Seasonal changes in bats at a derelict mine in southern New South Wales

Christopher Slade[1] and Bradley Law[2]

[1]University of New England, Ecosystem Management Armidale NSW 2351 *present address*: Forests NSW, Department of Primary Industries, Central Region Maher Street Wauchope NSW 2446, email: chriss@sf.nsw.gov.au (corresponding author)

[2]Science and Research, Department of Primary Industries, PO Box 100 Beecroft NSW 2119

ABSTRACT

Mumbulla mine is an abandoned mine on the far south coast of NSW. It is notable for its significant population of Eastern Horseshoe Bats *Rhinolophus megaphyllus*. Bat species and numbers inhabiting the mine were monitored during May, July, October and November 2002 and January, March, April and October 2003. Bat numbers were recorded through the use of an infrared gate and data logger with a maximum number of 999 bats recorded in October 2002 prior to the maternity season, and a minimum of 54 bats recorded in January 2003, during the maternity season. Eastern Horseshoe Bats were identified using an Anabat detector during all monitoring sessions while the Eastern Bent-wing Bat *Miniopterus schreibersii* was absent during November and January. Sustained activity through the night at the mine entrance in April/May coincides with the mating season, and this observation is consistent with bat swarming behaviour, not previously reported in Australia. Both bat species were recorded flying at the mine entrance throughout year, including winter. Winter activity indicates that surveys at mines, using an Anabat detector, can be productive during the cooler months of the year. Despite the fact that no evidence of breeding was noted during this study, high numbers through winter, peaking just prior to the maternity season and possible mating behaviour in autumn, indicates that the mine should still be regarded as a high priority for management.

Key words: Mumbulla, Eastern Horseshoe Bat, *Rhinolophus megaphyllus*, Eastern Bent-wing Bat, *Miniopterus schreibersii*, mine, Anabat detector, swarming, monitoring.

Introduction

Caves provide essential roosting habitat for some bat species, such as the Large Bent-wing Bat *Miniopterus schreibersii* and the Eastern Horseshoe Bat *Rhinolophus megaphyllus*. In many areas, low numbers of naturally occurring caves increases the significance of abandoned mines as habitat for bats (Hall *et al.* 1997). The far south coast of New South Wales (NSW), from Narooma to the Victorian border, is one area where natural inland caves are scarce (Eberhard 1997). Although inland caves are scarce, many abandoned mines exist throughout the region, clustered in discrete areas. Most notably these occur in the Montreal Goldfields – (Wallaga Lake), Mumbulla Mine (Mumbulla State Forest), Vimy Ridge mines (Tanja State Forest and adjacent private land), Wolumla Goldfields (Wolumla), Panbula Goldfields (Nullica State Forest), Whipstick Mines (Nullica State Forest), and the Yambulla Goldfields (Yambulla State Forest). Over the past five years *M. schreibersii* and *R. megaphyllus* have been recorded at many of these sites (C. Slade unpublished data).

There are few long-term studies of specific mine sites, although longer-term studies have been undertaken at roosting caves, enabling a determination of breeding cycles and population demographics of *M. schreibersii* at sites within the species' range in Australia (Dwyer 1963, Hall 1982). Long-term studies of these sites provide information on the value of the habitat, leading to an assessment of the need for management of such sites, such as mine closure, fencing or gating.

A significant population of *R. megaphyllus* has been observed roosting within a mine in Mumbulla State Forest throughout the year (Moore 1975; Lunney and Barker 1986; Law *et al.* 2000), but use of the site has largely been derived from opportunistic visits. A female with a neonate was observed at the site in November 1998 (A. Fay NPWS, pers. comm. May 1999). The observation of this female and its young led Mumbulla mine to be described as a maternity site requiring action to preserve its integrity for *R. megaphyllus* (Fay 1998). However, subsequent inspections during the summer maternity season (January 1999, December, 2001) failed to record any additional juveniles within the mine, suggesting that the site is probably not used as a maternity site (Law *et al.* 2000). The location of any maternity sites for *R. megaphyllus* on the far south coast of NSW is still unknown. Congregations of pregnant *R. megaphyllus* females observed at Mumbulla prior to departing to the as-yet-unknown maternity roost suggest that the mine is an important staging roost (Law *et al.* 2000). It is likely that the observation of the mother and young was the result of one of the pregnant females giving birth prior to moving to the maternity site. *Miniopterus schreibersii* is also present in this mine at times throughout the year. Human visitation to this site is frequent enough for a pathway to have developed from the nearby road. Other indications of human visitation to the mine include the remains of a Molotov cocktail within the mine near the entrance and horse dung on the pathway.

