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# The Vertebrate Fauna of Broombush *Melaleuca uncinata* Vegetation in North-western Victoria, with Reference to Effects of Broombush Harvesting

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*Abstract*

The vertebrate fauna of broombush *Melaleuca uncinata* vegetation in north-western Victoria was assessed by censusing in marked quadrats, trapping and wide-ranging observations. Most species of vertebrates known to occur in mallee shrublands in Victoria were recorded in broombush (those recorded included four amphibian, 42 reptile, 126 bird and 18 mammal species). This high diversity resulted from a substantial variation in vertebrate (particularly reptile and bird) species composition between broombush of differing ages (0–80 years). Some floristic variation between broombush stands and the local presence within these stands of particular plant species (notably *Triodia irritans* and *Banksia ornata*) also added to vertebrate species diversity. Locally, broombush patches were characteristically simple in structure and of low floristic diversity. Bird species diversity and density were low (<3 individuals per ha). Broombush is being harvested at an accelerating rate in Victoria. The effects of this industry on vertebrates generally are minor. No vertebrate species is restricted to broombush, and most vertebrate species recorded in this survey were found in harvested areas. Nonetheless, broombush is an important habitat for several species (e.g. *Ctenophorus pictus, Ctenotus uber, C. brooksi, Leipoa ocellata, Pachycephala rufogularis, Psophodes nigrogularis, Drymodes brunneopygia, Cercartetus lepidus* and *Notomys mitchelli*). Information on the ecology of most species of vertebrates living in the mallee is very limited, and some species may be affected by broombush cutting through a decrease in area of habitat of suitable age.

## Introduction

Broombush (or broom honey-myrtle) *Melaleuca uncinata* is characteristically a dominant species in mallee vegetation on solodised solonetz soils where a shallow (<50 cm) sand layer overlies semipermeable or limestone clay (Coaldrake 1951; Specht 1966; Lewis 1979). Such vegetation is typically floristically depauperate (compared to mallee heaths) and structurally simple, with broombush forming a narrow dense canopy. Associated species include *Eucalyptus incrassata* and *E. foecunda* (scattered individuals of which may protrude above the broombush canopy), *Baeckea behrii, Calytrix tetragona* and *Phebalium bullatum*. Vegetation dominated by broombush often forms distinct patches with abrupt boundaries, but may also intergrade with heath vegetation (dominated usually by *Banksia ornata* or *Casuarina pusilla*) or include some heath components (e.g. *Casuarina muellerana, Baeckea crassifolia, Callitris verrucosa, Hakea muellerana*).

Patches of broombush are of even age, usually resulting from vegetative regrowth following bushfires. Particular patches can be aged from detailed fire maps of the mallee area (Cheal *et al.* 1979). One fire in 1959 was particularly extensive and probably burnt most

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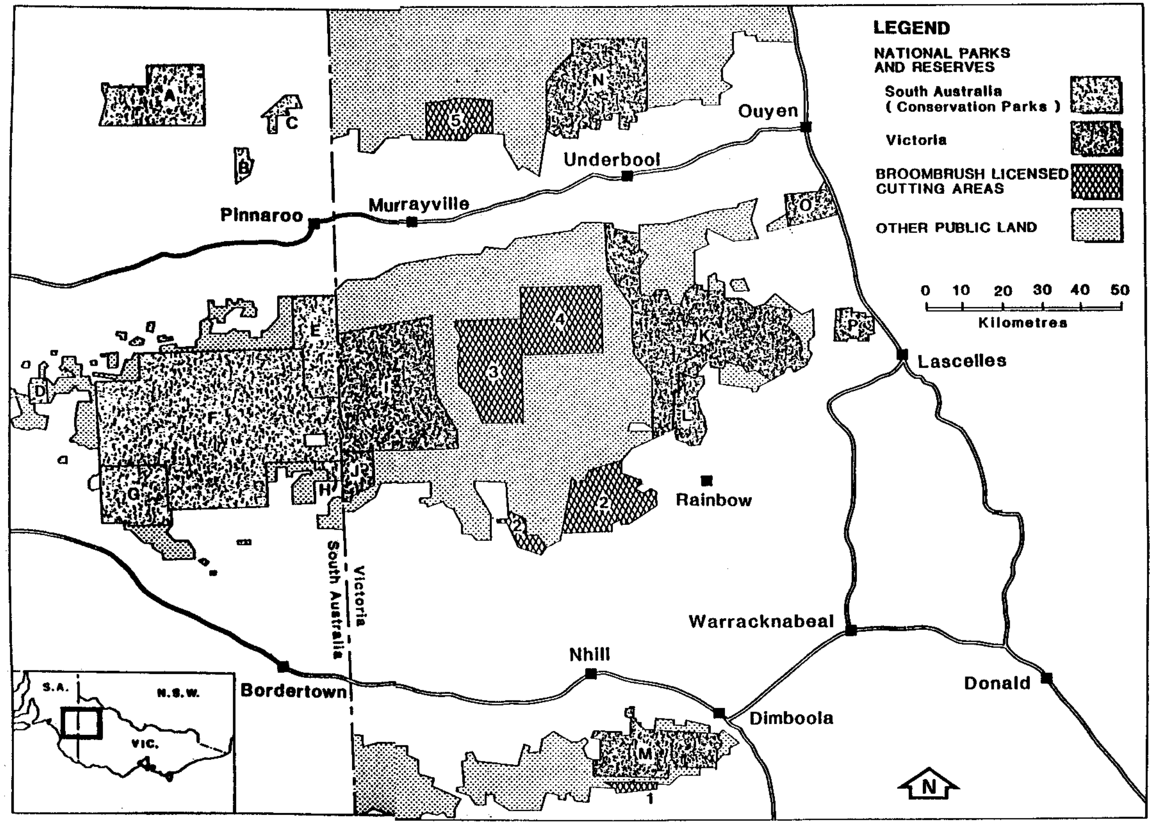


**Fig. 1.** Northwestern Victoria and adjacent South Australia, showing public land, national parks and conservation reserves, and broombush cutting areas. South Australia (Conservation Parks): A. Billiatt, B. Karte, C. Peebinga, D. Carcuma, E. Scorpion Springs, F. Ngarkat, G. Mount Rescue, H. Mount Shaugh. Victoria: I. Big Desert Wilderness, J. Red Bluff Faunal Reserve, K. Wyperfeld N.P., L. Lake Albacutya Station Park, M. Little Desert N.P., N. Pink Lakes State Park, O. Bronzewing Faunal Reserve, P. Wathe Faunal Reserve. Broombush licenced cutting areas: 1. Solomit Strawboards, 2. D. Wallis, 3. R. Freeman, 4. T. Delisio/T. Campbell, 5. A. MacLean.

of the broombush in the Big Desert. Frost may also defoliate broombush patches and lead to the establishment of new cohorts. This is a much rarer event and the effects of only one period of very severe frosts (winter 1982) were evident in this region.

Broombush is now also being harvested for fencing material over increasing areas of public and private land in north-western Victoria (Fig. 1). It is cut manually. Again, this leads to patches of broombush regrowth of nearly uniform age and structure. The effects of cutting differ from those of natural disturbance in that the pace of harvesting is relatively sedate, damage to coexisting plant species other than broombush is minor, and disturbance is restricted to 'high quality' broombush patches and not other adjacent vegetation. The removal of much broombush foliage may also affect local availability of nutrients in a manner different to that of frost and fire. However, broombush harvesting is typically a messy operation, with many broombush plants left lying on the ground.

Harvesting has occurred in the Victorian mallee on an extensive scale only since the 1970s (Woinarski 1988), but has a longer history in South Australia, and occurs on a similar scale in New South Wales. Preferred age for cutting is from 10–25 years, and cutters plan to return to regrowth from previously harvested areas. In this study all broombush patches that were harvested were of regrowth originating from the 1959 fire.

This work was prompted by concern about the environmental effects of such an industry in an area where there has been little biological work (Woinarski 1988). Accordingly, I sought to (1) document what vertebrate species occurred in broombush vegetation; (2) consider whether broombush was a particularly important habitat for these species; (3) compare the abundance of vertebrate species between broombush patches of different history; and (4) determine how these species were affected by broombush cutting.

## Materials and Methods

### *Study Area*

In Victoria, broombush occurs widely across the Big Desert, and less extensively, in the Sunset Country and the Little Desert. It may also be a dominant species of the mallee isolates of north central Victoria (Bridgewater 1979). The Big Desert region is semiarid, with hot, mainly dry summers and mild winters. Average annual rainfall is 300–350 mm, about 65% of which falls between May and October (Land Conseravation Council 1974).

Clearing of native vegetation in the mallee has been substantial this century (Frankenberg 1971), and continues on a large scale. However, extensive areas of uncleared land remain in the Big Desert, Sunset Country and, less so, the Little Desert. Vegetation in these areas is a complex mosaic, corresponding mainly to relatively minor local variations in microclimate, topography and soil type (Coaldrake 1951).

### *Procedure*

Eleven main sites were chosen to sample broombush habitats with a range of histories. Nine sites were in the Big Desert, and one each in the Little Desert and Sunset Country. At all sites, I established a series of 50 by 50 m (0·25 ha) quadrats. The vegetation in these quadrats was recorded in terms of disturbance history, floristics and structure. Vegetation was divided into seven vertical layers (>5 m, 3–5 m, 2–3 m, 1·5–2 m, 1–1·5 m, 0·5–1 m and 0·0–0·5 m) and the percentage projective cover of foliage was estimated separately for every layer and for every species. An estimate of the amount of foliage for every species was derived from this by summing, over all height intervals, the products of percentage cover and depths of respective intervals. The resulting value was divided by 100 to express amount as volume of foliage ($m^3$) above unti ground area ($m^2$). The proportion of ground covered by litter or left bare was also estimated for every quadrat.

In all, 210 quadrats were established in vegetation containing broombush; a further 21 were located in heathy vegetation without broombush but with history and structure comparable to nearby broombush areas. These quadrats were used for estimating densities of birds and the abundance of reptiles.

For censusing birds, I visited every quadrat 40 times, spacing the visits approximately evenly throughout the year. At every visit I immediately recorded the number and identity of all birds present in the quadrat. In practice, a short time was usually spent in searching the quadrat, but care was taken not to include birds entering the quadrat after I had. The density (number per ha) was calculated for every species by summing the number of individuals seen over all visits and dividing this by 10.

For censusing reptiles, I established an additional 15 quadrats and visited all quadrats once (between 1100 and 1800 on warm or hot days from September–December 1985). For 10 min I actively sought all reptiles present on the quadrat, by removing loose bark from trees, by raking leaf litter, by digging up burrows, by turning over rocks, fallen limbs, *Triodia* tussocks and other low spreading vegetation, by shaking hollows, and by scanning open ground with binoculars. All individuals caught or seen were identified and tallied.

