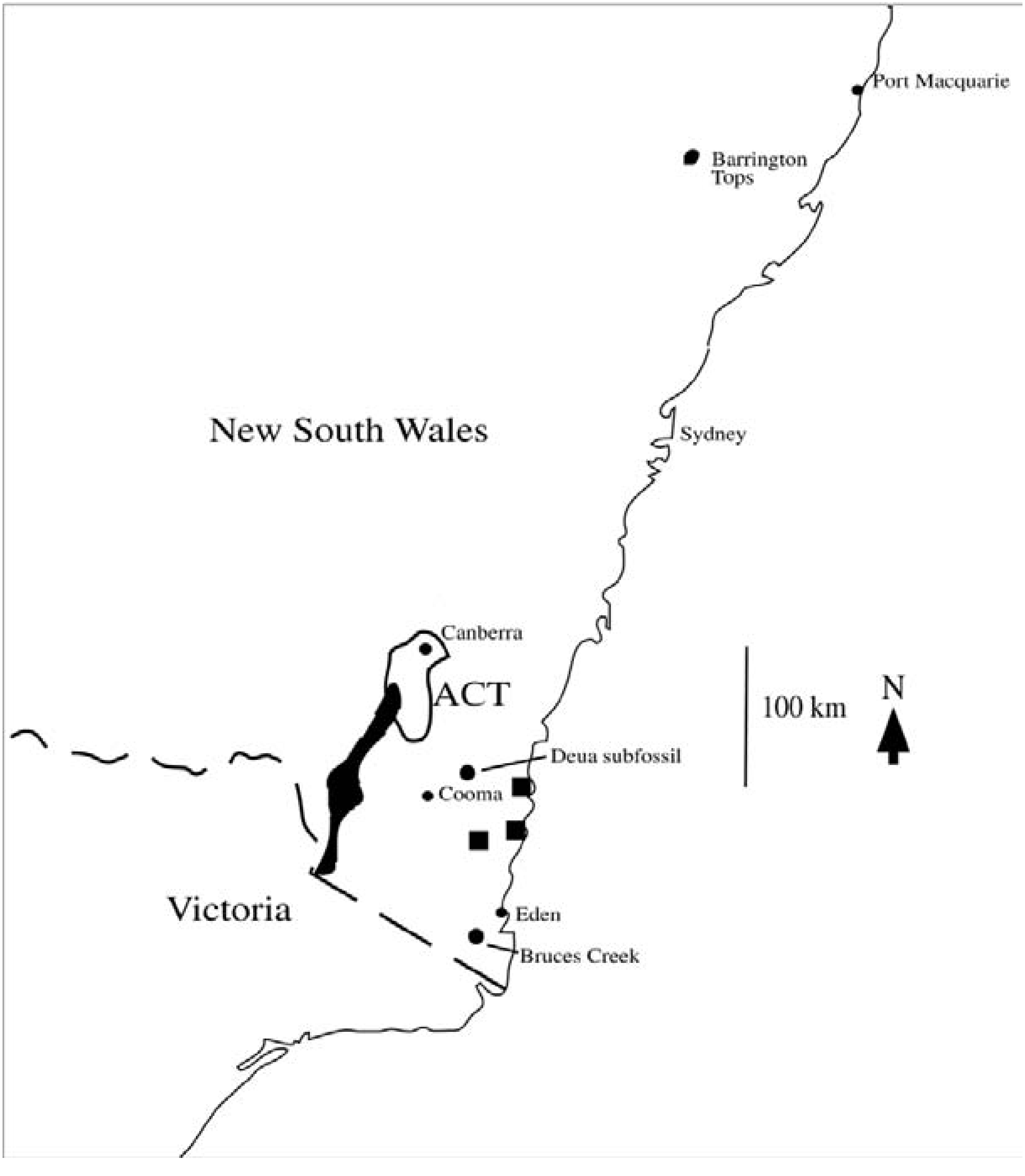

Figure 1. Distribution of *Mastacomys fuscus* in New South Wales and the Australian Capital Territory. The two shaded areas represent the known populations, circles are the two sites where remains were found in owl pellets (one a subfossil) and squares are coastal sites searched without success.