This study aimed to assess systematically the seasonal habitat value of Mumbulla Mine for *M. schreibersii* and *R. megaphyllus* by determining the presence of each species and numbers of bats using the mine over one 12-month period. If the mine is used as a maternity roost, we predicted high numbers would be present from November-January. This information is necessary to determine the value of the mine for the bats and contribute to determining appropriate management actions.

Methods

Study site

Mumbulla mine is located within Mumbulla State Forest, approximately 15 km north-east of Bega and 5 km from the coast along Knights Creek Road on a southerly slope at the head of a small dry upper catchment creek line (Figure 1). The mine is a horizontal adit approximately 70 m long with several small alcoves off the main drive.

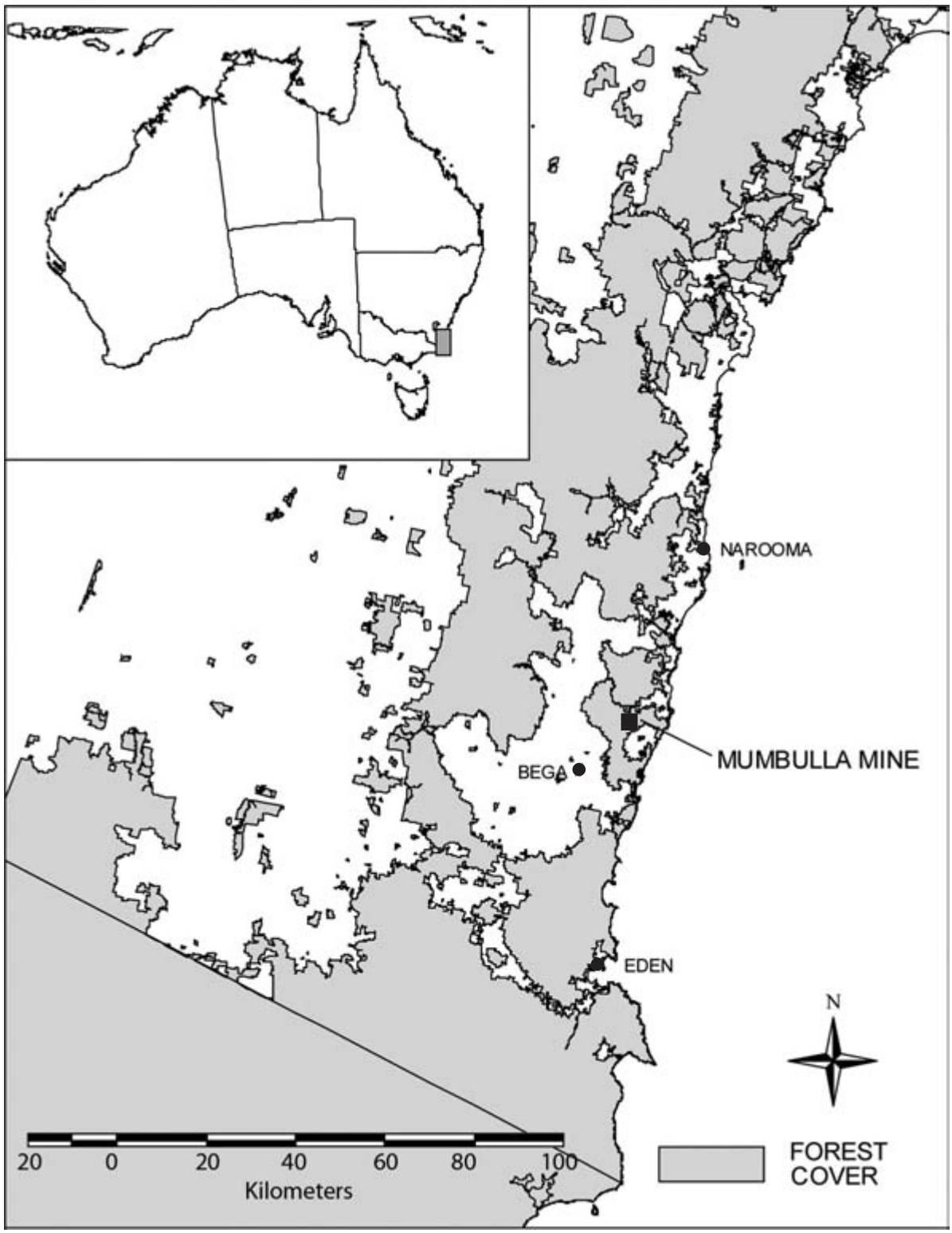

Figure 1. Location of Mumbulla Mine

A lower-level adit is connected to the entry-level adit by a short vertical shaft of approximately 3 metres (Figure 2).

Historic remains within the mine include wooden handcart rails, a ladder, pulley and pulley stand, and entrance posts and lintels. The entrance to the mine is relatively intact and located at the end of a six-metre shallow cutting approximately 1.4 m high and 1.1 m wide. Some collapse has occurred within the mine with boards and props located close to the ladder and pulley stand supporting a large amount of rock. It is also likely that the mine's current state is different from its state when mining activity was being undertaken. A vertical shaft, 60m upslope of the entrance to the horizontal adit, with much collapsed material at the bottom, probably connected with the horizontal adit in the past. An opening, now partly obscured by rubble, appears to head further upslope from the bottom of the shaft.