I established 17 trap-lines spaces over nine of the study sites. Trap-lines consisted of permanently placed large (28·5 cm by 45 cm) and small (20 by 28 cm) pitfall traps, connected by 15–20 cm high flywire driftlines, and with a spacing of 4–5 m between traps. Separated from this, by at least 10 m, was a line of baited Elliot (9 by 9 by 32 cm) and cage (16 by 20 by 36 cm) traps. Trapping period was for 36–72 h per visit, with four or five visits per site between March and December 1985. Pitfall traps were covered and driftlines, Elliot and cage traps removed between trapping visits. The number of traps and proportion of trap types varied between different sites, so I used an index of Effective Trap Period to calculate abundance for vertebrate species at all trap sites (Appendix 1).

The study period was from November 1984 to December 1985, with six main censusing trips of 3–6 weeks (January/February, March/April, May/June, July/August, September/October and November/December 1985). With some minor exceptions, all quadrats were censused for birds on all trips.

Additional to intensive censuses of quadrats and trapping I made wide-ranging searches for vertebrates, and recorded details of vertebrate species seen wherever they were encountered in broombush. For reptiles, I used a pro-forma recording sheet to describe vegetation in a circle of radius 5 m (centred on the reptile) whenever reptiles were seen within 5 m of at least one broombush plant. Vegetation details described were those used to describe the vegetation of census quadrats.

Quadrats were classified *a priori* into groups of varying history, and the abundance of birds and reptiles in these groups were compared using one-way analysis of variance.

I used Detrended Correspondence Analysis (DCA) (Hill 1979*b*) to ordinate plant species compositions of all 231 quadrats, and also of the 135 quadrat subset of these which contained broombush and were last burnt in 1959. These 135 quadrats fell into six groups: undisturbed since 1959; affected by severe frost 4 years before; and harvested 8 5, 3 and 1 years before. A similar procedure was followed for bird species composition of all 231, and of the subset of 135, quadrats.

Quadrats were also classified *a posteriori* by plant, bird and reptile species composition, using the classification procedure TWINSPAN (Hill 1979*a*). The interrelationships of the resulting groupings were considered with contingency coefficients (Siegel 1956).

I recorded details of foraging (plant species used, foraging site) for all birds recorded during quadrat censuses.

Terrestrial invertebrates were sampled incidentally through captures in pitfall traps. The number, size and taxon (to at least the level of order) of all invertebrates (> 1 mm in length) caught were recorded. I also sampled broombush foliage (50 samples of 100 g, with sampling spread throughout the year) and searched these for invertebrates (method as in Woinarski and Cullen 1984).

The reptiles of the Victorian mallee have been comparatively well studied. In two recent surveys (Mather 1979; Coventry, personal communication), a range of mallee habitats (including broombush) were trapped for reptiles. I analysed further the results from these surveys to compare abundance of reptile species in broombush with that in other mallee vegetation types. For both studies, I calculated a broombush preference index (BP) for every species as:

$$\mathrm{BP} = (n/N) \times (T/t)$$

where $n$ = the number of individuals caught in broombush, $N$ = the total number of individuals caught in all vegetation types, $t$ = the number of broombush traplines, and $T$ = the total number of traplines. This index varies from zero, if the species was not trapped in broombush, through one if trapped in the same rate in broombush as in all vegetation types sampled, to $T/t$ if trapped exclusively in broombush. Any departure from one can be tested for statistical significance by $\chi^2$ analysis.

## Results

### *Vegetation of Quadrats Grouped by History*

Quadrats of different history varied mainly in structure, ground cover and floristic diversity (Table 1). Vegetation height increased with age, with broombush reaching 5 m, 60 years after disturbance. Fire affected foliage profile more than frost or cutting, especially in reducing structural diversity. The proportion of bare ground decreased with vegetation age. Litter cover was more extensive in regrowth following cutting or frost damage than in regrowth of comparable age following fire. Average number of plant species decreased with vegetation age, although this was irregular. Many plant species occurred broadly across vegetation history, although some species (e.g. *Gyrostemon australasicus*, *Exocarpos sparteus*,

**Table 1. Vegetation of quadrats grouped according to disturbance history**

Values shown are means with s.d. in parentheses. *N*, No. of quadrats

| Quadrat history (years) | *N* | % Cover for height intervals (m) 0–0·5 | 0·5–1 | 1·0–1·5 | 1·5–2·0 | 2–3 | >3 | % Bare ground | No. plant species |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Broombush | | | | | |
| Cut 1–2 | 14 | 46·5 (7·7) | 31·5 (10·5) | 30·5 (7·7) | 22·0 (8·7) | 11·9 (6·5) | 0·9 (1·8) | 56·4 (8·4) | 12·6 (2·3) |
| Cut 3 | 9 | 34·8 (10·6) | 66·1 (9·2) | 55·0 (9·4) | 29·1 (11·0) | 8·3 (3·5) | 0 | 57·2 (5·7) | 7·7 (2·6) |
| Cut 4–5 | 26 | 34·0 (15·0) | 55·2 (15·7) | 47·3 (13·3) | 34·7 (11·1) | 28·8 (14·1) | 3·8 (7·9) | 42·7 (9·8) | 7·6 (2·7) |
| Cut 6–10 | 10 | 20·1 (4·4) | 35·7 (7·0) | 57·8 (10·6) | 50·2 (12·7) | 9·7 (6·2) | 1·0 (2·1) | 42·5 (11·4) | 7·0 (0·9) |
| Frost 3 | 22 | 45·0 (17·3) | 46·7 (14·4) | 57·0 (18·5) | 53·4 (23·9) | 24·5 (14·6) | 4·0 (6·6) | 46·1 (8·4) | 9·3 (3·5) |
| Fire 4 | 27 | 52·9 (12·8) | 55·2 (14·2) | 19·1 (16·0) | 7·2 (12·6) | 1·2 (4·0) | 0 | 83·7 (8·5) | 7·5 (4·2) |
| Fire 8 | 4 | 58·3 (16·5) | 67·8 (11·7) | 42·0 (7·8) | 13·0 (7·6) | 1·8 (2·4) | 0 | 55·0 (5·8) | 11·0 (2·9) |
| Fire 26 | 54 | 35·2 (14·6) | 39·0 (13·8) | 48·6 (15·6) | 41·4 (16·8) | 25·8 (23·3) | 6·3 (9·5) | 37·4 (16·0) | 10·1 (3·7) |
| Fire 40 | 17 | 11·3 (5·6) | 14·9 (5·2) | 15·7 (6·1) | 19·4 (9·4) | 48·2 (15·4) | 13·9 (9·0) | 14·4 (6·1) | 5·9 (2·1) |
| Fire 60–80 | 27 | 7·2 (11·6) | 8·3 (9·9) | 8·6 (5·8) | 11·5 (5·9) | 37·3 (10·8) | 16·0 (11·6) | 22·0 (11·8) | 4·0 (3·0) |
| | | | | Non-broombush | | | | | |
| Fire 1 | 2 | 41·5 | 33·5 | 3·0 | 0 | 1·0 | 0 | 90·0 | 12·0 |
| Fire 26 | 18 | 57·2 (24·6) | 78·9 (30·4) | 75·6 (23·7) | 40·7 (24·6) | 12·9 (15·0) | 6·9 (12·8) | 12·6 (7·2) | 10·1 (5·1) |
| Fire 60–80 | 1 | 23 | 53 | 52 | 42 | 20 | 5 | 30 | 9 |

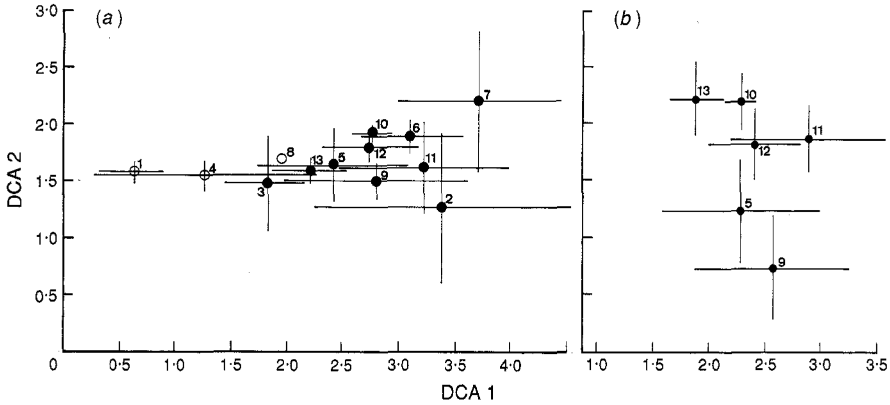


**Fig. 2*a*.** Ordination of the 231 quadrats by DCA of plant species composition. Circles show position of mean for all groups. Horizontal and vertical lines are one standard deviation along axes 1 and 2 respectively. Open circles are quadrats without broombush; closed circles are quadrats with broombush. The groups are: 1, burnt 1 year before ($N=2$); 2 burnt 4 years before ($N=27$); 3, burnt 8 years before ($N=4$); 4, burnt 26 years before ($N=18$); 5, burnt 26 years before ($N=54$); 6, burnt 40 years before ($N=17$); 7, burnt 80 years before ($N=27$); 8, burnt 80 years before ($N=1$); 9, burnt 26 years before, frost 4 years before ($N=22$); 10, burnt 26 years before, harvested 8 years before ($N=10$); 11, burnt 26 years before, harvested 5 years before ($N=26$); 12, burnt 26 years before, harvested 3 years before ($N=9$); 13, burnt 26 years before, harvested 1 year before ($N=14$).

Species significantly correlated on Axis 1 (only those recorded in at least 10 quadrats): *Acacia calamifolia* ($r=0·36$, $P<0·001$), *Hakea muellerana* ($r=0·13$, $P<0·05$), *Leptospermum coriaceum* ($r=0·19$, $P<0·01$), *Lepcopogon cordifolius* ($r=0·22$, $P<0·001$), *Melaleuca acuminata* ($r=0·20$, $P<0·01$), *Prostanthera aspalathoides* ($r=0·14$, $P<0·05$). *Astroloma conostephioides* ($r=-0·14$, $P<0·05$), *Baeckea crassifolia* ($r=-0·18$, $P<0·01$), *Callitris verrucosa* ($r=-0·17$, $P<0·01$), *Calytrix tetragona* ($r=-0·14$, $P<0·05$), *Casuarina pusilla* ($r=-0·15$, $P<0·05$), *Grevillea ilicifolia* ($r=-0·30$, $P<0·001$), *Hibbertia sericea* ($r=-0·14$, $P<0·05$), *Phebalium buliatum* ($r=-0·14$, $P<0·05$), *Phyllota pleurandroides* ($r=-0·28$, $P<0·001$), plant species diversity ($r=-0·19$, $P<0·01$). Correlated on Axis 2: *Acacia calamifolia* ($r=0·17$, $P<0·05$), *Adenanthos terminalis* ($r=0·30$, $P<0·001$), *Leptospemum coriaceum* ($r=0·25$, $P<0·001$), *Melaleuca acuminata* ($r=0·19$, $P<0·01$), *M. uncinata* ($r=0·14$, $P<0·05$), *Brachyloma ericoides* ($r=-0·17$, $P<0·01$), *Casuarina muellerana* ($r=-0·16$, $P<0·05$), *Cryptandra leucophracta* ($r=-0·13$, $P<0·05$), *Hibbertia stricta* ($r=-0·13$, $P<0·05$), *Phyllota pleurandroides* ($r=-0·19$, $P<0·01$).