The search in the southern part of NSW was conducted from 1999 to 2001 and was mainly concentrated in the Snowy Mountains region from the Victorian border northwards to the ACT. The search effort was concentrated along the higher ground aligned north-south, with searches at progressively lower elevations to the east and west in apparently suitable habitat until no evidence of *M. fuscus* could be found. At all locations visited, the most suitable habitat for *M. fuscus* was located and, within that habitat, searches were made for scats (following Happold 1989b and Wallis 1992) to determine whether the habitat had been used by *M. fuscus* in the recent past. Scats of *M. fuscus* are easily distinguished from those of sympatric species. They are fibrous, green when fresh, paling to straw-coloured with time, and contain small fragments of undigested grass cuticle and fibre (Happold 1989b). An individual produces 200-400 scats per day which may last for up to five years so that a search for scats is a quick method of determining usage of the habitat by *M. fuscus* (Happold 1989b). The search began at the most likely site within the chosen location. This was usually below spreading shrubs or beside boulders adjacent to grass. Searches were timed from commencement and were terminated after ten minutes if no scats were found. Six sites where *M. fuscus* had been located in the ACT were revisited in 2000 for a timed search for scats.

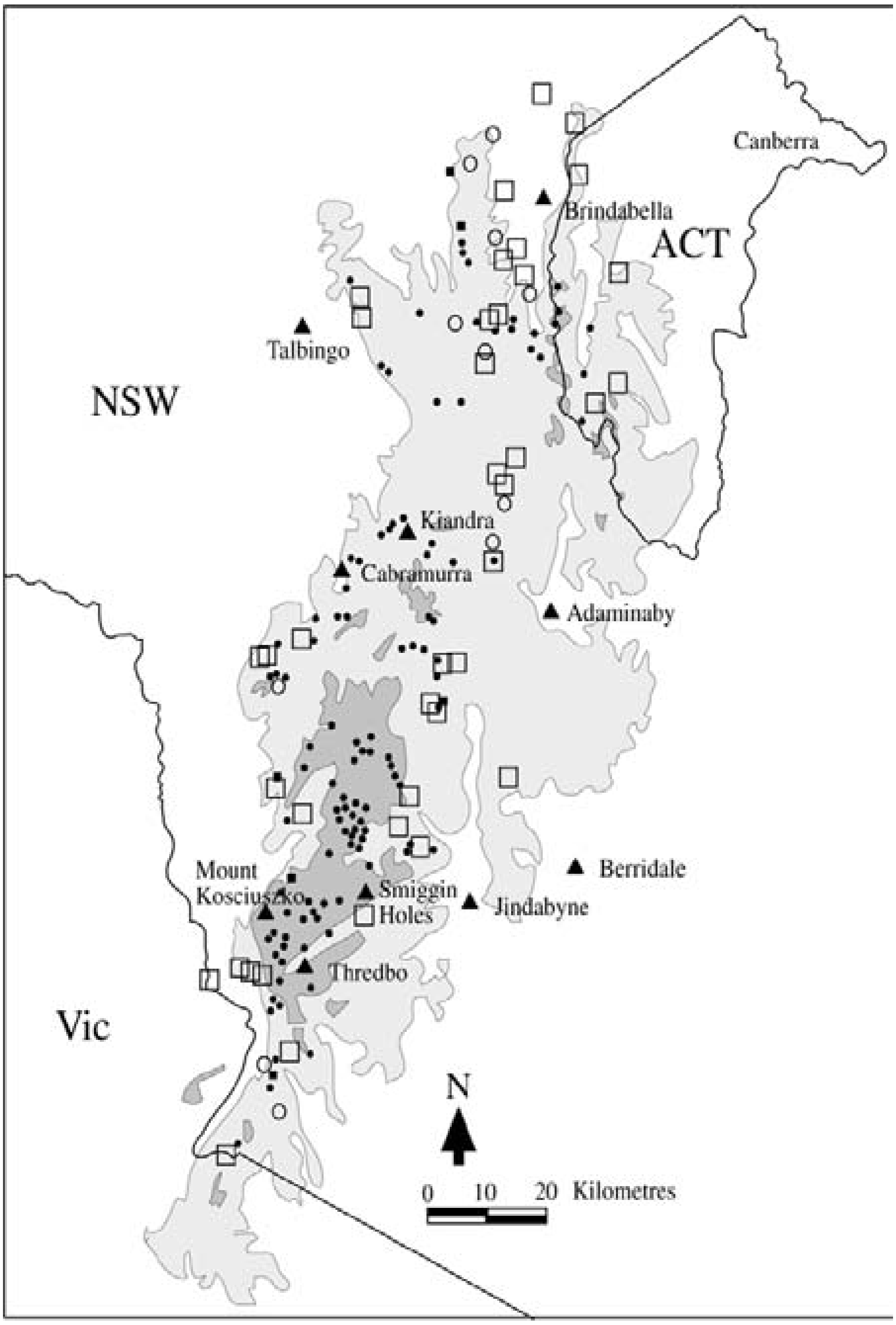

Figure 2a. Distribution of *Mastacomys fuscus* in the Snowy Mountains region in relation to altitude (pale shading >1000m, darker shading >1500m). *Mastacomys fuscus* found in 1-2 minutes (●), 3-4 minutes (❍), 5-10 minutes (■), not found (□).

At Barrington Tops, locations of all previous records of *M. fuscus* were searched in a similar manner, as was a selection of suitable sites distributed across the area. Similar ten-minute searches were conducted at the most suitable sites nearest to putative *M. fuscus* hair sample records in the south coast area of NSW (recorded in the Wildlife Atlas), at the location of the subfossil record at Deua National Park, and within the presumed home range of an owl around a site where evidence of *M. fuscus* was found in an owl pellet at Bruces Creek, south of Eden (Fig. 1).

At each site, the presence or absence of potential food such as grass or sedge was noted and the structural component responsible for most of the cover was recorded. Evidence of the presence of introduced grazing animals was also noted. The locations of all sites were plotted with a hand-held GPS unit. A Geographic Information System was used to plot all sites in relation to altitude. Terrain data were derived using extracted topography on a six minute grid. Data were then analysed using the predictive bioclimatic package BIOCLIM, and rainfall and temperature were modelled and interpolated.