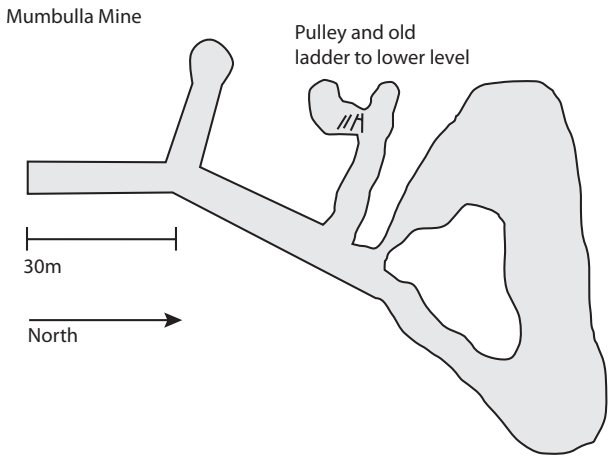

Figure 2. Representation of Mumbulla Mine.

Details are scarce on the history of Mumbulla mine with the nearest mine listed as being operated around 1930 with veins followed to obtain gold (Department of Primary Industries – Mineral Resources Division). Little else is known about the site including the amount of gold produced or the period of activity.

The mine lies adjacent to an ephemeral upper catchment drainage line in a mid to upper slope position within an open to moderately dense dry sclerophyll forest. The forest above the mine is open and consists of Silver-top Ash *Eucalyptus sieberi*, Woollybutt *E. longifolia*, and Rough-barked Apple *Angophora floribunda*, with Narrow-leaf Bower Wattle *Acacia cognata*, *Platylobium formosum*, *Lomatia ilicifolia*, Bracken *Pteridium esculentum* and a grass *Poa meionectes*. The forest below the mine is more dense and tends towards being classified as temperate rainforest with Mountain Grey Gum *E. cypellocarpa*, Yellow Stringybark *E. muelleriana* and Narrow-leaved Peppermint *E. radiata* dominating the overstorey. The understorey below the mine is dominated by Sweet Pittosporum *Pittosporum undulatum,* False Bracken *Calochloena dubia,* Lawyer Vine *Smilax australis* and Narrow-leaf Bower Wattle.

Logging was conducted in the vicinity of the mine during 1979 – 1981 and a fire occurred on 18/11/1980 (Forests NSW Southern Region, Eden records). Fire was also introduced into the general area of the mine during winter of 1999, as a means of reducing the fuel loads and minimising the risk of wildfire, however, this did not encroach on the mine entrance (Law *et al.* 2000).