**Fig. 2*b*.** Ordination of 135 broombush quadrats (all last burnt 26 years before) by DCA of plant species composition. Symbols and group numbers as for Fig. 2*a*. Species significantly correlated on Axis 1: *Dodonaea bursariifolia* ($r=0·58$, $P<0·001$), *Eutaxia microphylla* ($r=0·29$, $P<0·001$), *Lasiopetalum baueri* ($r=0·34$, $P<0·001$), *Melaleuca uncinata* ($r=0·56$, $P<0·001$), *Astroloma conostephioides* ($r=-0·39$, $P<0·001$), *Paeckea behrii* ($r=-0·17$, $P<0·05$), *Baeckea crassifolia* ($r=-0·29$, $P<0·001$), *Brachyloma ericoides* ($r=-0·40$, $P<0·001$), *Calytrix tetragona* ($r=-0·33$, $P<0·001$), *Casuarina muellerana* ($r=-0·27$, $P<0·01$), *Cryptandra leucophracta* ($r=-0·34$, $P<0·001$), *Dillwynia glaberrima* ($r=-0·41$, $P<0·001$), *Grevillea pterosperma* ($r=-0·33$, $P<0·001$), *Hakea muellerana* ($r=-0·50$, $P<0·001$), *Hibbertia sericea* ($r=-0·30$, $P<0·001$), *H. stricta* ($r=-0·48$, $P<0·001$), *Leptospermum coriaceum* ($r=-0·47$, $P<0·001$), *Leucopogon cordifilius* ($r=-0·19$, $P<0·05$), *Micromyrtus ciliatus* ($r=-0·24$, $P<0·01$), *Phebalium bullatum* ($r=-0·22$, $P<0·01$), plant species diversity ($r=-0·73$, $P<0·001$). Species significantly correlated with Axis 2: *Acacia calmifolia* ($r=0·48$, $P<0·001$), *Baeckea behrii* ($r=0·28$, $P<0·001$), *Dodonaea bursariifolia* ($r=0·21$, $P<0·05$, *Lasiopetalum baueri* ($r=0·30$, $P<0·001$), *Leucopogon cordifolius* ($r=0·44$, $P<0·001$), *Phebalium bulatum* ($r=0·28$, $P<0·001$), *Brachyloma ericoides* ($r=-0·49$, $P<0·001$), *Calytrix tetragona* ($r=-0·47$, $P.<0·001$), *Dillwynia glaberrima* ($r=-0·36$, $P<0·001$), *Eucalyptus foecunda* ($r=-0·63$, $P<0·001$), *Eutaxia microphylla* ($r=-0·38$, $P<0·001$), *Hibbertia stricta* ($r=-0·44$, $P<0·001$), *Leucopogon rufus* ($r=-0·19$, $P<0·05$), *Micromyrtus ciliatus* ($r=-0·34$, $P<0·001$).

*Helichrysum leucopsideum*, *Olearia lepidophylla*, *O. rudis* and *Scaevola aemula*) were restricted to recently disturbed areas. There was no apparent invasion of harvested areas by weedy species (Woinarski 1988).

The 13 quadrat groups showed substantial segregation on the first axis of DCA by plant species composition (Fig. 2*a*). Floristic diversity declined along this axis, with the floristically rich non-broombush quadrats (groups 1 and 4) falling at the extreme left, and the oldest broombush sites on the extreme right. A range of plant species characteristic of heaths was negatively correlated with this axis. The second axis probably relates to vegetation age, with those groups that had remained unburnt for the longest period (Nos 6 and 7) scoring highest on this axis, and a recently burnt group (2) the lowest. With the DCA restricted to the 135 quadrats last burnt in 1959 (Fig. 2*b*), the first axis was again related to declining floristic diversity. The group of quadrats which had been cut most recently (13) had the highest floristic diversity. The second axis clearly separated the four harvested groups from the frost-damaged and undisturbed groups. Plant species associated with this axis are listed in the caption for this figure. This floristic difference may be an effect of harvesting. Alternatively, it may reflect the selection of broombush sites by harvesters. This possible floristic response to harvesting could be determined through a repeated floristic description of sites before and after harvesting.

**Table 2. Number of invertebrates caught in pitfall traps (all trapsites combined), per 1200 trap h**

| Taxon | Day | Night |
|---|---|---|
| Arachnida | | |
| Scorpions | 0·2 | 0·2 |
| Mites | 1·5 | 0·1 |
| Spiders | 7·5 | 11·5 |
| Collembola | | |
| Springtails | 0 | 0·1 |
| Blattodea | | |
| Cockroaches | 0·6 | 0·8 |
| Isoptera | | |
| Termites | 0·1 | 0 |
| Orthoptera | | |
| Grasshoppers and crickets | 1·8 | 1·5 |
| Hemiptera | | |
| Bugs | 0·2 | 0·1 |
| Neuroptera | | |
| Lacewings | 0 | 0·1 |
| Coleoptera | | |
| Beetles | 4·9 | 8·0 |
| Diptera | | |
| Flies | 0·5 | 0·2 |
| Lepidoptera | | |
| Moths and butterflies | | |
| Adults | 0 | 0·2 |
| Larvae | 0·2 | 0·3 |
| Hymenoptera | | |
| Ants | 191·2 | 81·2 |
| Other | 0·8 | 0·3 |
| Chilopoda | | |
| Centipedes | 0·2 | 1·3 |
| Diplopoda | | |
| Millipedes | 0·5 | 2·2 |
| Annelida | | |
| Worms | 0·1 | 0·4 |
| Total | 209·9 | 108·1 |
| Total individuals caught | 2732 | 1960 |
| Total trapdays | 1301 | 1813 |

*Invertebrates*

Over all samples, the average density of invertebrates on broombush foliage was 0·09 individuals per $m^2$ of foliage. This is remarkably low, and appreciably less than the average of 10·1 per $m^2$ for 125 other Victorian plant species sampled by Woinarski and Cullen (1984).

In contrast, the terrestrial invertebrate community under broombush vegetation was rich (Table 2). Ants were the most abundant taxon, especially during daylight hours. Catch rates (for all taxa combined) increased from July/August (116 individuals per 2400 traphours) to November/December (427 individuals per 2400 traphours). Ants were more numerous in recently burnt sites than elsewhere, and total invertebrate density was highest in intermediate-aged (26 year old) broombush (Table 3). Catch rates for ants and for all invertebrates combined, was lowest in broombush over 40 years old.

**Table 3. Significant variation between broombush histories in the percentage of traps catching invertebrates**

***$P < 0·001$

| Invertebrate Taxon | Cut | Frost | 4 yr fire | 26 yr fire | >40 yr fire | $\chi^2$ |
|---|---|---|---|---|---|---|
| Ants | 30 | 30 | 38 | 33 | 23 | 19·8*** |
| All invertebrates | 49 | 46 | 54 | 59 | 42 | 20·5*** |
| No. of traps | 601 | 184 | 186 | 825 | 1138 | |

*Amphibians*

Four frog species were trapped in broombush during this survey (Table 4). No other Victorian amphibian species has been recorded from broombush. The burrowing frog *Neobatrachus pictus* was common and often caught far from standing water (though usually during or soon after rains). Trapping success was highest in old broombush.

*Reptiles*

(i) *Results from other studies.* Trapping results from Mather (1979) and A. J. Coventry (personal communication) are summarised and re-analysed in Table 5. For five species, *Lucasium damaeum*, *Ctenophorus pictus*, *Ctenotus brooksi*, *C. uber* and *Lerista bougainvillii*, the broombush preference index was greater than one in both studies. Three species, *Phyllodactylus marmoratus*, *Lialis burtonis* and *Ctenophorus fordi* were under-represented in broombush in both; for *C. fordi* this was markedly significant. Eight species showed broombush preference indices which were inconsistent, probably because of low sample sizes in one or both studies. Most species were distributed widely across the vegetation types sampled, and no species (with at least five individuals captured) was restricted to broombush.

(ii) *Results from this study.* The reptile community of broombush vegetation varied according to history (Table 6). In searches of quadrats with old broombush (>30 years old) I found few species and few individuals, although the skink *Lerista bougainvillii* was recorded most frequently in such quadrats. Quadrats with recent (<10 years) natural disturbance had high numbers of the dragons *Ctenophorus fordi* and *C. pictus*. Quadrats where broombush had been harvested had the highest numbers of the gecko *Diplodactylus intermedius* and the skinks *Menetia greyii* and *Morethia obscura*. Quadrats without broombush had relatively high numbers of *C. fordi*, *M. obscura*, *M. greyii*, *Delma australis* and *Ctenotus uber*.

Trapping results (Table 4) were broadly similar to results from quadrat searches. *C. pictus*, *C. uber* and *M. greyii* were trapped most commonly in recently disturbed (<10 years) areas. Other than *Trachydosaurus rugosus*, few reptiles were trapped in old (>30 years) broombush. Most (16 of 20) species were trapped in areas from which broombush had been harvested.

