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The Conservation of Arboreal Marsupials in the Montane Ash Forests of the Central Highlands of Victoria, South-East Australia: II. The Loss of Trees with Hollows and its Implications for the Conservation of Leadbeater's Possum *Gymnobelideus leadbeateri* McCoy (Marsupialia: Petauridae)

D. B. Lindenmayer,[a] R. B. Cunningham,[b] M. T. Tanton[a] & A. P. Smith[c]

[a] Department of Forestry, [b] Department of Statistics, Australian National University, GPO Box 4, Canberra, ACT 2601, Australia
[c] Department of Ecosystem Management, University of New England, Armidale, NSW 2351, Australia

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ABSTRACT

Leadbeater's possum, Gymnobelideus leadbeateri *McCoy, a rare and endangered arboreal marsupial inhabiting the montane ash forests of the Central Highlands of Victoria, is dependent on hollows in mature and dead trees.*

The number of trees with hollows that had collapsed between 1983 and 1988 was assessed at 32 sites located in ash-type forests in the Central Highlands of Victoria, south-eastern Australia. The extent of decay amongst standing trees with hollows was also determined. A simple stochastic model of the decline and collapse of these trees was calculated from the data. The model was applied to data on trees with hollows collected from 497 other sites within the study region to predict their future abundance and availability over the next 75 years.

Almost 18% of the total measured population of trees had collapsed in the 5-year interval between assessments. A subjective categorization of the form of the trees was the best predictor of the susceptibility to collapse. More senescent trees were those most vulnerable to collapse and they also exhibited the highest rates of decay.

Stochastic models based on transition probabilities of trees with hollows predict that very few of the sites surveyed will support such trees in 50 years *time and imply a severe future shortage of trees containing suitable nest hollows for wildlife until at least the end of the next century. Silvicultural practices which result in ash-type forests being clear-felled on a short-term (80–120 year) rotation will further accelerate and exacerbate the anticipated shortage. The implications of these effects for wildlife, particularly* G. leadbeateri, *are discussed.*

INTRODUCTION

Smith (1980, 1982) noted that many trees with hollows in the Central Highlands of Victoria were collapsing and that this was not being countered by the recruitment of new trees containing potential nest sites. This was because current silvicultural practices resulted in forests being harvested before hollows could develop. Eventually a shortage of hollows for animals in montane ash forests could seriously threaten the long-term survival of leadbeater's possum *G. leadbeateri* McCoy, which is dependent on hollows in trees as a primary source of den sites (Lindenmayer *et al.*, 1989). In recognizing these problems, the Australian Biological Research Group (1984) and Smith *et al.* (1985) recommended an investigation of the survival of existing hollow-bearing trees in montane ash forests.

Our study attempted to estimate the rate of decay and collapse amongst trees with hollows in ash-type forests and identify which measurable factors, if any, can be used as predictors of the loss of these trees. The future abundance and availability of these trees has then been predicted from these data. The findings are discussed in terms of timber harvesting procedures and the anticipated impact on animals, particularly *G. leadbeateri.*

METHODS

Study area

The study area is described in Part I (Lindenmayer *et al.*, 1990).

Field measurements

The number and condition of trees with hollows were measured at 529 sites, each of 3 ha. The characteristics of trees which were selected for measurement are defined by Smith and Lindenmayer (1988). Trees were measured at 32 sites first in 1983–84, as part of a study on the habitat requirements of *G. leadbeateri* (Smith *et al.*, 1985; Smith & Lindenmayer, 1988). The height, form, diameter and species of each tree with hollows were recorded (Lindenmayer *et al.*, 1990). Sites varied with respect to the composition and age of the dominant tree species, slope, aspect and topographic position (i.e. gully, midslope and ridge) (Lindenmayer *et al.*, 1990). The trees on these sites were re-assessed in 1988. Another 497 sites then were measured in 1988–89.

Each site was traversed on foot and all trees with hollows were numbered with spray paint and their positions plotted on a map.

In the 1988 survey, the form and whether the tree was still standing were recorded. A hollow-bearing tree was classed as collapsed if it had fallen over and left a stump < 2 m in height. This group was placed in form 9, which was an additional category to those described in Lindenmayer *et al.* (1990).