Bat monitoring

The numbers of bats roosting in Mumbulla mine were monitored using an infrared gate and data-logger, while species presence was determined with an Anabat detector (Titley Electronics, NSW). The infrared gate and data-logger were set for a period of 4 nights in each sample period in May, July, October and November of 2002 and January, March and April 2003. The infrared gate was set at the entrance of the mine such that all bats entering and departing the mine had to fly through it. Two sets of beams attached to this gate detect objects that pass through it. The data-logger records numbers of bats flying both in and out of the mine at 15 min intervals, enabling a net exit count to be derived by subtracting in-counts from out-counts for each interval. Although the gate counted all night, the population count was derived from exit counts at or just after sunset, for about one hour, after which in-counts usually exceeded out-counts.

An Anabat detector was used remotely to determine the presence or absence and activity levels of *M. schreibersii* and *R. megaphyllus* at the site for each of the sampling periods. The detector was located outside and approximately 2 m from the mine entrance. It was directed slightly away from the entrance to record individuals departing the mine and reduce recordings of individuals flying within the mine. Activity was recorded at or just after sunset for about one hour after the first bat departed.

Several inspections were undertaken within the mine in June, September and October of 2002 to determine whether bats were in torpor. Extreme caution was exercised during the inspections so as not to disturb the bats. The inspections were conducted after the initial fly-out period to determine whether any bats remained within the mine following the flyout.

The internal temperature of the mine was recorded over the study period with a Thermochron iButton (Dallas Semiconductor, USA). The data-logger was positioned about 30 m into the mine at a height of 1.3 m above the ground. This was close to where bats roosted, but not where temperatures would be affected by clustering bats. Records of ambient temperature were collated from a weather station at Merimbula airport approximately 40 km south of Mumbulla mine. Temperatures were compared to the level of bat activity throughout the different seasons.

As a result of the high level of human disturbance, such as the remains of a Molotov cocktail, horse dung and burnt paper, observed at the mine, an experimental gating trial was conducted for two months during March and April, 2003. The results of which will be presented elsewhere but indicate that there is much to learn about mine gating, as a way to control human access into mines. The study recommends monitoring of mine sites before and after management actions and the testing of template structures.

Results

Anabat detectors identified two species at the mine. *Rhinolophus megaphyllus* was present at the site throughout the year, while *M. schreibersii* was present from March to October, but not detected during the November and January surveys (Table 1). The net exit count of bats using the mine varied from 999 in October 2002 to 54 in January 2003 (Table 1). The data logger failed during October 2003 so there are no data available for that sampling period. A visual assessment during that October logger set-up confirmed that bats were present in relatively large numbers.

Table 1. Numbers of bats (average of net exit counts, all species) and species present at Mumbulla mine during monitoring. n=number of nights sampled within a monitoring session. (Data logger errors have restricted the number of nights' data available).

Survey Session	Numbers of bats	*M. schreibersii*	*R. megaphyllus*
May 2002	505 (n = 1)	X	X
July 2002	385 (n = 3)	X	X
October 2002	999 (n = 1)	X	X
November 2002	635 (n = 2)		X
January 2003	54 (n = 3)		X
March 2003	520 (n = 2)	X	X
April 2003	287 (n = 1)	X	X
October 2003	Not available	X	X

X - denotes presence

The numbers of bats recorded in April 2003 were low compared to the similar period in the previous year, probably because of the experimental gating trial being undertaken between March and April of 2003, at this and other mines within the region.

The infrared gate used to determine net exit counts also provides details of movement patterns of bats departing and entering the mine throughout the night. Figure 3 a-g shows the patterns of bats departing and entering Mumbulla Mine for a single night during the monitoring periods of May, July, October and November of 2002 and January, March and April of 2003. The data logger failed before midnight in May 2002 preventing a full analysis of the night's activity.

Bats departed the mine during a short period at or just after, sunset in all seasons. In some months there was a peak return of bats just before sunrise; and in all periods there was some activity throughout the night. The July sample lacks a peak return of bats around sunrise with many bats returning between two and three hours after initial departure (Figure 3 b). In contrast, bat activity at the mine remained high throughout the night in April 2003 (Figure 3 g). A similar pattern of high activity after the initial fly-out was also recorded during May 2003, but due to datalogger failure before midnight the remaining night's activity was unable to be confirmed. Sustained activity throughout the night in April could be related to *R. megaphyllus* and *M. schreibersii* mating at this time of year. Bats were observed chasing each other with audible social calls recorded during both autumn surveys.