**Table 4. Percentage trapping success for all vertebrate species, according to vegetation history**

| Species | Total caught | Burnt 1959, cut since | Burnt 1959, frost or fire since | Burnt 1959, undisturbed since | Last burnt >40 yrs ago |
|---|---|---|---|---|---|
| Amphibians | | | | | |
| *Limnodynastes dumerilii* | 7 | 0 | 0 | 0 | 1·6 |
| *Neobatrachus pictus* | 17 | 0·8 | 2·4 | 1·1 | 1·2 |
| *N. sudelli* | 3 | 0 | 0·4 | 0 | 0·4 |
| *Pseudophyrne bibronii* | 2 | 0 | 0 | 0 | 0·4 |
| Total | 29 | 0·8 | 2·8 | 1·1 | 3·6 |
| Reptiles | | | | | |
| *Diplodactylus vittatus* | 21 | 0·6 | 0 | 0·8 | 0·6 |
| *Lucasium damaeum* | 5 | 0·5 | 0 | 0·6 | 0·9 |
| *Phyllodactylus marmoratus* | 10 | 0 | 0·1 | 0 | 0 |
| *Delma australis* | 3 | 0·3 | 0 | 0 | 0·2 |
| *Pygopus lepidopodus* | 1 | 0 | 0 | 0·1 | 0 |
| *Amphibolorus nobbi* | 1 | 0 | 0 | 0 | 0·3 |
| *A. norrisi* | 5 | 0·2 | 0 | 0·2 | 0 |
| *Ctenophorus fordi* | 24 | 1·0 | 0 | 1·2 | 0 |
| *C. pictus* | 13 | 0·3 | 5·9 | 0·8 | 0 |
| *Pogona vitticeps* | 1 | 0 | 0 | 0 | 0·3 |
| *Ctenotus brooksi* | 2 | 0·1 | 0 | 0·1 | 0 |
| *C. robustus* | 2 | 0·1 | 0 | 0·1 | 0 |
| *C. uber* | 11 | 0·8 | 0·6 | 0·1 | 0 |
| *Lerista bougainvillii* | 11 | 0·4 | 0 | 0·4 | 0·3 |
| *Menetia greyii* | 5 | 0·6 | 2·3 | 0 | 0·6 |
| *Morethia obscura* | 36 | 1·5 | 0·6 | 1·6 | 0·4 |
| *Tiliqua occipitalis* | 1 | 1·2 | 0 | 0 | 0 |
| *Trachydosaurus rugosus* | 24 | 2·7 | 2·9 | 0 | 6·4 |
| *Ramphotyphlops australis* | 3 | 0·1 | 0 | 0·1 | 0·2 |
| *Unechis nigriceps* | 5 | 0·2 | 0 | 0·2 | 0·1 |
| Total | 175 | 10·6 | 12·3 | 6·4 | 10·2 |
| Mammals | | | | | |
| *Sminthopsis murina* | 4 | 0·8 | 0 | 0·8 | 0 |
| *Cercartetus concinnus* | 15 | 0·6 | 0 | 1·5 | 1·0 |
| *C. lepidus* | 30 | 1·3 | 0·4 | 0·7 | 0·9 |
| *Mus musculus* | 59 | 1·6 | 3·9 | 2·8 | 1·5 |
| *Notomys mitchelli* | 18 | 1·0 | 0·9 | 0·3 | 1·0 |
| *Pseudomys apodemoides* | 18 | 2·4 | 2·1 | 0·4 | 0·5 |
| Total | 144 | 7·6 | 7·3 | 6·4 | 4·9 |
| Birds | | | | | |
| *Drymodes brunneopygia* | 4 | 1·7 | 0 | 0·5 | 0 |
| | | Total trap periods | | | |
| Large pitfalls (day) | | 162 | 18 | 128 | 291 |
| (night) | | 189 | 21 | 163 | 339 |
| Small pitfalls (day) | | 990 | 160 | 1030 | 385 |
| (night) | | 1064 | 224 | 1125 | 521 |
| Elliot traps (day) | | 342 | 163 | 367 | 572 |
| (night) | | 425 | 214 | 522 | 787 |
| Cage traps (day) | | 84 | 40 | 89 | 179 |
| (night) | | 109 | 48 | 123 | 205 |

Another 457 individuals of 28 reptile species were observed within 5 m of broombush plants. For these records the vegetation history is summarised in Table 7, and vegetation structure for the 10 species with most records is given in Fig. 3. Only three (rarely observed) species were not recorded in cut areas. Four species, *D. australis*, *C. fordi*, *C. pictus* and

**Table 5. Trapping success for reptiles in broombush habitats relative to other mallee habitats, from studies of Mather (1979) and A. J. Coventry, personal communication**

*N*, No. of individuals caught in all habitats; B.I., broombush preference index; *P*, probability that the trap success is significantly different in broombush than in other habitats. *$P<0\cdot05$; **$P<0\cdot01$; ***$P<0\cdot001$

| Species | Mather | | | Coventry | | |
|---|---|---|---|---|---|---|
| | *N* | B.I. | *P* | *N* | B.I. | *P* |
| More common in broombush | | | | | | |
| *Lucasium damaeum* | 55 | 2·03 | ** | 8 | 3·24 | |
| *Ctenophorus pictus* | 48 | 3·00 | *** | 72 | 1·26 | |
| *Ctenotus brooksi* | 57 | 2·38 | *** | 30 | 1·00 | |
| *C. uber* | 3 | 8·00 | | 45 | 1·06 | |
| *Lerista bougainvillii* | 21 | 1·52 | | 50 | 2·08 | *** |
| *Pygopus lepidopodus* | 0 | – | | 7 | 1·86 | |
| *Amphibolurus nobbi* | 25 | 1·28 | | 0 | – | |
| *Tympanocryptis lineata* | 0 | – | | 1 | 4·33 | |
| *Egernia inornata* | 6 | 5·34 | | 0 | – | |
| *Unechis spectabilis* | 0 | – | | 5 | 1·73 | |
| Less common in broombush | | | | | | |
| *Phyllodactylus marmoratus* | 1 | 0 | | 2 | 0 | |
| *Delma australis* | 2 | 0 | | 26 | 1·00 | |
| *Lialis burtonis* | 1 | 0 | | 5 | 0·87 | |
| *Ctenophorus fordi* | 278 | 0 | *** | 213 | 0·44 | *** |
| *Unechis nigriceps* | 1 | 0 | | 13 | 1·00 | |
| *Diplodactylus intermedius* | 9 | 0·89 | | 0 | – | |
| *Pogona vitticeps* | 0 | – | | 13 | 0·67 | |
| *Varanus gouldii* | 0 | – | | 1 | 0 | |
| *V. rosenbergi* | 0 | – | | 2 | 0 | |
| *Ctenotus brachyonyx* | 8 | 0 | | 0 | – | |
| *Tiliqua occipitalis* | 0 | – | | 1 | 0 | |
| *Ramphotyphlops bituberculatus* | 0 | – | | 23 | 0·38 | |
| *Echiopsis curta* | 0 | – | | 9 | 0·48 | |
| *Pseudonaja textilis* | 0 | – | | 2 | 0 | |
| Inconsistent preferences | | | | | | |
| *Diplodactylus vittatus* | 12 | 0 | | 21 | 1·64 | |
| *Aprasia inaurita* | 9 | 0·89 | | 15 | 2·60 | *** |
| *Amphibolurus norrisi* | 2 | 0 | | 42 | 1·44 | |
| *Ctenotus robustus* | 12 | 4·00 | *** | 73 | 0·47 | * |
| *Menetia greyii* | 4 | 0 | | 18 | 1·93 | * |
| *Morethia obscura* | 55 | 0·44 | | 54 | 1·20 | |
| *Ramphotyphlops australis* | 2 | 0 | | 3 | 1·44 | |
| *Drysdalia mastersii* | 2 | 0 | | 21 | 2·06 | ** |

*C. uber*, occurred typically in areas with dense low vegetation but with little foliage above 2 m. Ground cover varied substantially; *Phyllodactylus marmoratus*, *C. fordi*, *C. pictus* and *C. uber* usually occurred at sites where more than 50% of the ground was bare, whereas all other species occurred where litter covered an average of more than 60% of the ground. Sites where these 10 reptile species were recorded also varied in floristic composition (Table 8). Most notable was an association of *C. fordi* and *D. australis* with the refuge-providing grass *Triodia irritans*.

Additional to this survey, other studies (Cohen 1985; Hillas 1985; Land Conservation Council 1985; A. J. Coventry, personal communication) have recorded 10 more Victorian reptile species from broombush vegetation (Appendix 2). In broombush vegetation in central New South Wales, Caughley (1985) trapped a further four species whose range is known to extend to Victoria.

**Table 6. Results of quadrat searches for reptiles**

Values shown are number of individuals recorded and, in parentheses, the number of quadrats recorded. Only significant $\chi^2$ values are shown. $^{**}P<0\cdot01$; $^{***}P<0\cdot001$

| Species | Burnt 1959, cut since | Burnt 1959, frost or fire since | Burnt 1959, undisturbed since | Last burnt >40 years ago | Total | $\chi^2$ |
|---|---|---|---|---|---|---|
| No. of quadrats | 69 | 53 | 59 | 44 | 225 | |
| *Diplodactylus intermedius* | 4 (3) | 0 | 0 | 0 | 4 (3) | |
| *Delma australis* | 6 (5) | 3 (1) | 2 (2) | 0 | 11 (8) | |
| *Ctenophorus fordi* | 9 (8) | 17 (12) | 10 (8) | 0 | 36 (28) | 15·9** |
| *C. pictus* | 1 (1) | 15 (12) | 8 (4) | 0 | 4 (17) | 25·9*** |
| *Ctenotus uber* | 3 (3) | 3 (3) | 1 (1) | 0 | 7 (7) | |
| *Lerista bougainvillii* | 3 (3) | 2 (2) | 1 (1) | 5 (4) | 11 (10) | |
| *Menetia greyii* | 30 (22) | 1 (1) | 4 (4) | 7 (6) | 42 (33) | 35·5*** |
| *Morethia obscura* | 23 (18) | 11 (9) | 7 (6) | 3 (2) | 44 (35) | 12·1** |
| All other species | 5 (5) | 5 (4) | 4 (3) | 1 (1) | 15 (13) | |
| Total individuals | 87 | 56 | 38 | 16 | 127 | 21·4*** |
| Total quadrats with reptiles | 45 | 33 | 25 | 12 | 115 | 9·4** |
| Mean No. per quadrat | 1·26 | 1·06 | 0·64 | 0·36 | 0·88 | |

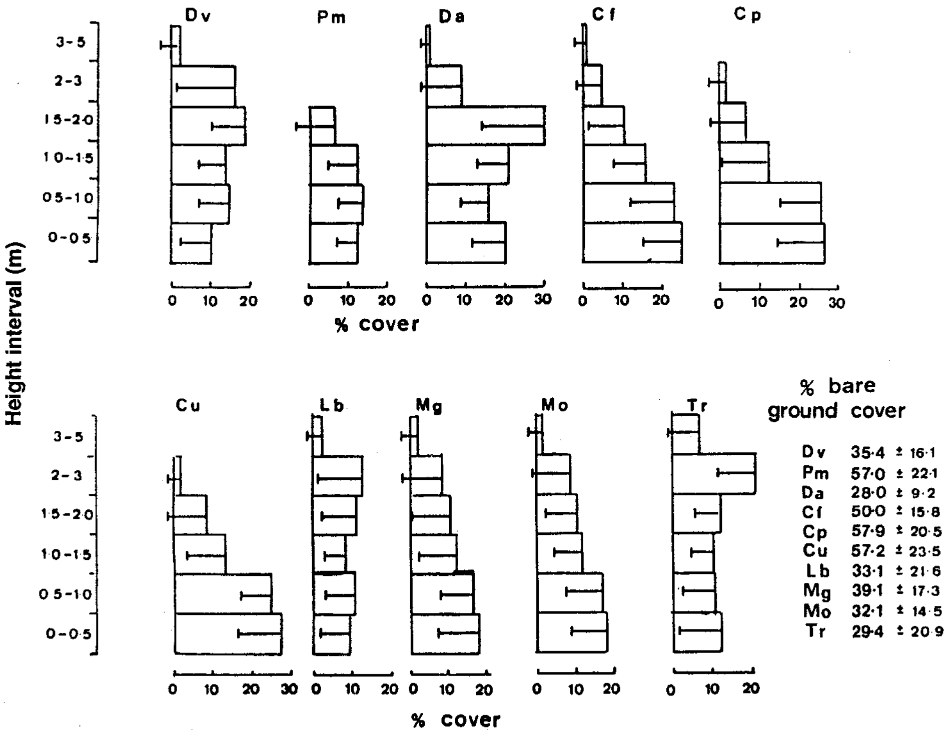


**Fig. 3.** Vegetation structure (% horizontal cover for six height intervals) for broombush sites where reptiles species were recorded. Sample sizes as for Table 7. Reptile species: Dv *Diplodactylus vittatus*; Pm *Phyllodactylus marmoratus*; Da *Delma australis*; Cf *Ctenophorus fordi*; Cp *C. pictus*; Cu *Ctenotus uber*; Lb *Lerista bougainvillii*; Mg *Menetia greyii*; Mo *Morethia obscura*; Tr *Trachydosaurus rugosus*. One standard deviation below the mean is indicated by horizontal line. For all height intervals and bare ground, cover differs significantly ($P<0\cdot001$) between reptile species (ANOVA).