Statistical analyses

Logistic regression analyses (McCullagh & Nelder, 1983) were used to explore the relationships between the form, diameter and species of a tree with hollows and its susceptibility to collapse.

The probability of the transition of a tree from a given form to another was calculated using a Markov Chain stochastic procedure (Bailey, 1964). Calculations were based on the assumption that the present form of a tree is probabilistically dependent on the form observed in the most immediate past. This, in turn, provides a powerful tool for modelling the decline of the trees.

The Markov Chain method has been applied in other studies of forest succession (Horn, 1975). The basic assumption underlying the matrix is that there is a uni-directional shift in the sequence of tree forms. This assumption appears to be valid as no trees were recorded as less decayed than when initially examined in 1983–84.

A Markov Chain can be completely represented by transition probabilities, p_{ij}. In this study, p_{ij} represents the probability of a tree being assigned to form j in 1988 given it was in form i when first measured in 1983 (where i, j represent forms $1, 2, 3 \ldots 9$). Thus, the transition probabilities can be represented in the form of a matrix

$$P = \begin{array}{cc|ccccccccc|} & & \multicolumn{9}{c}{\text{Form 1988}} \\ & & 1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 & 9 \\ \hline & 1 & p11 & p12 & \cdots & & & & & & p19 \\ & 2 & p21 & & & & & & & & \\ & 3 & \vdots & & & & & & & & \\ \text{Form 1983} & 4 & \vdots & & & & & & & & \\ & 5 & \vdots & & & & & & & & \\ & 6 & \vdots & & & & & & & & \\ & 7 & \vdots & & & & & & & & \\ & 8 & p81 & \cdots & & & & & & & p89 \\ \hline \end{array}$$

Where **P** represents the matrix and the value of p_{ij} is calculated from the equation

$$p_{ij} = \frac{\text{number of trees changing from form } i \text{ to form } j}{\text{total number of trees originally in form } i}$$

The matrix of transition probabilities calculated in this study is given in Table 1.

Predicted decline of trees in ash-type forests

Calculations of the decline of trees were based on the use of n-step transition probabilities, $p_{ij}^{(n)}$ (or the matrix $\mathbf{P}^{(n)}$) which simply depend on the conditional probability that the values in the Markov chain will undergo a transition from form i to form j in n time steps given that the process begins with trees in form i. It can be shown that

$$\mathbf{P}^{(n)} = \mathbf{P}^{(n-1)}\mathbf{P} = \mathbf{P}^{n} \tag{1}$$

The rate of collapse of trees was calculated over a period of 5 years and the time step here $(n) = 1$. Thus, n-step transition probabilities can be determined by powering the original transition matrix by n. Predictions of the trees in each form on the 529 survey sites after 25, 50 and 75 years were calculated by post-multiplying by the n-step transition matrices where $n = 5$, 10 and 15 respectively.

TABLE 1
The Probability, expressed as a Percentage, of the Transition of a Tree Moving between given Forms over the 5 Year Period between Field Surveys

	New Form (1988)[a]								
	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
Old form (1983)									
1	84	13	0	0	0	0	0	0	3
2	*[b]	87	0	2	4	2	0	0	6
3	*	*	21	43	21	0	0	7	7
4	*	*	*	38	29	7	9	2	16
5	*	*	*	*	53	26	11	3	8
6	*	*	*	*	*	29	22	20	30
7	*	*	*	*	*	*	43	36	21
8	*	*	*	*	*	*	*	58	42
Totals	31	54	14	45	40	51	15	36	53

[a] Two study sites were clear-felled in the interval between measurements. Trees from these sites have not been included in the analyses.
[b] * Indicates that the decay of nest trees is uni-directional and can only proceed toward more advanced stages of senescence.

RESULTS

Collapse of trees containing hollows

In 1983–84 the 32 sites yielded 302 trees with hollows. All forms of standing trees were represented by 14 or more individuals and the number of trees on a site ranged from 4 to 22 per 3 ha. Two sites were logged during the interval between measurements and none of the marked trees was still standing. Data from these two sites were not included in subsequent analyses.

During the 5 years between assessments 53 (=18%) of the trees collapsed (Fig. 1). When only those trees that housed colonies or individuals of *G. leadbeateri* were analysed, the rate of collapse was almost identical to that for all trees. *G. leadbeateri* was recorded from 36 trees, of which 6 (=17%) collapsed during the 5-year interval.