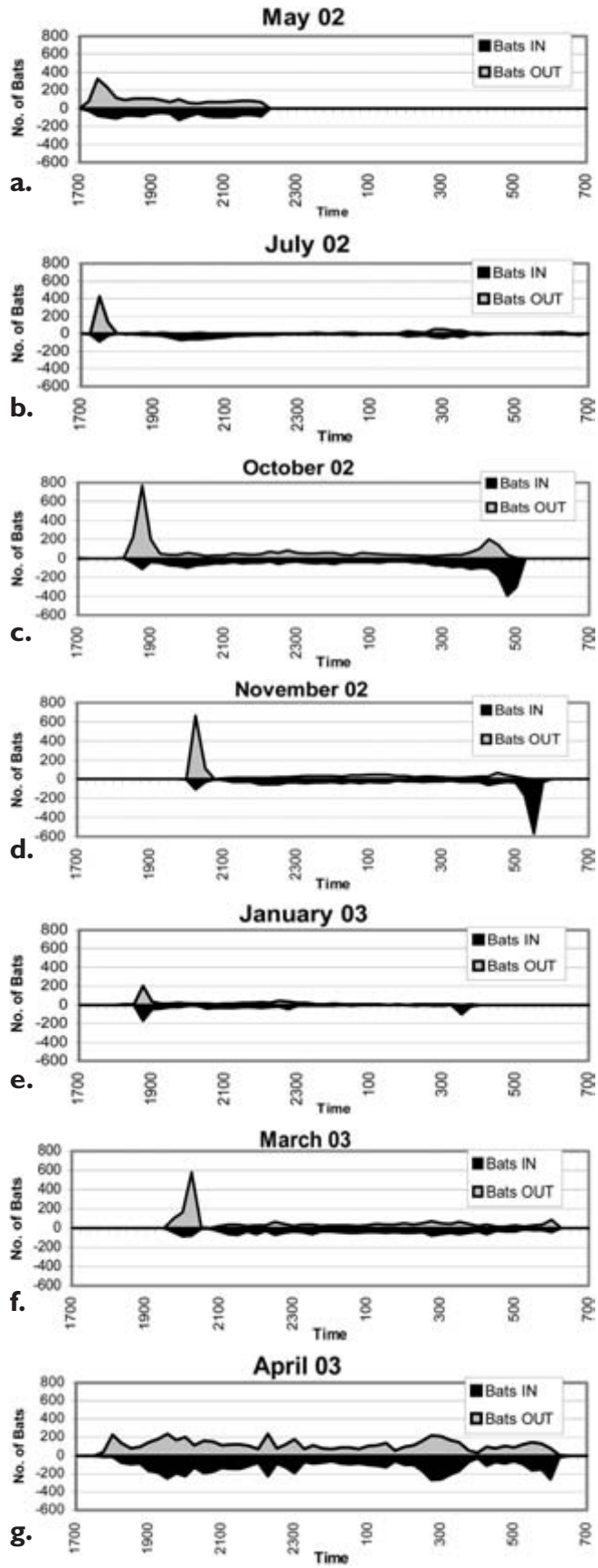

Figure 3. Patterns of bats departing and entering Mumbulla mine during May, July, October and November, 2002 and January, March and April of 2003. The Y-axis refers to the number of bats recorded flying through the infrared gate over 15-minute periods throughout the night for one sample night for each period.