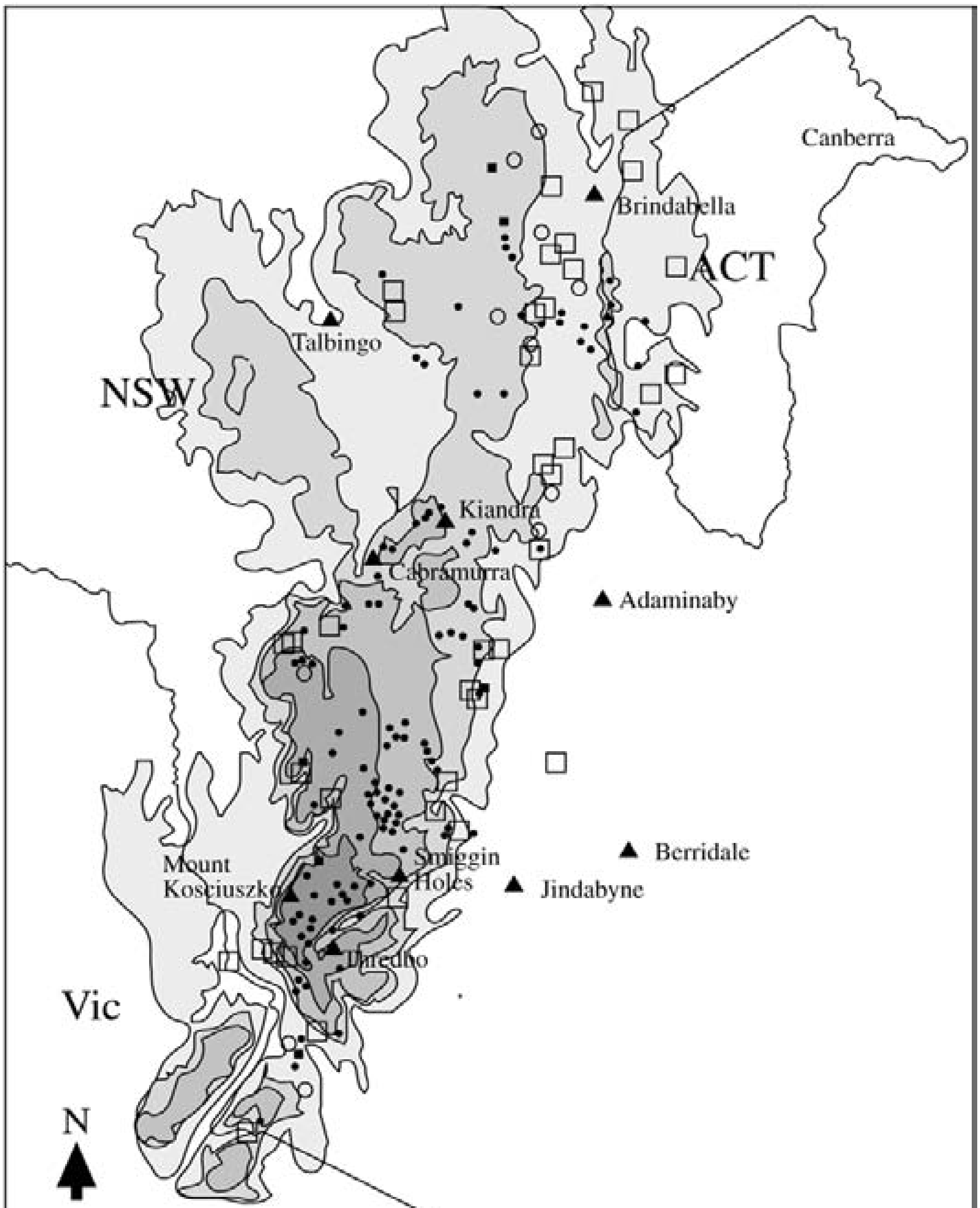

Figure 2b. Distribution of *Mastacomys fuscus* in the Snowy Mountains region in relation to average annual precipitation (lightest shading 1001-1250mm to darkest shading >2000mm in 250mm intervals). Timed searches as in Figure 2a.

Results

Snowy Mountains Region

Evidence of *M. fuscus* was found at 25 of the 63 sites searched in the ACT and adjacent region over the period 1988-1990. Within the Snowy Mountains region generally, over the period 1999 to 2001, the scat search technique proved to be an efficient method of confirming the presence of *M. fuscus* at chosen sites. For those sites at which scats of *M. fuscus* were found within the first minute of searching (79% of all sites), 64% of the first detections were made in the first five seconds. In the timed searches, over the period 1999 to 2001, evidence of *M. fuscus* was found at 196 sites in and adjacent to Kosciuszko National Park including the ACT, Buccleuch State Forest, Bimberi Nature Reserve and Scabby Nature Reserve. No evidence was found at 35 sites. Most records (152) where the presence of *M. fuscus* was confirmed were found within one minute of starting the search, declining to only four records in the last five minutes of a ten minute search. Thus, had timed counts been terminated at five minutes, this technique would have missed only 2% of confirmed sites, suggesting that the probability of *M. fuscus* being present in the 35 sites where evidence could not be found within ten minutes is exceedingly low.

Evidence of *M. fuscus* was found in six broad habitat types at 196 of 231 sites in which searches were conducted. At alpine altitudes, the most common location was in rock outcrops and boulder fields immediately adjacent to grassy