Trees collapsed at a rate of 3·6% of the total population per annum. This figure is lower than that recorded by Smith (1980,1982), who observed that 6 of the 55 (=5·5% per annum) trees with hollows in his 28-ha study site at Cambarville, central Victoria, collapsed over a 3-year period. Differences in the results may be due to the small sample size in the study by Smith and the collection of data from a single locality. The difference between the two rates of fall may also represent differences in site-specific factors such as fire history, wind speed, precipitation, exposure and other environmental influences.

Trees collapsed at all but three of the sites surveyed (mean = 1·8 collapsed trees per site). Although trees of all standing forms collapsed, the rate increased amongst the more senescent forms with the highest rates for forms

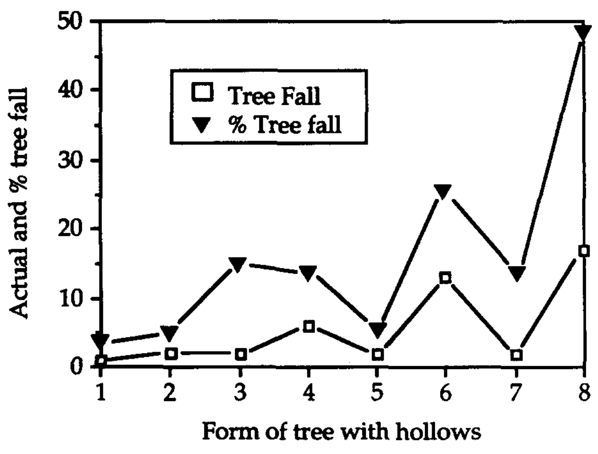

Fig. 1. The actual and percentage collapse of trees with hollows measured on 32 3-ha survey sites in montane ash forests in the Central Highlands of Victoria, south-eastern Australia.

6–8. Almost 50% of trees classified as form 8, and 25% of those classified as form 6, collapsed during the 5-year period between measurements. Of the trees occupied by *G. leadbeateri*, 75% belonged to forms 6, 7 and 8.

A smaller proportion of trees of form 7 collapsed than of forms 6 and 8 (Fig. 1). Only 15 trees of form 7 were encountered, and it appears possible that few trees occur in this class because many collapse while in form 6. Trees of form 6 are dead with the top 50–70% broken away (Lindenmayer *et al.*, 1990). A weak point at the base of such a tree, possibly where fire damage has been severe, could result in its collapse during high winds. Many collapsed trees had a relatively intact main trunk, indicating that they had not passed through stages 7 and 8.

Logistic regression analyses confirmed a significant difference ($\chi^2 = 33{\cdot}66$, $p < 0{\cdot}01$) between the forms of trees and their susceptibility to collapse (see Fig. 1). By 1988, 58% of all trees examined were decayed by an increased 1–2 categories of form than in 1983. The highest rates of transition were amongst trees of form 6 and 8. Thus, trees in montane ash forests have a natural ontogeny of forms and the classification system has considerable value.

Transition probabilities amongst trees with hollows

From the matrix of transition probabilities (Table 1) it can be seen that

(1) the lowest rates of transition are experienced by trees in the early stages of senescence (forms 1 and 2);
(2) the highest rates of transition occur in forms 6, 7 and 8, which are trees in advanced phases of decline. Trees in these forms were more likely to progress through 2 or more stages of decay than those in other forms;
(3) the probability of collapse increased with advancing senescence (Fig. 1);
(4) a high rate of transition was observed amongst trees of form 3. Trees in this form have only recently died and have all their branches intact. Such trees will tend to pass quickly into more advanced stages of decay.

Future decline and availability of trees

Application of the transition probability matrix to data on the number of trees at each of 529 sites surveyed revealed that in 50 years time all trees now classified in forms 6, 7 and 8 would have collapsed. In 75 years time all trees now in forms 3 to 8 would have fallen (Fig. 2). Only 40% of those trees currently classified as form 1, and 23% of those of form 2, are expected to be still standing in 75 years time (Fig. 2).