**Table 7. History of broombush vegetation (in years) for all reptile sightings**

*N*, No. of records

| Species | *N* | Latest fire | | | | Frost | Cut | |
|---|---|---|---|---|---|---|---|---|
| | | <5 | 6–15 | 16–30 | >30 | <5 | <5 | 6–15 |
| *Diplodactylus intermedius* | 3 | | | 3 | | | 2 | 1 |
| *D. vittatus* | 13 | | | 6 | 7 | | | 2 |
| *Lucasium damaeum* | 2 | | | 1 | 1 | | | |
| *Phyllodactylus marmoratus* | 10 | | | 10 | | | | 2 |
| *Delma australis* | 10 | | | 10 | | | | 2 |
| *Pygopus lepidopodus* | 2 | | | 1 | 1 | | | |
| *Aprasia inaurita* | 3 | | | 1 | 2 | | 1 | |
| *Lialis burtonis* | 1 | | | 1 | | | 1 | |
| *Amphibolorus nobbi* | 3 | | | 2 | 1 | | 1 | |
| *A. norrisi* | 4 | | | 4 | | | 1 | |
| *Ctenophorus fordi* | 94 | 11 | 9 | 74 | | 1 | 22 | 7 |
| *C. pictus* | 77 | 40 | 5 | 30 | 2 | 6 | 6 | |
| *Pogona vitticeps* | 4 | 1 | 1 | 2 | | | 2 | |
| *Varanus gouldii* | 3 | | | 1 | 2 | | 1 | |
| *Ctenotus brooksi* | 5 | | | 5 | | | 2 | |
| *C. robustus* | 3 | | | 2 | 1 | 1 | | 1 |
| *C. uber* | 18 | 8 | 2 | 8 | | | 3 | 1 |
| *Egernia inornata* | 2 | | | 1 | 1 | | 1 | |
| *Lerista bougainvillii* | 26 | 3 | 1 | 8 | 14 | 1 | 3 | 2 |
| *Menetia greyii* | 54 | 3 | 1 | 40 | 10 | 1 | 32 | 4 |
| *Morethia obscura* | 74 | 3 | 1 | 60 | 10 | 2 | 32 | 5 |
| *Tiliqua occipitalis* | 3 | | | 3 | | | 2 | |
| *Trachydosaurus rugosus* | 39 | | 2 | 5 | 32 | 5 | | 1 |
| *Lampropholis delicata* | 1 | | | | 1 | | | |
| *Ramphotyphylops australis* | 3 | | | 1 | 2 | | 1 | |
| *Drysdalia mastersii* | 1 | | | 1 | | | | |
| *Pseudonaja textilis* | 1 | | | 1 | | | 1 | |
| *Unechis nigriceps* | 2 | | | 2 | | | 2 | |

**Table 8. Plant species with significant variation in presence between sites for the 10 most commonly-recorded reptile species**

Values shown are $m^3$ of foliage/100 $m^2$ of ground area. $\chi^2$ values are based on the relative proportion of sites where given plant species occurred. *$P<0·05$; **$P<0·01$; ***$P<0·001$. Abbreviations for reptile species as in Fig. 2

| Plant species | Reptile species | | | | | | | | | | $\chi^2$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Dv | Pm | Da | Cf | Cp | Cu | Lb | Mg | Mo | Tr | |
| *Baeckea behrii* | 9·5 | 3·5 | 3·4 | 6·1 | 3·4 | 3·6 | 4·4 | 5·9 | 6·1 | 3·5 | 65·6*** |
| *B. crassifolia* | 0·9 | 0·7 | 1·2 | 1·4 | 0·5 | 0·8 | 0·3 | 0·5 | 0·8 | 0·5 | 40·2*** |
| *Brachyloma ericoides* | 0·8 | 0·9 | 0·3 | 1·4 | 0·6 | 0·6 | 0·5 | 0·4 | 1·1 | 0·9 | 36·8*** |
| *Callitris verrucosa* | 1·6 | 0·3 | 0·7 | 1·0 | 1·0 | 1·1 | 1·1 | 0·4 | 0·6 | 1·4 | 17·1* |
| *Calytrix tetragona* | 1·1 | 1·6 | 0·2 | 2·4 | 1·5 | 0·9 | 1·7 | 0·5 | 1·4 | 0·5 | 51·8*** |
| *Eucalyptus foecunda* | 0·2 | 0 | 4·2 | 1·0 | 2·9 | 0·9 | 1·3 | 1·4 | 1·5 | 5·4 | 33·9*** |
| *E. incrassata* | 9·4 | 0·4 | 16·3 | 8·5 | 8·2 | 9·2 | 9·8 | 7·1 | 9·2 | 11·3 | 18·2* |
| *Hakea muellerana* | 0·4 | 0·5 | 0 | 1·0 | 0·7 | 0 | 0 | 1·0 | 0·7 | 0·3 | 20·5* |
| *Hibbertia stricta* | 1·0 | 0·2 | 1·0 | 1·4 | 0·9 | 0·7 | 0·4 | 0·3 | 0·8 | 1·2 | 38·6*** |
| *Lasiopetalum behrii* | 0·7 | 0 | 1·6 | 0 | 0·4 | 0 | 0·4 | 0·9 | 0·4 | 0·3 | 25·8** |
| *Leptospermum coriaceum* | 2·5 | 0·9 | 1·8 | 3·0 | 0·8 | 1·7 | 1·3 | 1·5 | 1·7 | 1·5 | 50·4*** |
| *Triodia irritans* | 0 | 0 | 2·7 | 2·7 | 0·5 | 0·8 | 0·2 | 0·9 | 0·4 | 0 | 86·7*** |

**Table 9. Mean density (No./10 ha) for bird species recorded in at least 10 broombush quadrats**

*N*, No. of records. $*P<0{\cdot}05$; $**P<0{\cdot}01$

| Species | *N* | Cut 1–2 yr | Cut 3 yr | Cut 4–5 yr | Cut 6–10 yr | Frost 3 yr | Fire 4 yr | Fire 8 yr | Fire 26 yr | Fire 40 yr | Fire 60–80 yr | *F*-ratio (d.f. = 9200) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No. of quadrats | | 14 | 9 | 16 | 10 | 22 | 27 | 4 | 54 | 17 | 27 | |
| *Leipoa ocellata* | 14 | 0 | 0 | 0 | 0 | 0·09 | 0 | 0 | 0·06 | 0·05 | 0·4 | 4·2** |
| *Phaps chalcoptera* | 10 | 0·07 | 0·1 | 0 | 0 | 0·09 | 0 | 0 | 0·02 | 0 | 0·2 | 2·2* |
| *Drymodes brunneopygia* | 124 | 0·6 | 1·4 | 1·2 | 3·5 | 4·9 | 0·3 | 0·3 | 2·9 | 2·7 | 0·9 | 9·0** |
| *Petroica goodenorii* | 24 | 0 | 0 | 0·2 | – | 0·09 | 0 | 0 | 0·07 | 0·2 | 0·7 | 5·9** |
| *Pachycephala pectoralis* | 81 | 0·6 | 0·2 | 0·8 | 1·0 | 0·6 | 0·3 | 0 | 0·6 | 0·5 | 0·5 | 1·2 |
| *Colluricincla harmonica* | 71 | 0·2 | 0·1 | 0·4 | 0·08 | 1·0 | 0·5 | 0·3 | 0·6 | 0·5 | 0·3 | 2·4* |
| *Cinclosoma castanotum* | 19 | 0 | 0·7 | 0·04 | 0 | 0 | 0·7 | 0 | 0·2 | 0·05 | 0 | 2·4* |
| *Pomatostomus superciliosus* | 30 | 0·1 | 0·6 | 0 | 0 | 0·3 | 0·07 | 1·0 | 0·6 | 0·6 | 2·9 | 6·2** |
| *Malurus splendens* | 30 | 0 | 4·4 | 1·1 | 0·2 | 0·4 | 0·3 | 0 | 0·09 | 0 | 1·8 | 8·0** |
| *M. lamberti* | 46 | 1·5 | 1·6 | 0·4 | 0 | 0·7 | 1·2 | 5·8 | 0·4 | 0 | 1·1 | 6·3** |
| *Sericornis cautus* | 67 | 0·4 | 0·2 | 0·7 | 0·3 | 0·5 | 1·3 | 1·0 | 0·3 | 0·1 | 0 | 6·0** |
| *Smicrornis brevirostris* | 119 | 5·0 | 2·6 | 4·4 | 0·2 | 5·3 | 3·3 | 0·5 | 4·3 | 1·4 | 2·0 | 2·8** |
| *Acanthiza apicalis* | 170 | 2·9 | 3·8 | 3·0 | 2·6 | 2·3 | 2·9 | 0·3 | 5·7 | 1·8 | 1·3 | 6·6** |
| *A. nana* | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2·8 | 8·0** |
| *Anthochaera carunculata* | 19 | 0 | 0 | 0·1 | 0·08 | 0·3 | 0·04 | 0 | 0·5 | 0 | 0·3 | 0·9 |
| *Acanthagenys rufogularis* | 27 | 0 | 0·3 | 0·08 | 0·2 | 0·1 | 0 | 1·3 | 0·3 | 0 | 0·9 | 2·1* |
| *Lichenostomus leucotis* | 159 | 0·6 | 1·9 | 2·5 | 1·0 | 4·6 | 1·1 | 1·0 | 2·7 | 1·7 | 2·8 | 4·6** |
| *L. cratitius* | 89 | 0·6 | 0·6 | 1·5 | 0·3 | 2·9 | 0·07 | 3·0 | 1·8 | 0·2 | 0·7 | 3·9** |
| *L. ornatus* | 20 | 0 | 0·3 | 0·3 | 0 | 0·4 | 0·04 | 0 | 0·4 | 0 | 0·04 | 0·8 |
| *Melithreptus brevirostris* | 34 | 1·0 | 0·2 | 0·8 | 0 | 0·5 | 0·1 | 0·8 | 0·5 | 1·0 | 0·6 | 0·9 |
| *Phylidonyris melanops* | 30 | 0·1 | 0·4 | 0·1 | 0·08 | 0·3 | 0·4 | 6·3 | 0·2 | 0 | 0 | 18·0** |
| *P. albifrons* | 10 | 0 | 0·1 | 0·04 | 0 | 0·09 | 0 | 1·3 | 0·2 | 0 | 0·6 | 1·4 |
| *Pardalotus xanthopygus* | 76 | 0·2 | 0·3 | 0·5 | 0·2 | 3·8 | 1·1 | 0 | 2·9 | 0·09 | 0·4 | 4·1** |
| *Zosterops lateralis* | 10 | 0 | 0·2 | 0 | 0 | 0·09 | 0 | 0 | 0·2 | 0 | 0·2 | 1·0 |
| *Cracticus torquatus* | 17 | 0 | 0·1 | 0·05 | 0·1 | 0 | 0 | 0 | 0·2 | 0·09 | 0·1 | 1·0 |
| *Strepera versicolor* | 17 | 0·2 | 0 | 0·08 | 0·1 | 0·2 | 0 | 0 | 0·09 | 0 | 0·04 | 1·5 |
| Total individuals (all spp.) | | 15·4 | 20·6 | 19·0 | 10·1 | 30·7 | 14·9 | 24·5 | 26·8 | 11·7 | 24·8 | 5·1** |
| Mean No. of species/quadrat | | 6·0 | 7·4 | 7·4 | 3·8 | 8·9 | 5·7 | 7·8 | 7·4 | 5·8 | 7·6 | 4·2** |