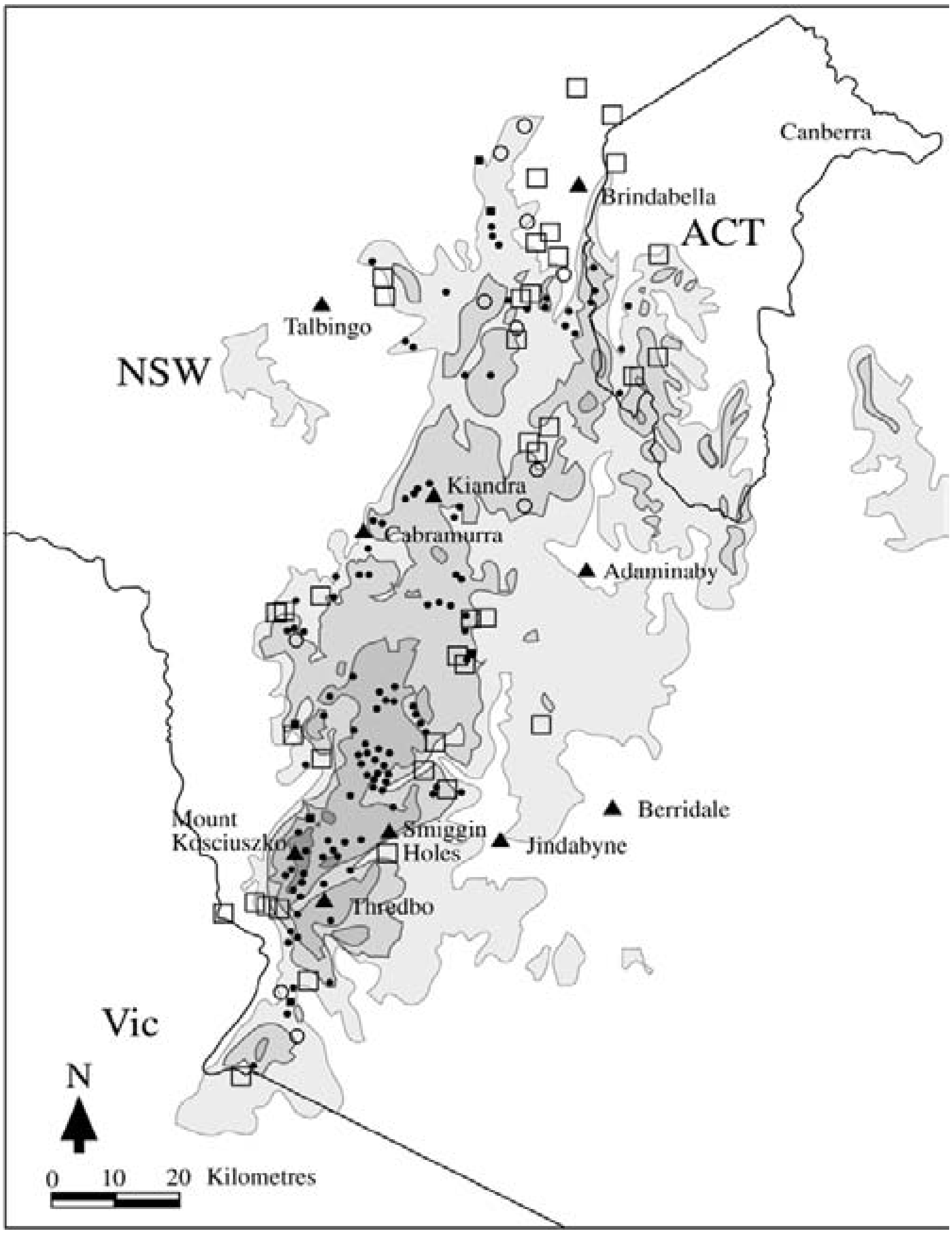

Figure 2c. Distribution of *Mastacomys fuscus* in the Snowy Mountains region in relation to average annual temperature (lightest shading 8-10° to darkest shading <4° in 2° intervals). Timed searches as in Figure 2a.

sites. These constituted 25% of all 196 sites. Other important subalpine and alpine habitats in which scats were found were dry heath, dominated by *Nematolepis ovatifolium,* and wet heath. In lower elevation cold air drainage areas (frost hollows), scats were recorded in *Poa labillardieri* tall tussock grassland, particularly along the banks of streams (e.g. Thredbo Valley and Long Plain in Kosciuszko National Park and Upper Cotter River in the ACT). In the frost hollow grasslands extending to the north of Kosciuszko National Park there was no evidence of *M. fuscus* in the extensive shorter grassland adjacent to this riparian tussock grassland. The two less commonly occurring habitats were open grassland with no summer cover but with protection provided through winter by a cover of snow, and anthropogenic sites. The simplest habitat was at one such anthropogenic site, the metal walkway leading from Thredbo towards the summit of Mt. Kosciuszko. This habitat had just two components for most of its length – grass and cover. There was no evidence of *M. fuscus* on either side of the walkway except where it passed between boulders. Evidence of *M. fuscus* was also found in dense mats of millfoil *Achillea millefolium*.