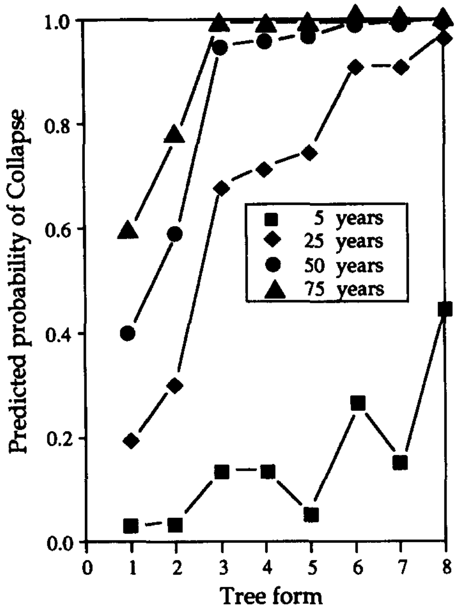

Fig. 2. The predicted probability of collapse of trees with hollows calculated for time intervals of 5, 25, 50 and 75 years from 1983 using Markov Chain methods (see text).

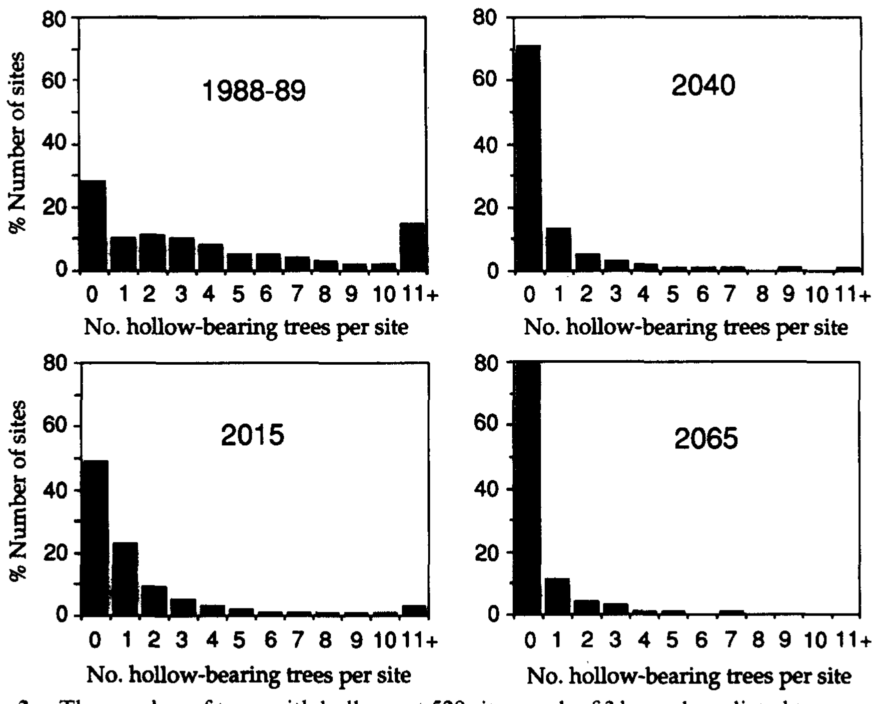

Fig. 3. The number of trees with hollows at 529 sites, each of 3 ha and predicted to occur in the years 2015, 2040 and 2065.

Less than 5% of the 529 sites surveyed are predicted to support more than 3 trees with hollows per 3 ha in 50 years time and no sites could be expected to support 8 or more such trees per 3 ha in 75 years (Fig. 3).

DISCUSSION

Implications of the decline and collapse of trees for the conservation of *G. leadbeateri*

The declining number of trees with hollows has clear implications for the long-term survival of *G. leadbeateri*. The species has specific needs for trees which are in an advanced stage of decay. However, these more senescent forms of trees are the most susceptible to collapse, and large areas of montane ash forest in the Central Highlands of Victoria are rapidly becoming, or are already, extensively depleted of suitable nesting sites for *G. leadbeateri*. Many of the trees examined were more suited for occupation by other species of arboreal marsupials. In addition, present clear-felling practices will exacerbate this situation, with the effects continuing over at least the next 150–200 years (Smith *et al.*, 1985). A low frequency of occurrence of trees with hollows gives a reduced probability of the presence of *G. leadbeateri* (Smith & Lindenmayer, 1988). Current rates of tree fall must lead to a considerable reduction in the abundance and distribution of *G. leadbeateri* and Smith *et al.* (1985) estimated more than a 90% reduction in the total population of the species over the next 50 years.