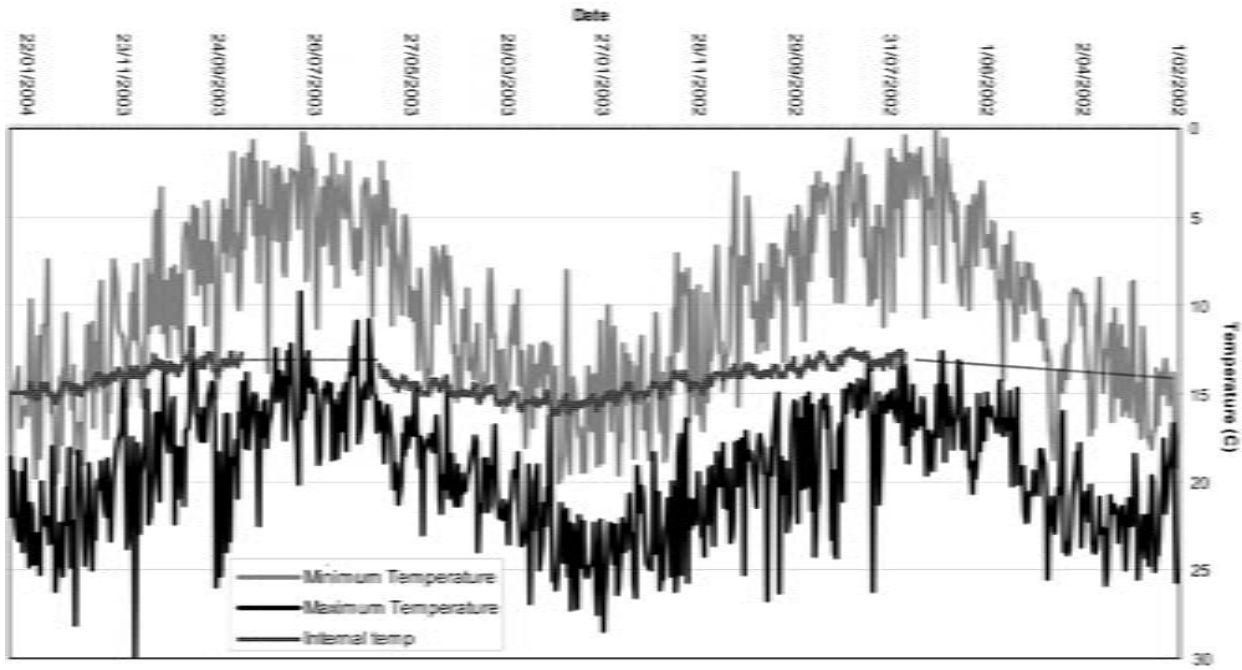

Figure 4. Internal mine temperature and ambient temperature for Merimbula Airport for the period May 2002 to January 2004. Note: the dashed line for the internal mine temperature indicates missing data.

Visual mine inspections to identify torpid bats were undertaken after the initial flyout. Torpid bats were classified as those that did not take flight during observations, unlike other times of the year. *Miniopterus schreibersii* was observed to be roosting in a cluster during the July 2002 inspection in an area on the ceiling 30 metres from the entrance, whereas *R. megaphyllus* was observed roosting individually further within the mine. During the October 2002 inspection, *R. megaphyllus* was observed roosting either individually or in clusters comprising 2 to 5 individuals throughout the mine. No *M. schreibersii* were observed, although they were recorded using the anabat detector. Temperatures inside the mine were relatively constant, varying from 12.5°C in August to 16.0°C in February (Figure 4). In contrast, minimum temperatures, at Merimbula airport, dropped to less than 5°C on several nights between July and September 2002 and 2003 (Figure 4). The months of July, October and November of 2002 exhibited 87%, 3% and 7% of nights where minimum temperatures dropped to less than 5°C, respectively. Bats were still active during nights where temperatures dropped to below 5°C. Minimum temperatures for the July sample period over the four nights were 3.4°C, 0.4°C, 3.2°C and 7.2°C with the corresponding maximum temperatures for the same days being 15.2°C, 13.4°C, 17.9°C and 14.2°C, respectively.

Discussion

Monitoring of bats at Mumbulla mine over a period of one year revealed that *M. schreibersii* was absent in November and January, and presumably December. The observations of a cluster of torpid *M. schreibersii* during the visual mine inspections in July suggests that the mine is used as a hibernation site after which they depart to other roost sites. *Miniopterus schreibersii* returns to the mine in March, which coincides with the period when juveniles disperse from their maternity roosts, possibly either Wee Jasper or Bungonia caves (Dwyer and Hamilton-Smith 1965, Dwyer 1969).