All sites where evidence of *M. fuscus* was found had a modelled annual average temperature ≤10°C, were at or above 1000m altitude, in areas of >1000mm average annual rainfall (Fig. 2a-c). As the search moved to the limit of these parameters, to lower, drier and warmer sites, the chances of finding evidence of *M. fuscus* were reduced (Fig. 2a-c). The declining success in finding evidence of *M. fuscus* at lower, peripheral sites was also, in part, due to the greater number of larger herbivores. No evidence of rabbits *Oryctolagus cuniculus* or hard- hoofed herbivores was found above 1500m and the vegetative cover appeared pristine. Below 1500m, rabbits had opened up the intertussock spaces on frost hollow plains and to the north of Kosciuszko National Park, hard- hoofed herbivores had also damaged the protective cover. Evidence of *M. fuscus* could be found within metres of the latter sites where hard-hoofed herbivores had been prevented from grazing by fallen trees.

Barrington Tops

Searches for scats confirmed the presence of *M. fuscus* at 14 of 27 sites surveyed at Barrington Tops. These were in the two large swamp complexes on Barrington Tops, Polblue Swamp and the swamps forming the catchment of Barrington River, together with Little Murray Swamp (lying between the two larger complexes). The presence of *M. fuscus* could not be confirmed at sites where they were recorded previously – southwards at Gloucester Tops and north of Polblue Swamp. All sites where the presence of *M. fuscus* was confirmed had a modelled annual average temperature ≤10°C, were at or above 1400m altitude, in areas of >1500mm annual average rainfall. In the Snowy Mountains, scats were found at nearly 40% of sites in two seconds or less compared to only two of the 14 sites at Barrington Tops. These two sites were at Polblue Swamp, where *M. fuscus* was also trapped by Green (2000) and Happold (*pers. comm.* 2000), and at one of the sites where *M. fuscus* was trapped by Dickman and McKechnie (1985).

Deua National Park

No evidence of the presence of *M. fuscus* was found in Deua National Park. The site from which the subfossil was collected is located at 800m altitude, within the band of 10-12°C annual average temperature, with precipitation in the range 750-1000mm.

Coastal Sites

No evidence of the presence of *M. fuscus* was found at any of the sites recorded in the Wildlife Atlas for the south coast area of NSW. These records collected during the Comprehensive Regional Assessment that preceded the Regional Forest Agreement for the south coast area of NSW were of hair samples initially identified as *M. fuscus*. The hair samples originally collected from these locations were subsequently proven to be from *R. fuscipes* and the Atlas records were deleted. However, a jaw and a skull found in owl pellets from Bruces Creek proved to be from *M. fuscus* (Barbara Triggs *pers. comm. 2001*). An intensive search of potential habitat around the Bruces Creek location revealed no other evidence of *M. fuscus*. Bruces Creek is located at 80m altitude, with average annual temperatures >12°C and precipitation in the range 750-1000mm.

Discussion

The presence of scats of *M. fuscus* in an area may say nothing about the present status of the species in the area – the scats may be up to five years old and may only indicate that one or more *M. fuscus* used that habitat within that period (Happold 1989b). The results presented here also do not provide a guide to preferred habitats because sampling sites were not selected randomly, with the most intensive concentration being at higher elevations in habitats such as alpine rock outcrops and heaths. Given the constraints, however, the method has proven to be a quick way of determining potential presence of *M. fuscus* within an area. In the ACT study, 15 minutes had been allotted for the search but the time to find the first scat was not recorded. The ten minutes allotted for each search in NSW appeared adequate, with only 2% of sites being confirmed after five minutes had elapsed and none after nine minutes.

The failure to confirm the previously accepted distribution of *M. fuscus* at Barrington Tops was not a failure of the technique. Dickman and McKechnie (1985) found evidence of *M. fuscus* in a collection of only 20 carnivore scats from Barrington Tops. In 1999, however, there was no evidence of *M. fuscus* in 101 fox scats and 41 dog scats collected from Barrington Tops. Evidence of *Rattus lutreolus* occurred in the area for the first time, in 32% of fox scats and 2.5% of dog scats (Green 2000). Additionally, a further 50 fox scats collected in the two years preceding Green's study also contained no remains of *M. fuscus* (Chris Howard NPWS *pers. comm.* 2000). Given this, failure to find evidence of the presence of *M. fuscus* or to trap it in some areas (Green 2000) was not a result of either the search or trapping technique but may be indicative of a decline in numbers, coincident with the invasion of *R. lutreolus* which was caught on Barrington

Tops for the first time by Green (2000). Competition between *R. lutreolus* and other rodent species, with *R. lutreolus* being the dominant competitor, has been discussed by Haering and Fox (1995) and Maitz and Dickman (2001) among others. However, the present paper presents data sufficient only to document the ingress of *R. lutreolus* rather than the cause of the decline of *M. fuscus*. The situation at Barrington Tops awaits a full study to determine the presence and intensity of competition between *M. fuscus* and *R. lutreolus*.