**Table 10. Bird densities (No./10 ha) in floristically rich ($N=3$; Little Desert) and depauperate ($N=20$; Manya) broombush quadrats unburnt for 60–80 years**

Only bird species with mean density of over 1·0 individuals/10 ha are included. Only significant $t$-values shown (* $P<0·05$; ** $P<0·01$; *** $P<0·001$)

| | Rich quadrats | | Depauperate quadrats | | $t$-value (d.f. = 21) |
|---|---|---|---|---|---|
| | Mean | s.d. | Mean | s.d. | |
| No. of woody plant species/quadrat | 10·3 | 1·5 | 2·5 | 0·8 | 13·7*** |
| *Drymodes brunneopygia* | 6·3 | 0·6 | 0·1 | 0·2 | 34·6*** |
| *Pachycephala inornata* | 2·0 | 1·0 | 0·3 | 0·7 | 3·6** |
| *Pomatostomus superciliosus* | 3·7 | 6·4 | 2·8 | 3·7 | |
| *Malurus splendens* | 0 | | 1·7 | 3·5 | |
| *M. lamberti* | 3·3 | 1·5 | 1·0 | 1·5 | 2·5* |
| *Smicrornis brevirostris* | 2·0 | – | 1·9 | 3·5 | |
| *Acanthiza nana* | 0 | | 2·3 | 3·9 | |
| *Acanthagenys rufogularis* | 7·0 | 2·7 | 0·1 | 0·2 | 11·5*** |
| *Lichenostomus leucotis* | 11·3 | 3·5 | 1·8 | 1·9 | 7·2*** |
| *L. cratitius* | 6·3 | 3·5 | 0 | | 8·1*** |
| *Melithreptus brevirostris* | 5·05 | 6·2 | 0 | | 3·6** |
| *Phylidonyris albifrons* | 5·3 | 4·5 | 0 | | 5·3*** |
| *Anthochaera carunculata* | 2·3 | 2·5 | 0 | | 4·1*** |
| No. of individuals | 62·0 | 17·3 | 18·1 | 9·9 | 6·4*** |
| No. of bird species | 14·7 | 2·3 | 6·3 | 3·0 | 4·7*** |

**Table 11. Comparison of bird densities between quadrats dominated by broombush and those dominated by other heathy species (only for quadrats last burnt in 1959)**

Values shown are mean density (No./10 ha) with standard deviations in parentheses. Only species with mean values of >0·5 individuals/10 ha are listed. Only significant $t$-values are shown. * $P<0·05$; ** $P<0·01$

| Species | Broombush ($N=54$ quadrats) | Non-broombush ($N=18$ quadrats) | $t$-value (d.f. = 70) |
|---|---|---|---|
| *Phaps* | 0 | 0·6 (0·9) | 21·9** |
| *Drymodes brunneopygia* | 2·9 (2·9) | 1·5 (1·9) | |
| *Pachycephala pectoralis* | 0·6 (0·9) | 0·7 (1·0) | |
| *Colluricincla harmonica* | 0·6 (0·9) | 0·3 (0·6) | |
| *Pomatostomus superciliosus* | 0·6 (2·0) | 0·2 (1·0) | |
| *Malurus lamberti* | 0·4 (1·3) | 1·4 (2·7) | |
| *Smicrornis brevirostris* | 4·3 (5·2) | 1·8 (3·7) | |
| *Acanthiza apicalis* | 5·7 (4·1) | 4·6 (2·7) | |
| *A. reguloides* | 0 | 0·7 (2·6) | |
| *A. iredalei* | 0 | 0·9 (2·5) | |
| *Anthochaera carunculata* | 0·5 (1·6) | 0·1 (0·2) | |
| *Acanthagenys rufogularis* | 0·3 (0·7) | 0·5 (0·8) | |
| *Lichenostomus leucotis* | 2·7 (3·1) | 1·6 (1·7) | |
| *L. cratitius* | 1·8 (2·5) | 0·2 (0·4) | 7·0* |
| *L. ornatus* | 0·4 (1·8) | 8·5 (15·4) | 14·6** |
| *Melithreptus brevirostris* | 0·5 (1·3) | 0·7 (1·2) | |
| *Phylidonyris melanops* | 0·2 (0·4) | 4·5 (4·2) | 57·4** |
| *P. albifrons* | 0·2 (1·1) | 0·7 (0·9) | |
| *P. novae-hollandiae* | 0·04 (0·2) | 3·8 (5·6) | 24·8** |
| *Pardalotus xanthopygus* | 2·9 (5·8) | 1·1 (2·6) | |
| Total individuals | 26·8 (17·1) | 34·8 (28·7) | |
| No. of species/quadrat | 7·4 (2·9) | 8·0 (4·3) | |

**Table 12. Summary of foraging records (%) of birds in all quadrats**

Only species with at least 10 foraging records are included. $N$ = total number of foraging acts recorded. '% in broombush' is based on foraging records from plants only (i.e. excluding ground and air)

| Species | $N$ | Ground | Air | Bark | Branches | Leaves | Flowers | % in broombush |
|---|---|---|---|---|---|---|---|---|
| *Leipoa ocellata* | 17 | 100 | | | | | | |
| *Turnix velox* | 10 | 100 | | | | | | |
| *Phaps chalcoptera* | 10 | 100 | | | | | | |
| *P. elegans* | 11 | 100 | | | | | | |
| *Drymodes brunneopygia* | 462 | 100 | | | | | | |
| *Petroica goodenovii* | 38 | 47 | | | 42 | 11 | | 10 |
| *Pachycephala rufogularis* | 45 | 44 | 9 | 2 | 11 | 33 | | 14 |
| *P. inornata* | 34 | 21 | | | 53 | 27 | | 56 |
| *P. pectoralis* | 218 | 18 | 1 | 1 | 31 | 50 | | 26 |
| *P. rufiventris* | 15 | | | 13 | 53 | 33 | | 7 |
| *Colluricincla harmonica* | 106 | 57 | | 3 | 37 | 4 | | 4 |
| *Cinclosoma castanotum* | 32 | 100 | | | | | | |
| *Pomatostomus superciliosus* | 57 | 79 | | | 16 | 5 | | 92 |
| *Malurus splendens* | 58 | 83 | | | 3 | 14 | | 70 |
| *M. lamberti* | 89 | 80 | | | | 20 | | 50 |
| *Sericornis cautus* | 111 | 96 | | | 1 | 3 | | |
| *Smicrornis brevirostris* | 309 | | | | | 100 | | 0 |
| *Acanthiza apicalis* | 625 | | | 2 | 1 | 97 | | 50 |
| *A. reguloides* | 15 | 73 | | | 7 | 20 | | 0 |
| *A. uropygiatis* | 21 | 52 | | 19 | 14 | 14 | | 30 |
| *A. nana* | 38 | | | | | 100 | | 71 |
| *Acanthagenys rufogularis* | 57 | | | 21 | 51 | 28 | | 9 |
| *Lichenostomus leucotis* | 504 | 1 | 1 | 43 | 26 | 30 | 1 | 2 |
| *L. cratitius* | 189 | 1 | | 1 | 2 | 66 | 30 | 1 |
| *L. ornatus* | 100 | | | | | 55 | 45 | 0 |
| *Melithreptus brevirostris* | 54 | | | 2 | 6 | 72 | 20 | 4 |
| *Phylidonyris melanops* | 121 | 31 | 1 | | 5 | 23 | 40 | 4 |
| *P. albifrons* | 41 | 2 | | | 10 | 34 | 54 | 5 |
| *P. novae-hollandiae* | 39 | | | | 3 | 26 | 72 | 0 |
| *Anthocaera carunculata* | 34 | | 9 | | 3 | 41 | 47 | 0 |
| *Pardalotus xanthopygus* | 185 | | | | | 100 | | 0 |
| *P. striatus* | 10 | | | | | 100 | | 0 |
| *Zosterops lateralis* | 12 | | | | | 100 | | 42 |
| *Cracticus torquatus* | 19 | | | | 95 | 5 | | 5 |
| *Strepera versicolor* | 17 | 94 | | | 6 | | | 0 |

*Birds*

In all, 26 species of birds were recorded in 10 or more quadrats (Table 9). The density of all bird species combined was very low (1–3 individuals per ha). For 18 of these 26 species, there were significant differences in density between vegetation of different histories. This was mainly age-related. Young (<10 years old) vegetation had highest densities of *Phylidonyris melanops*, *Cinclosoma castanotum* and *Sericornis cautus*; intermediate-aged (10–30 years old) of *Drymodes brunneopygia*, and older-aged (>30 years old) of *Leipoa ocellata*, *Pomatostomus superciliosus* and *Acanthiza nana*. Only two of these 26 species were not recorded in harvested quadrats. Another 41 bird species were recorded in less than 10 broombush quadrats, and a further 38 bird species were recorded in broombush in wide-ranging searches (Appendix 2).