The overall number of bats was highest in October-November and lowest during January, which supports the suggestion by Law *et al.* (2000) that *R. megaphyllus* females use the mine as a staging roost before departing to a maternity site during early to mid-summer. There have been no detections of large congregations of bats in summer within the mine suggesting no further evidence of breeding, since that reported by Fay (1998). It is likely that the neonate observed within Mumbulla mine (Fay 1998) was an early birth and presumably the adult females departed to the maternity site shortly after. Both the temperature recorded inside the mine during summer, and an internal humidity at this time of 84-90 % (Law *et al.* 2000), are at the lower end of the preferred conditions for *R. megaphyllus* maternity roosts (Hall *et al.* 1975).

The numbers of bats using the mine and the seasonality of mine usage in 1974 (Moore 1975) are consistent with the results of this study. Twelve bats were observed during a survey conducted in January 1974 and an estimated 200 bats in November 1973 (Moore 1975). The pattern of mine usage by bats at Mumbulla, in this study, has been determined through eight sampling periods over a 12-month period. There is however potential for variation from year to year.

Internal inspections at the mine revealed *R. megaphyllus* and *M. schreibersii* individuals in states of torpor suggesting that the mine is used as a hibernation site. Nocturnal activity was, however, also recorded during monitoring sessions at the same time. Further observations of bats in torpor during the night in winter will allow for a more definitive

conclusion about whether the mine is used by both species as a hibernation site. Ambient temperatures at this time varied from less than 5 ^{0}C to 17.9^{0}C in July 2002. Activity patterns for the July sampling period lacked a peak return of bats at dawn, but instead bats were observed to return to the mine within two hours of dark. Presumably the nights with cooler temperatures at this time did not have the same level of insect abundance as would be present during spring and summer. This supports research conducted in south-east Queensland where *R. megaphyllus* was observed to be active throughout winter and only entered periods of torpor in inclement weather (Young 2001).

While it could be assumed that not all bats depart the mine during the cooler evenings, with some likely to remain in long-term torpor, the level of activity at this time of year has implications for the survey of such sites. Survey of caves and mine shafts for bats are limited to internal inspections and external surveys through the use of Anabat detectors and/or some form of counting. Internal inspections are problematic for a number of reasons, including disturbance to the bats, which during winter can deplete energy reserves, and the exposure of surveyors to serious safety risks. External surveys of caves and mines are not recommended during the cooler months of the year (eg. IFOA 1999). The fact that bats were observed to be active during winter suggests that external surveys could still be a viable survey option at this time of year, although we acknowledge that mines used at other times will not necessarily be used in winter.

The sustained activity through the night during May 2002 and April / May 2003 coincides with the maximum development of testes in male *M. schreibersii* during May (Dwyer 1963) and May / June for *R. megaphyllus* (Dwyer 1966), and suggests that mating is likely to be occurring for both species at this time of year. The high activity throughout the night that we observed could be a type of swarming. Swarming is a phenomenon where large numbers of predominantly male bats of several species are observed to gather at underground sites during late summer and autumn (Parsons *et al.* 2003). Swarming has been recorded for European and American bats, but not in Australia. The swarming behaviour and observations of bats chasing each other into and out of mines with audible social calls appears to play an important reproductive function (Parsons *et al.* 2003). There were several occasions during the autumn surveys where chasing behaviour was observed and audible social calls recorded indicating the possibility of the phenomenon occurring at Mumbulla mine. This behaviour was not observed to the same extent during other survey times.

Despite the suggestion that Mumbulla mine is not a maternity site for *R. megaphyllus*, the mine is important as it is used during winter, allowing the bats to enter into periods of torpor, as a staging roost prior to females establishing a maternity roost elsewhere and it is potentially important for breeding in autumn. As the site shows signs of frequent visits by humans, is partly collapsed, and has a high likelihood of carbon dioxide build-up at the lower level, it deserves high priority for management, such as gating or other form of human access prevention.

An understanding of how key roost sites are used over different seasons is of vital importance prior to any management action. This understanding will enable a determination of the significance of the site and can only be achieved through long-term monitoring. Without such information, inappropriate management actions, such as gating, fencing or filling in shafts may be undertaken at inappropriate times of the year, while bats are absent, with results being falsely indicative of success. Monitoring of significant roost sites over the longer term will also provide an opportunity for the assessment of risk posed by visitation to the site, which in turn allows for a better understanding of the need for management.