Seebeck (1971) regarded the diversity of habitats used by *M. fuscus* as making characterisation of the habitat difficult. This view was shared by Carron (1985) who concluded that it was possible that the only necessary conditions for *M. fuscus* were rough microtopography and an abundance of grasses and, where food was not limiting, *M. fuscus* was restricted by structural features. The two microhabitat requirements for *M. fuscus* apparent from the present study are food and protection from predators. All habitats had grass or sedge as an essential component and in the six habitat types that can be distinguished it was only the cover component that differed. In Victoria, *M. fuscus* has also been found in tall open forest of *Eucalyptus regnans*, plantations of *Pinus radiata*, and coastal dune grassland, all with good cover and plentiful food (John Seebeck, NRE*pers. comm. 2001*). The importance of cover was evident in two habitat types. *Mastacomys fuscus* was found to occur at the interface between boulder fields or tors and surrounding grassland and, in the large grassy plains in the northern end of Kosciuszko National Park, occurred only where grass tussock development was sufficient to provide shelter. Evidence of *M. fuscus* could not be found more than a metre from these two forms of cover.

Happold (1995) reported that, throughout its range, habitats of *M. fuscus* range from sea level to 2200m and are characterised by high precipitation, a cool summer, cool to cold winter and a moderate to dense ground cover of grasses sedges and shrubs. Precipitation at sites in Tasmania is about 2500mm annually (Watts and Aslin 1981). In Victoria, Wallis *et al.* (1982) reported that *M. fuscus* was confined to areas with an average annual precipitation of more than 1000mm, although rainfall at Parker River Inlet, a confirmed site near Cape Otway, is between 850 and 900mm per year (John Seebeck *pers. comm. 2002*). The distribution in Victoria includes the alpine area and South Gippsland, the Dandenong Ranges, Otway Ranges, Wilsons Promontory, and with remains from predator scats being found at Naringal and near Cann River in East Gippsland (Wallis *et al.* 1982; Menkhorst 1995). The species has not been found in the south-western Victorian heathlands where rainfall is less than 800mm per year (Wallis *et al.* 1982).

Although the species is widespread at lower elevations in western Tasmania and Victoria, in NSW and the ACT it has been regarded as being restricted to higher elevations. In a faunal survey from September 1968 to March 1972, Dimpel (unpublished) speculated that the higher observed altitudinal range of *M. fuscus* in NSW might be due to the climatic difference between the two states, with Victoria having a cooler, wetter climate. The sites in NSW and ACT at which we found evidence of *M. fuscus* can be characterised by rainfall and temperature. All sites at which the species was detected were predicted to have >1000mm of mean annual precipitation and a mean annual temperature of <10°C. These conditions are achieved in the Snowy Mountains region only at elevations above about 1000m, but further north at Barrington Tops, elevations over 1400m are required to produce these conditions. The present study failed to find evidence of *M. fuscus* at lower elevation sites where temperatures are higher and mean annual precipitation (in the case of the south coast sites) is lower. However, Seebeck (*pers. comm. 2001*) has recorded *M. fuscus* in swales in sand dunes at Parker River Inlet (Victoria), and the jaw and skull from owl pellets at Bruces Creek are unlikely to have come from the nearest known population in the Snowy Mountains. Therefore it is likely that there are coastal sites in New South Wales, drier and warmer than the ones reported here, at which *M. fuscus* exists. If this is the case then these populations, which are so far undetected, must be considered to be seriously at risk.