Bird species composition in broombush was affected not only by history but also by floristics. Two sites had quadrats located in very old (60–80 years) vegetation dominated by broombush. At one site broombush grew in association with many other plant species. Quadrats here had more bird species and a higher total density than those quadrats in the floristically more depauperate site (Table 10). Quadrats placed in heath vegetation had

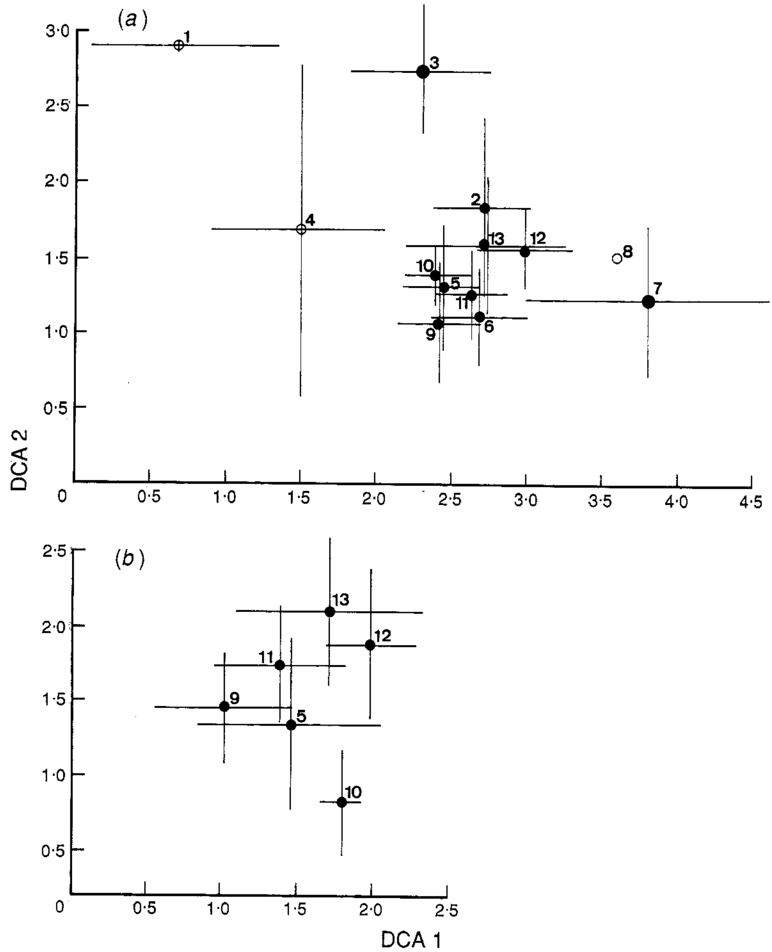


**Fig. 4*a*.** Ordination of the 231 quadrats by DCA of bird species composition. Symbols and group numbers as for Fig. 2*a*. Species significantly correlated with Axis 1: *Leipoa ocellata* ($r=0·15$, $P<0·05$), *Phaps chalcoptera* ($r=0·29$, $P<0·001$), *Petroica goodenovii* ($r=0·34$, $P<0·001$), *Pomatostomus superciliosus* ($r=0·33$, $P<0·001$), *Malurus splendens* ($r=0·45$, $P<0·001$), *M. lambertii* ($r=0·15$, $P<0·05$), *Acanthiza nana* ($r=0·52$, $P<0·001$, *Drymodes brunneopygia* ($r=-0·20$, $P<0·01$), *Lichenostomus cratitius* ($r=-0·19$, $P<0·01$), *L. ornatus* ($r=-0·26$, $P.<0·001$), *Phylidonyris melanops* ($r=-0·42$, $P<0·001$), *P. albifrons* ($r=-0·20$, $P<0·01$), *P. novaehollandiae* ($r=-0·26$, $P<0·001$). Species significantly correlated with Axis 2: *Cinclosoma castanotum* ($r=0·21$, $P<0·01$), *Malurus lambertii* ($r=0·28$, $P<0·001$), *Sericornis cautus* ($r=0·19$, $P<0·01$), *Phylidonyris melanops* ($r=0·40$, $P<0·001$), *Leipoa ocellata* 8$r=-0·20$, $P<0·01$), *Drymodes brunneopygia* ($r=-0·25$, $P<0·001$), *Pachycephala pectoralis* ($r=-0·26$, $P<0·001$), *Colluricincla harmonica* ($r=-0·22$, $P<0·001$), *Pomatostomus superciliosus* ($r=-0·21$, $P<0·01$), *Smicrornis brevirostris* ($r=-0·38$, $P<0·001$), *Lichenostomus leucotis* ($r=-0·31$, $P<0·001$), *L. ornatus* ($r=-0·30$, $P<0·001$), *Phylidonyris novaehollandiae* ($r=-0·22$, $P<0·001$), *Pardalotus xanthopygus* ($r=-0·34$, $P<0·001$).

**Fig. 4*b*.** Ordination of the 135 broombush quadrats (all last burnt 26 years before) by DCA of bird species composition. Symbols and group numbers as for Fig. 2*a*. Species significantly correlated with Axis 1: *Malurus splendens* ($r=0·38$, $P<0·001$), *M. lambertii* ($r=0·21$, $P<0·05$), *Acanthiza apicalis* ($r=0·23$, $P<0·01$), *Colluricincla harmonica* ($r=-0·40$, $P<0·001$), *Smicrornis brevirostris* ($r=-0·42$, $P<0·001$), *Lichenostomus leucotis* ($r=-0·50$, $P<0·001$), *L. cratitius* ($r=-0·28$, $P<0·001$), *L. ornatus* ($r=-0·27$, $P<0·01$), *Pardalotus xanthopygus* ($r=-0·52$, $P<0·001$), total density ($r=-0·38$, $P<0·001$), bird species diversity ($r=-0·39$, $P<0·001$). Species correlated with Axis 2: *Malurus splendens* ($r=0·28$, $P<0·001$), *M. lambertii* ($r=0·34$, $P<0·001$), *Smicrornis brevirostris* ($r=0·50$, $P<0·001$), bird species diversity ($r=0·20$, $P<0·05$), *Drymodes brunneopygia* ($r=-0·56$, $P<0·001$), *Pachycephala pectoralis* ($r=-0·26$, $P<0·01$), *Lichenostomus cratitius* ($r=-0·22$, $P<0·05$).

higher bird densities than those sited in broombush vegetation of comparable age and structure (Table 11).

Most of the bird species present in broombush vegetation foraged on the ground, among *Eucalyptus* foliage or from flowers of *Eucalyptus*, *Banksia* or epacrid species, rather than among broombush foliage, stems or flowers (Table 12). Broombush flowers did not attract honeyeaters and the foliage had a low density of invertebrates. There were few granivorous and no frugivorous birds. Hollow-nesting species were also absent, except as transient foragers, and no treecreepers or sittellas were recorded from broombush.

Other than the species recorded from broombush in this survey, an additional 24 bird species have been reported in broombush vegetation in Victoria by other studies (Schodde 1964; Hunt and Kenyon 1970; Schodde 1981).

Ordination of the bird species composition of the 231 quadrats was analogous to that of the comparable ordination for plant species composition. Again, the non-broombush (heathy) sites separated on the first axis from the broombush sites (Fig. 4*a*). Birds negatively associated with this axis were mainly those species occurring in floristically rich and dense heaths, while those showing a positive correlation favoured more open broombush areas. Again the second axis was associated with vegetation age. Bird species positively correlated with this axis included those typically occurring in recently burnt sites; those negatively associated were restricted mainly to sites with a relatively tall canopy. The six broombush groups that had been burnt last in 1959 were clustered closely (and joined also by the group of sites last burnt 40 years previously). This suggests that variation in bird species composition associated with harvesting was appreciably less than that between very old and very young broombush or between broombush and heath vegetation. Nonetheless, some segregation was apparent when the ordination was restricted to these six groups. The first axis was correlated negatively with density and diversity. It was not related clearly to whether quadrats had been harvested or not, although three of the four harvested groups were on the right of this axis. Species negatively associated were those requiring a *Eucalyptus* canopy; those positively associated were species foraging on the ground or in shrubs. The second axis separated the three most recently harvested groups from the others. Birds positively associated were the two *Malurus* species and *Smicrornis brevirostris*. Those negatively associated were species requiring a fairly dense shrubby canopy, and these species (*Drymodes brunneopygia*, *Pachycephala pectoralis* and *Lichenostomus cratitius*) are probably disadvantaged for up to 8 years after harvesting.

### *Mammals*

Six species of small mammals were trapped (Table 4), most of which were widespread across broombush histories. Overall, trap success was highest in harvested areas and declined with vegetation age. In wide-ranging searches, 12 additional species were recorded from broombush vegetation and other studies (Menkhorst and Beardsell 1982; Coventry and Dixon 1984; Land Conservation Council 1985; J. Caughley, personal communication) have reported a further seven species from broombush in Victoria (Appendix 2).

**Table 13. Contingency coefficients for classification of quadrats by bird species composition, reptile species composition, plant species composition, and history**

Significance of association was tested by $\chi^2$: *$P<0\cdot05$; ***$P<0\cdot001$

| Species | Reptile | Plant | History |
|---|---|---|---|
| Bird | 0·36* | 0·65*** | 0·75*** |
| Reptile | | 0·61*** | 0·53*** |
| Plant | | | 0·80*** |

### *Quadrat Classifications*

All quadrats with broombush were classified into groups determined independently by bird species composition, plant species composition, reptile species composition, and history.

The resulting schemes showed substantial and significant congruity (Table 13). The floristic classification closely matched that of history, suggesting some succession of plant species. The classification of quadrats according to their bird species composition matched closely a classification based on history and also (though less well) that based on floristics. For reptile species composition, the classification was less congruent (though still highly significant) with that of history and plant species composition. The poorer matching may be a consequence of the small number of reptiles recorded per quadrat relative to the number of birds. There was a significant, but weak, correlation between the classification of quadrats by bird and reptile species compositions.

## Discussion

Ahern (1985) listed the extant native vertebrate fauna from the Mallee district of Victoria, and those species he considered to occur within mallee shrubland, including broombush, in this district. His totals were nine and four species respectively for amphibians, 75 and 65 for reptiles, 265 and 121 for birds, and 29 and 19 for mammals. (The significantly lower proportion of Mallee district birds and amphibians recorded from mallee shrubland is due to the restriction of many species in these groups to permanent wetlands.) During this study and through recent literature records, the number of native Victorian species recorded from broombush vegetation comprised four amphibians, 42 reptiles, 126 birds and 18 mammals. At least for birds, the high species total in broombush is inflated by records for many species whose use of broombush is probably incidental; few bird species regularly occur in extensive broombush and those that do are characteristically of only a very limited number of foraging types (Table 9, 12). Nonetheless, these totals represent extraordinary high proportions of the vertebrate species known from mallee shrublands. Such a result may imply that broombush vegetation is a particularly important or pivotal habitat for mallee vertebrate species or, alternatively, that most species of mallee vertebrates occur across a broad range of vegetation types. The former is unlikely, because no vertebrate species was found to be restricted to broombush, and broombush vegetation was depauperate in several important resources (e.g. hollows, foliage invertebrates, nectar-rich flowers, fruit). The latter explanation is more likely and is augmented by the diversity within broombush vegetation. This variability in broombush habitats is related to disturbance history, edaphic factors and mixing of floristic elements from adjacent vegetation types. Previous studies (e.g. Rawlinson 1966; Gilmore and McVicar 1973) have suggested that for mallee reptiles of south-eastern Australia (and, incidentally, south-western Australia, Chapman and Dell 1985) a very broad habitat range is typical.

Succession of vertebrates associated with time since disturbance has been documented elsewhere for mallee reptiles (Cogger 1979; Mather 1979; Longmore and Lee 1981; Caughley 1985), mallee mammals (Cockburn 1981*a*) and suggested for some mallee bird species (Meredith 1982). It has also been demonstrated for vertebrate species in structurally similar heathlands of coastal south-eastern Australia (Kikkawa *et al.* 1979).