The collapse of trees in ash-type forests has important implications for the management of forests for timber production. Living trees stand in the forest longer than dead ones. *E. regnans* may live at least 400 years and there is an increase in the number of cavities in a tree with increasing age (Ambrose, 1982). Living trees may provide den sites for at least 250 years plus an additional period during which the dead trees remain standing. This highlights the importance of manipulating mature montane ash forests to retain den trees for the long-term conservation of *G. leadbeateri*. It also suggests a need either to exclude mature and multi-aged forests from commercial harvesting or to modify present silvicultural methods to retain and protect adequate numbers of living trees in logged forests. It is these trees which will provide den trees in the even-aged regrowth on felled sites.

We measured only the number of standing and collapsed trees with hollows. If the internal characteristics of hollows could have been assessed for their suitability for habitation, there is little doubt that many trees with hollows would have proved to be unsuitable for the specific requirements of *G. leadbeateri*. Therefore, the number of trees available to the species may be far less than the number of trees with hollows present in the forest.

Rate of decay of trees

The processes of decay amongst trees are rapid, particularly amongst more senescent forms. Saunders *et al.* (1982, 1985) reached similar conclusions from studies of woodlands in agricultural areas in Western Australia. The majority of trees with hollows in montane ash forests in the Central Highlands resulted from wildfires in 1939. As most are dead and in an advanced state of decay rates of tree fall will continue to be high. This conclusion is supported by Smith (1980), who found a rate of tree fall of approximately 5·5%—1·5 times that of this study. There are already extensive areas in the montane ash forests of the Victorian Central Highlands which do not have any trees with hollows. Of all the sites surveyed (=529), 28% had no trees with hollows and more than 65% had 4 or less such trees (Fig. 3).

There was no significant relationship between the diameter or the species of a tree and its susceptibility to collapse. Perhaps the influence of species and diameter are masked by other factors such as aspect, exposure and the fire intensity at the time of death. The potential impacts of these variables on the decline of trees were not examined in this study but warrant further investigation.

Predictions of the future availability of trees with hollows

Our models predict a substantial decline in the population of trees with hollows over the next 75 years and when this is coupled with the already large number of sites without such trees (Fig. 3), it is clear that much of the montane ash forest will be devoid of potential nest sites not only for *G. leadbeateri* but also for other wildlife.

In 75 years' time virtually all of the sites predicted to support 4 or more trees per 3 ha will occur in two areas (Deep Creek and Watts Creek Reference areas) which are managed primarily for water production by the Melbourne and Metropolitan Board of Works. The importance of these areas for wildlife will increase with time and it is strongly recommended that these forests remain protected from harvesting. Other areas of mature or multi-aged montane ash forest occurring on lands managed by the Board of Works and the Department of Conservation, Forests and Lands should also be excluded from harvesting as they represent some of the only forests predicted to support trees with hollows in the future.

Within the 75-year span over which predictions were made in our study, it is unlikely that many new trees with hollows will become available to wildlife. Most of the montane ash forests within the Central Highlands are even-aged, having originated from the 1939 wildfires. Living trees in these stands are now 50 years old. Ambrose (1982) showed that cavities first begin forming in *E. regnans* at an age of approximately 120 years. The longest predicted interval which estimates tree decline (75 years) extends until only the fastest growing species in montane ash forests (*E. regnans*) will *first* begin to support cavities.

Clear-felling and the loss of trees

Clear-felling is the predominant form of harvesting in montane ash forests (Victorian Government, 1986). Few, or no, large living trees are retained on logging coupes as they are considered to inhibit the vigour and quality of regenerating stands (Loyn, 1985). Inadequate regeneration is put forward as a disadvantage of using selective logging regimes (Cremer *et al.*, 1984), but may be only a perceived problem inferred from studies of other types of forests (Incoll, 1979; Rotherham, 1983).

Even where trees are excluded from harvesting they may suffer rapid deterioration from exposure and windthrow and many appear to die within two years of clear-felling of surrounding areas. Where large trees are retained, some are subsequently felled to collect seed to be used in the regeneration of harvested coupes.