Acknowledgements

Peter Jarman provided input into the project design and comments on early drafts, Mark Chidel provided valuable technical support, advice and comments on an early draft, Sharon Davey gave time in the field and support with equipment, Trent Penman provided field assistance, Frank Lemckert provided comments on early drafts and the Southern Regional office of Forests NSW in Eden provided a vehicle and equipment. This research was undertaken under the Forests NSW Animal Ethics Committee project number 02/03 and NSW National Parks and Wildlife Service scientific licence number S11203.

References

Dwyer, P. D. 1963. The Breeding biology of *Miniopterus schreibersii blepotis* (Temminck) (Chiroptera) in north-eastern New South Wales. *Australian Journal of Zoology*, **11**: 219 – 40.

Dwyer, P. D. 1966. Observations on the Eastern Horseshoe Bat in north-eastern New South Wales. *Helictite* **4**: 73-82.

Dwyer, P. D. 1969. Population ranges of *Miniopterus schreibersii (Chiroptera)* in south-eastern Australia. *Australian Journal of Zoology* **17:**665 – 686.

Dwyer, P.D. and Hamilton-Smith, E. 1965. Breeding Caves and Maternity colonies of the Bent-winged Bat in South-Eastern Australia. *Helictite* **4**: 3-21

Eberhard, S. 1997. Sea Caves of the Far-south Coast of New South Wales, Survey of bats fauna and terrestrial invertebrates. Unpublished Report to the NSW National Parks and Wildlife Service

Fay, A. 1998. (NSW National Parks and Wildlife Service). Action Plan for Cave Bats and their Habitat in NPWS Eden District, on the Far South Coast of NSW.

Forestry Commission 1987. Batemans Bay State Forests, Batemans Bay Forestry Region Project Map. Forestry Commission of NSW.

Hall, L. S. 1982. The effect of cave microclimate on winter roosting behaviour in the bat, *Miniopterus schreibersii blepotis*. *Australian Journal of Ecology* **7**: 129-136.

Hall, L., Young, R.A., and Spate, A.P. 1975. Roost selection of the eastern horseshoe bat *Rhinolophus megaphyllus*. Pp 47-56 in *Proceedings of the Australian Speleological Federation* 10th Biennial Conference, edited by A. Graham. Broadway, Sydney.

Hall, L., Richards, G., McKenzie, N. and Dunlop, N. 1997. The importance of abandoned mines as habitat for bats. Pp 326-333 in *Conservation outside Reserves*, edited by P. Hale and D. Lamb. Centre for Conservation Biology, University of Queensland.

Integrated Forestry Operations Approval Package (IFOA) 1999. Forestry and National Park Estate Act 1998, Integrated Forestry Operations Approval for the Eden Region.

Law, B., Chidel, M and Slade, C. 2000. Monitoring Eastern Horseshoe Bats at Mumbulla Mine. Unpublished Report, State Forests of NSW, West Pennant Hills.

Lunney, D. and Barker, J. 1986. Mammals of the coastal forests near Bega, New South Wales II. Annotated Checklist. *Australian Zoologist* 23: 41-49.

Moore, D. 1975. Bermagui Caver, Newsletter of the Bermagui Speleological Association. Unpublished newsletter, Bermagui NSW

Parsons, K. P., Jones, G., Davidson-Watts and Greenaway, F. 2003. Swarming of bats at underground sites in Britain – implications for conservation. *Biological Conservation* **111**: 63-70.

Young, R. A. 2001. The eastern horseshoe bat, Rhinolophus megaphyllus, in south-east Queensland, Australia: colony demography and dynamics, activity levels, seasonal weight changes, and capture-re-capture analyses. *Wildlife Research* **28**: 425 – 434.

APPENDIX I

Eastern Horseshoe Bat *Rhinolophus megaphyllus.*

Photo courtesy of Les Hall.

Eastern Bentwing Bats *Miniopterus schreibersii.*

Photo courtesy of Brian Tolhurst

APPENDIX 1

Infrared Counter and data logger at Mumbulla Mine. Note Superb Lyrebird nest above entrance.

Photo. C. Slade