The populations in NSW are severely fragmented. There is no continuous line of habitat from contiguous populations centred in the Snowy Mountains region to the apparently extinct population at Deua National Park or to Bruces Creek. From these southern locations, to the northern populations at Barrington Tops, is a distance of some 450 km with much drier habitat intervening and there are no Wildlife Atlas records of *M. fuscus* to connect the northern and southern populations. The extreme paucity of records outside the two known populations, coupled with the extent of predator invasion of intervening country, suggests that there would be little opportunity for recolonisation following any local extinction, particularly of the Bruces Creek population. Additional to that is the low reproductive rate of *M. fuscus* (Happold 1989a) which means that a population, once depressed, could not recover quickly. *Mastacomys fuscus* may have occurred in the Lower Glenelg River district (Victoria) contemporaneously with introduced species such as the rabbit (Cockburn 1979) but there is no evidence of its continued existence there (Menkhorst and Beardsell 1982). *Mastacomys fuscus* was trapped in late 1973 at Parker River Inlet but, despite much trapping, has not been trapped there since (John Seebeck *pers. comm. 2002*). The Deua record (NSW) was of a single subfossil specimen and, despite searches in the area since that discovery in the late 1970s, no evidence of live animals has ever been found (this study, DCD Happold *pers. comm. 2002*). A later range reduction has also apparently occurred in suboptimal areas of the Barrington Tops.

The large swamp complexes were the only sites where the presence of *M. fuscus* could be confirmed on Barrington Tops. Unlike the study of Green (2000), Dickman and McKechnie (1985) found no evidence of *R. lutreolus* on Barrington Tops, either in traps or in fox scats. The failure by Green (2000) to find evidence for *M. fuscus* in fox scats from Barrington Tops suggests that the population has declined to a very low level. Possible reasons for this decline may relate to increased predation, competition from *R. lutreolus*, habitat change and climate warming which may be acting independently or synergistically. Subsequent to the fieldwork on Barrington Tops for this study, the population was declared to be Endangered by the New South Wales Scientific Committee established under the *Threatened Species Conservation Act 1995*.

The major threats to *M. fuscus* are believed to be habitat destruction or modification, fox predation (Green and Osborne 1981, Green 2002) and global warming (Busby 1988, Brereton *et al.* 1995). The present study has found that rabbits and hard-hoofed herbivores were responsible for damaging native vegetation, opening up inter-tussock areas where *M. fuscus* normally constructed runways. The absence of *M. fuscus* from such sites suggests that this activity either predisposes *M. fuscus* to predation or causes it to vacate the area entirely.

The long-term global warming trend is expected to affect the extent and duration of snow cover in the Australian Alps profoundly (Galloway 1988; Whetton *et al.* 1996; Whetton 1998) and with it, the ecology of low-temperature-dependent species including *M. fuscus* (Busby 1988; Brereton *et al.* 1995). A change in climate would increase winter mortality at the higher elevations because of easier access by foxes to their prey in shallow snow. It may also lead to increased competition from other species in marginal habitat. Populations at lower altitudes, which are probably climatically marginal already, may not be able to sustain populations of *M. fuscus* with further warming of the climate.

The decline of *M. fuscus* at Barrington Tops was either caused by, or coincident with, the spread of *R. lutreolus* into this area. This is cause for concern as to the status in other parts of the range of *M. fuscus*. Tasmanian sites frequently have both species occurring sympatrically but in cold wet areas where there may have been some niche specialisation. In Victoria, Macreadie *et al.* (1998) found both species at Bunyip State Park and Seebeck (*pers. comm.* 2002) caught a single *R. lutreolus* on his trapping grid at Bellel Creek for several months. If the factors favouring the invasion of *R. lutreolus* at Barrington Tops are not just peculiar to that site then concern must be expressed for other populations.

The populations about which least is known are those at lower altitudes (possibly at Deua National Park and Bruces Creek) in areas remote from other, more substantial, populations. If these locations were, in fact, occupied by *M. fuscus* then, if they are not extinct like the population in the Lower Glenelg River district of Victoria, they may be seriously threatened. There is a continuum of populations from the ACT to the Victorian border and into the Cobberas Range through the Snowy Mountains. However, a minor restriction of gene flow between the main Victorian populations and those of NSW/ACT has been reported by Greville (1990). Greville (1990) did not examine the most isolated mainland site at Barrington Tops but did warn of possible extinction of marginal populations due to restriction of gene flow. There is a very real possibility of this occurring given a combination of threats from livestock grazing, the activities of feral animals and global climate change. Currently the only population in the NSW/ACT that is secure in the short term is the contiguous population in the Snowy Mountains region with its stronghold at the higher altitudes.

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