After harvesting, most of the trees retained on a clear-felled coupe are substantially taller than the surrounding regrowth stand and are very exposed and susceptible to windthrow. There are few data on windthrow in Australian forests, although Featherstone (in Australian Biological Research Group, 1984) reported an annual collapse of 5% of living trees reserved for seed production on harvested coupes in East Gippsland, Victoria.

A conflict exists between the desire of land managers to retain some tall, living trees on harvested areas and the use of intense fires to promote the regeneration of vegetation on these sites. Fires are used to create an ash bed, which facilitates seed germination of eucalypts and enhances the vigour of the subsequent regrowth. These fires may kill or badly damage retained trees. A fire lit to regenerate a forest will be the second intense fire experienced by many trees. Some trees may remain standing after such fires but are converted to hollow pipes. These are not suitable as den or roost sites for most wildlife that is dependent on hollows. At one clear-felled and regenerated site examined in 1983, all trees with hollows carried recent fire scars. Only one of these trees was still standing in 1988. Studies in eucalypt forests other than those of ash-type species indicate that trees with hollows are likely to be badly damaged by a regeneration burn. Inions (1985) noted that within forests of jarrah *Eucalyptus marginata* and marri *Eucalyptus calophylla* in south-west Western Australia the condition of trees with hollows was an important factor influencing their survival after fire. Dead and extensively decayed trees were most susceptible to the effects of fire and damage to trees increased with increasing fire intensity. Perry *et al.* (1985) and Saunders (1979) reported similar findings.

If clear-felling continues on relatively short-term rotations of 80–120 years, few or no trees reach an age when cavities can develop to a stage suitable for occupation by wildlife. The absence of trees with hollows after clear-felling means that recruitment to the various forms of standing trees will be slow. In addition, catastrophic events such as the 1939 wildfires will not produce large numbers of trees with hollows as has occurred in the past. The majority of stands now contain trees too small to contain hollows suitable for occupation.

The longevity of trees retained on logged areas

Our models of tree decline and collapse, together with knowledge of the effects on standing trees of windthrow and of fires lit to promote regeneration, lead us to predict that the majority of retained trees will not survive more than 25 years. This is well short of the interval between harvesting rotations and the length of time before hollows become available to animals. As a result it appears unlikely that animals that are dependent on hollows in trees could recolonize a harvested area in which no trees had been left until at least 120 years after logging. Smith *et al.* (1985) showed that trees preferred by *G. leadbeateri* were at least 190 years old.

Policies which call for the retention of 10 'habitat trees' per 15 ha of logged forest (Department of Conservation, Forests and Lands, 1988) appear to be inadequate and there must be an urgent re-appraisal of clear-felling operations in montane ash forests. More trees need to be retained and particular attention needs to be directed toward ensuring the survival of existing living mature trees as these have the longest standing life.

The effects of logging on the longevity of existing trees with hollows must be examined. The identification of techniques for retaining trees, as well as ensuring the perpetual supply of nest sites for fauna dependent on hollows in harvested areas, must be a major priority of wildlife management research in montane ash forests in Victoria.

Management strategies to ensure the retention of trees in montane ash forests

(1) Retain more large living trees (form 1) on harvested areas. These have the highest probability of long-term survival.
(2) Retain trees excluded from harvesting in clusters. These provide retained trees with greater protection from exposure and windthrow,

as well as minimizing the impacts of shelterwood on the quality of the regrowth stand. Clusters should be retained in more sheltered areas where they are likely to be less exposed and not as vulnerable to windthrow. Where possible these clusters should be distributed in a regular pattern.

(3) Investigate the longevity of trees retained on logged coupes. Means of protecting these trees should be identified and applied.

(4) Exclude mature and multi-aged forests from harvesting. Those administered by the Melbourne and Metropolitan Board of Works should not be logged by clear-felling methods as they constitute some of the largest contiguous areas of mature montane ash forest and therefore have significant conservation value.

(5) Do not fell any trees with hollows during harvesting.

(6) Investigate methods of regenerating harvested forests that do not use high-intensity fires.

(7) Harvest montane ash forests over a longer period of rotation to allow at least some trees to develop hollows suitable for occupation by wildlife.

(8) Although most montane ash forests are now predominantly even-aged, management strategies should be developed which produce multi-aged stands.