Patterns for reptiles are the most apparent, and appear to be influenced directly by availability of food and shelter. Reptile species which require litter for refuge may be excluded from recently burnt areas, and occur only after the vegetation has aged sufficiently to provide a deep layer of fallen leaves and branches. Species which shelter in burrows (e.g. *Ctenophorus fordi*, *C. pictus*, *Ctenotus brooksi*, *Varanus gouldii* and *Egernia inornata*) may not be limited by refuge material, but rather by soil type. Most of these species can move swiftly, and can live relatively safely in areas with much bare ground between refuge sites. No reptile species recorded in broombush was primarily arboreal, so that increasing height and structural development of vegetation is not of itself an important factor in reptile succession. However, increased amount of foliage may moderate surface temperatures, and permit the occurrence of reptile species not physiologically capable of surviving in open exposed areas.

Ants are particularly abundant in recently burnt broombush areas, which may be typical for mallee vegetation (e.g. Andersen 1983). For some reptile species (e.g. *C. pictus* and *C. fordi*) ants are the major food source (Baverstock 1979; A. J. Coventry, personal communication) and such species may achieve very high densities if they can colonise recently burnt areas. However, most reptile species are generalists in diet choice (e.g. Witten and Coventry 1984) and their abundance may be related to the total number of invertebrates, which peaks in broombush of intermediate age. Broombush harvesting probably affects the shelter, microclimate and food availability of reptiles in a similar way to severe frost, and these effects seem much less substantial than those due to bushfire. For those other vertebrates whose distribution is related to vegetation age, the factors determining distribution are probably analogous to those described above for reptiles, except that microclimate may be comparatively unimportant for birds and mammals.

Variability between broombush patches in the associated plant species is also important in determining the distribution of at least some vertebrates (Tables 8, 10, 11), although this factor is confounded by a relationship between history and plant species composition. Particularly important plant species are *Triodia irritans* and *Banksia ornata*. Presence or absence of the former may determine suitability for at least the reptiles *Ctenophorus fordi*, *Delma australis* and *Pygopus lepidopodus*, the mammal *Ningaui yvonneae* and the birds *Amytornis striatus* and *Stipiturus mallee*. *Banksia ornata* has been shown to influence the distribution of *Pseudomys apodemoides* (Cockburn 1981*a*, 1981*b*) and several species of honeyeaters.

Accordingly, there is no discrete vertebrate community tightly associated with broombush, although some species may reach local peaks in abundance within broombush vegetation. Notable species showing such a preference for broombush include the reptiles *Ctenophorus pictus*, *Ctenotus uber*, *C. brooksi*, *Aprasia inaurita*, *Lerista bougainvillii*, *Diplodactylus vittatus*, *Lucasium damaeum* and *Unechis spectabilis*, the birds *Leipoa ocellata*, *Pachycephala rufogularis*, *Psophodes nigrogularis*, *Drymodes brunneopygia* and the mammals *Cercartetus lepidus*, *Pseudomys apodemoides* and *Notomys mitchelli* (Cockburn 1981*a*, 1981*b*; Woinarski 1988). Three of these species may be rare or declining (*L. ocellata*, *P. rufogularis* and *P. nigrogularis*), and information on *C. brooksi*, *U. spectabilis* and *C. lepidus* may be inadequate to determine status. These are the species which may be most affected by harvesting of broombush. For *Psophodes nigrogularis*, available data on habitat and population size are inadequate; for *Pachycephala rufogularis*, detrimental effects are minor and short-lived (Woinarski 1987). The mallee-fowl, *Leipoa ocellata*, may be the species most severely affected, not because its preferred habitat is immediately disturbed, but because cyclical cutting of broombush will increase the proportion of young (<20 years old) vegetation, at the eventual expense of the old and tall broombush patches used by *L. ocellata*. Such old patches are already limited in area, as their occurrence depends on their mostly fortuitous escape from repeated major bushfires. Although these patches are typically depauperate in density and richness of vertebrates, and floristic diversity, the preference of several vertebrate species for vegetation of such age makes their protection highly desirable. Accordingly management of mallee communities should include active attempts to maintain at least the existing proportion of long, undisturbed vegetation.

Harvesting of broombush may be more pernicious than fire or frost if it leads to the spread of pests and weeds. Track-making, traffic, semipermanent campsites, clearing, rubbish-dumping and other human disturbance are associated with brush-cutting, and these are either absent or very minor in mallee vegetation on most public land outside broombush harvesting areas. Cockburn (1981*a*) found that some introduced weed species had colonised recently cleared broombush, but Land Conservation Council (1985) suggested that invasion of broombush areas was minor and restricted to only a few annual grasses. I found no introduced plant species in several recently harvested areas (Woinarski 1988), and no species had colonised appreciably along brush-cutting tracks. The extensive track network used by brush-cutters favours the dispersal of introduced mammals (dog, *Canis familaris*; cat, *Felis catus*; fox, *Vulpes vulpes*; and perhaps rabbit, *Oryctolagus cuniculus*), which are rarely recorded in mallee away from tracks and clearings (Gilmore and McVicar 1973; James 1982). An increase in the distribution and abundance of these species may substantially disturb the native plant and vertebrate communities of broombush and other mallee vegetation types. Traffic associated with broombush harvesting may lead also to localised erosion (Lewis 1979).

The results reported here suggest that broombush harvesting, at current levels, does not have a serious detrimental effect on the vertebrates of broombush communities. This should be qualified by some concern for those, relatively few, species associated mainly with old broombush, by the limited ecological knowledge about many vertebrate species, and by the uncertainty about any extrapolation of these findings if the rates and extent of broombush harvesting are to increase (as has been proposed Ferguson 1985). That said, broombush harvesting represents a further step in the historic degradation of the mallee environment. A preferable focus for the industry would be the marginal farmland fringing the vegetated public land of the Big Desert, Little Desert and Sunset Country blocks. Inquiry into the cultivation of broombush on this already cleared land should be considered immediately.

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## Appendix 1. Example of calculation for Effective Trap Periods and percentage trapping success

Over all sites, total trap periods were 599 trap-days (and 712 trap-nights) for large pitfalls, 2605 trap-days (2984 trap-nights) for small pitfalls, 1444 trap-days (1948 trap-nights) for Elliot traps and 372 trap-days (485 trap-nights) for cage traps. For house mouse, *Mus musculus*, I caught 13 individuals in large pitfalls set at night (a trap success of 1·85%), four in small pitfalls at night (0·13%), two in Elliot traps during the day (0·14%), 40 in Elliot traps at night (2·05%) and none in any of the other trap regimes. All trap regimes were then expressed as a proportion of the most successful regime (in this case the 2·05% for Elliot traps at night). An effective trapping effort for this species at any site could then be calculated, by multiplying the number of large pitfalls set at that site during the day by 0, at night by 0·89 (=1·85/2·05), of small pitfalls during the day by 0, at night by 0·06, of Elliot days by 0·07, of Elliot nights by 1, of cage days by 0, and of cage nights by 0. The number of individuals captured at any site was then expressed as a percentage of this effective trap period.

## Appendix 2. Additional Victorian vertebrate species recorded in broombush during wide-ranging searches of this survey, or by other recent studies

*Reptiles*

Cohen (1985); Hillas (1985): *Delma inornata, Ctenotus brachyonyx, Lerista punctatovittata, Pseudonaja textilis.*

Land Conservation Council (1985): *Amphibolurus muricatus, Pogona barbata.*

A. J. Coventry (personal communication): *Tympanocryptis lineata, Ramphotyphlops bituberculatus, Echiopsis curta, Unechis spectabilis.*

Caughley (1985): *Rhynchoedura ornata, Underwoodisaurus milii, Cryptoblepharus carnabyi, Simoselaps australis.*

*Birds*

This survey: *Dromaius novae-hollandiae, Elanus notatus, Haliastur sphenurus, Aquila audax, Circus assimilis, Falco berigora, F. cenchroides, Accipiter fasciatus, A. cirrhocephalus, Coturnix novae-zelandiae, Turnix varia, T. velox, Ocyphaps lophotes, Phaps elegans, Geopelia placida, Cacatua roseicapilla, Glossopsitta porphyrocephala, Nymphicus hollandicus, Melopsittacus undulatus, Psephotus haematonotus, P. varius, Barnardius barnardi, Neophema elegans, Cuculus pyrrhophanus, Chrysococcyx basalis, C. osculans, C. lucidus, Ninox novaeseelandiae, Tyto alba, Aegotheles cristatus, Podargus strigoides, Caprimulgus guttatus, Apus pacificus, Dacelo novaeguineae, Halcyon sancta, Cheramoeca leucosternum, Hirundo neoxena, Cecropis nigricans, C. ariel, Coracina novae-hollandiae, Petroica phoenicea, Microeca leucophaea, Pachycephala rufogularis, P. inornata, P. rufiventris, Oreoica gutturalis, Rhipidura fuliginosa, R. leucophrys, Stipiturus mallee, Malurus cyaneus, Amytornis striatus, Aphelocephala leucopsis, Acanthiza pusilla, A. uropygialis, A. reguloides, A. chrysorrhoa, Daphoenositta chrysoptera, Manorina flavigula, M. melanotis, Plectorhyncha lanceolata, Lichenostomus virescens, Phylidonyris novae-hollandiae, Certhionyx niger, Ephthianura tricolor, E. albifrons, Dicaeum hirundinaceum, Pardalotus striatus, Carduelis carduelis, Passer domesticus, Sturnus vulgaris, Corcorax melanorhamphos, Artamus cyanopterus, A. personatus, A. superciliosus, A. cinereus, Gymnorhina tibicen, Corvus coronoides, C. mellori, C. bennetti.*

Schodde (1964): *Eopsaltria australis.*

Hunt and Kenyon (1970): *Psophodes nigrogularis.*

Schodde (1981): *Hieraaetus morphnoides, Falco longipennis, Burhinus magnirostris, Calyptorhynchus funereus, Glossopsitta concinna, Trichoglossus haematodus, Neophema chrysostoma, Cuculus pallidus, Ninox connivens, Hirundapus caudacatus, Merops ornatus, Coracina maxima, Lalage sueurii, Petroica multicolor, Melanodryas cucullatus, Myiagra inquieta, Cinclorhamphus mathewsi, Climacteris picumnus, Pardalotus punctatus, Emblema guttata, Poephila guttata, Grallina cyanoleuca.*

*Mammals*

This survey: *Tachyglossus aculeatus, Sminthopsis crassicaudata, Trichosurus vulpecula, Macropus fuliginosa, M. rufogriseus, Tadarida australis, Canis familiaris, Vulpes vulpes, Felis catus, Ovis aries, Lepus capensis, Oryctolagus cuniculus.*

Coventry and Dixon (1984): *Ningaui yvonneae.*

Menkhorst and Beardsell (1982): Land Conservation Council (1985): *Mormopterus planiceps, Chalinolobus gouldii, C. morio, Eptesicus vulturnus, Nycticeius balstoni, Nyctophilus geoffroyi.*

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