REFERENCES

Ambrose, G. J. (1982). An ecological and behavioural study of vertebrates using hollows in eucalypt branches. PhD thesis, La Trobe University, Bundoora, Victoria.

Australian Biological Research Group (1984). The impacts of timber production and timber harvesting on native flora and fauna. Report to the Board of Inquiry into the Timber Industry, Victoria.

Bailey, N. T. (1964). *The Elements of Stochastic Processes with Application to the Natural Sciences*. Wiley, London.

Cremer, K. W., Cromer, R. N. & Florence, R. G. (1984). Stand management. In *Eucalypts for Wood Production*, ed. W. E. Hillis & A. G. Brown. Academic Press, Sydney. pp. 81–135.

Department of Conservation, Forests & Lands (1988). Summary of Forest Prescriptions for the Dandenong Region. Department of Conservation, Forests and Lands, Melbourne.

Horn, H. S. (1975). Forest succession. *Scient. Am.*, **232**, 90–8.

Incoll, W. D. (1979). Effects of overwood trees on growth of young stands of *E. sieberi*. *Aust. For.*, **42**, 110–6.

Inions, G. (1985). The interactions between possums, habitat trees and fire. BSc thesis, Australian National University, Canberra.

Lindenmayer, D. B., Smith, A. P., Craig, S. A. & Lumsden, L. F. (1989). A survey of the distribution of leadbeater's possum, *Gymnobelideus leadbeateri* McCoy, in the Central Highlands of Victoria. *Vict. Nat.*, **106**, 174–8.

Lindenmayer, D. B., Cunningham, R. B., Tanton, M. T., Smith, A. P. & Nix, H. A. (1990). The conservation of arboreal marsupials in the montane ash forests of the central highlands of Victoria, south-east Australia, I. Factors influencing the occupancy of trees with hollows. *Biol. Conserv.*, **54** (this issue), 111–31.

Loyn, R. H. (1985). Strategies for conserving wildlife in commercially productive eucalypt forest. *Aust. For.*, **48**, 95–101.

McCullagh, P. & Nelder, J. A. (1983). *Generalized Linear Models.* Chapman and Hall, New York.

Perry, D. H., Lenz, M. & Watson, J. A. (1985). Relationships between fire, fungal rots and termite damage in Australian forest trees. *Aust. For.*, **48**, 46–53.

Rotherham, I. (1983). Suppression of surrounding vegetation by veteran trees in karri (*Eucalyptus diversicolor*). *Aust. For.*, **46**, 8–13.

Saunders, D. A. (1979). The availability of tree hollows for use as nest sites by white-tailed cockatoos. *Aust. Wildl. Res.*, **6**, 205–16.

Saunders, D. A., Smith, G. T. & Rowley, I. (1982). The availability and dimensions of tree hollows that provide nest sites for cockatoos (Psittaciformes) in Western Australia. *Aust. Wildl. Res.*, **6**, 205–16.

Saunders, D. A., Rowley, I. & Smith, G. T. (1985). The effects of clearing for agriculture on the distribution of cockatoos in the southwest of Western Australia. In *Birds of Eucalypt Forests and Woodlands: Ecology, Conservation and Management*, ed. A. Keast, H. Recher, H. Ford & D. Saunders. Royal Australasian Ornithologists Union and Surrey Beatty and Sons, Sydney. pp. 309–21.

Smith, A. P. (1980). The diet and ecology of leadbeater's possum and the sugar glider. PhD thesis, Monash University, Melbourne.

Smith, A. P. (1982). Leadbeater's possum and its management. In *Species at Risk: Research in Australia*, ed. R. H. Groves & W. D. Ride. Australian Academy Science, Canberra. pp. 129–47.

Smith, A. P. & Lindenmayer, D. B. (1988). Tree hollow requirements of leadbeater's possum and other possums and gliders in timber production forests of the Victorian Central Highlands. *Aust. Wildl. Res.*, **15**, 347–62.

Smith, A. P., Lindenmayer, D. B. & Suckling, G. C. (1985). The ecology and management of leadbeater's possum. Research Report to World Wildlife Fund, University of New England, Armidale, NSW.

Victorian Government (1986). Timber Industry Strategy. *Government Statement No. 9.* August 1986. Government Printer, Melbourne.