From the Editors

Although this issue is not ‘themed’ as such, its contents have a decided leaning towards the botanical end of the natural history spectrum. Two of the papers offered here focus on aspects of plant life. Even within that commonality, however, there is diversity in many features. The localities concerned — Wilsons Promontory and the alpine zone in the Snowy Mountains — are of different types; and the specific focus of each report differs markedly.

Both of these papers are good examples of natural history studies, all the more interesting because of the differing context in which the work reported was done. That one study was carried out within the academic world while the other was in large measure a voluntary study done principally for the interest of its participants, only underlines the view that natural history has applications in a broad range of contexts.

By way of maintaining our usual diversity of content, we include in this issue a paper on sightings of Killer Whales around the south-east coast. Sightings of whales around the Victorian coast are a common occurrence, which is more than can be said for sightings of papers about whales in The Victorian Naturalist.
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Front cover: Austral Grass-tree Xanthorrhoea australis. Photo by Ralph Laby (see p.87).
Back cover: Salmon Sun Orchid Thelymitra rubra. Photo by Dan Carey Photography.
Decline in species richness and cover of exotic plants with increasing altitude

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Abstract
Increasing altitude can result in reduced diversity of exotic plants while disturbance usually benefits exotics. Species richness and cover of exotics was examined in paired 120 m² roadside and adjacent natural vegetation plots at 10 sites along a 1000 m altitudinal gradient from montane to the alpine zone in the Snowy Mountains. Species richness and cover of exotics decreased linearly with increasing altitude in both habitats. The effect of altitude was partly offset by disturbance, with more species and greater cover of exotics on roadside plots. There was high diversity of annual/biennial forbs particularly at low altitude, and few exotic annuals/biennials above 1510 m. The decline in diversity with altitude may be due to differences in disturbance history, with the highest plots having lower levels of use, but the decline in diversity is most likely due to differences in environmental conditions with increasing altitude that limit exotics, particularly annuals/biennials. (The Victorian Naturalist 125 (3), 2008, 64-75)

Introduction
Currently there is a debate about the causes of patterns in species richness including which factors account for a commonly observed decrease in species richness with increasing altitude (Rahbek 1995; Körner 2002). For example, a pattern of decreasing diversity of exotic plant species with increasing altitude has been found in several mountain regions including south-central Chile (Pauchard and Alaback 2004), the Swiss Alps (Becker et al. 2005) and the northwest mountains in North America (Parks et al. 2005). Some studies suggested that climate was a major factor affecting the diversity of exotic plants, while others also considered factors such as a lag effect associated with the dispersal of exotics from valleys or differences in the patterns of human disturbance at higher altitudes as important (Pauchard and Alaback 2004).

In addition to the effects of altitude on species richness, many studies have found that human disturbance benefits exotics including in mountain regions (Lozon and MacIsaac 1997; Jesson et al. 2000; Johnston and Pickering 2001; McDougall 2001; Becker et al. 2005; Godfree et al. 2004; Parks et al. 2005; Hill and Pickering 2006). Disturbance in mountain regions has facilitated the introduction of exotics, both accidentally (by vehicles, in horse feed etc.) and deliberately (rehabilitation/ revegetation) (Mallen-Cooper 1990; Jesson et al. 2000; Tsuyuzaki 2002; Pauchard and Alaback 2004; McDougall et al. 2005). Disturbance also favours the spread of exotics through alteration of habitats. Disturbed sites such as road verges are often characterised by low cover of native vegetation (potentially reducing competition, and providing safe sites for establishment), as well as increased nutrient availability and moisture (Jesson et al. 2000; McDougall 2001; Johnston and Johnston 2004; Johnston 2005; Hill and Pickering 2006). For example, in the Snowy Mountains in the Australian Alps, there is a strong association between exotic plants and human disturbance, with most exotic species occurring along roadsides and around buildings (Costin 1954; Mallen-Cooper 1990; Johnston and Pickering 2001; Bear et al. 2006).

Determining what may be limiting exotic diversity is particularly important in mountain regions, as temperatures are likely to increase, and snow cover decrease with climatic change (Grabherr et al. 1994; Hennessy et al. 2003; Pickering et al. 2004). Therefore, if climate is currently a
limiting factor for exotic species richness in these regions, warming conditions could result in a greater risk of biological invasions (Pickering et al. 2004).

This study examines the effect of altitude and disturbance on exotic species richness. Specifically, the diversity and percentage cover of exotic species in paired sites along roadsides and in adjacent native vegetation were compared along an altitudinal gradient in the Snowy Mountains in Australia. It was hypothesised that:

(1) species richness and cover of exotics would decline with increasing altitude in both roadsides and adjacent plots.

(2) As disturbance is likely to benefit exotics, including at high altitude, species richness and cover of exotic plants would be greater on roadsides than in adjacent plots; and

(3) any decline in species richness and cover of exotics with increasing altitude would, at least in part, be offset by disturbance.

Determining the diversity of exotics and what factors are important in limiting their establishment and spread is critical for the management of biological invasions in mountain regions.

Methods
Study area
The Snowy Mountains in Kosciuszko National Park are located in south-eastern Australia and are part of the Australian Alps (Fig. 1). There are three main floristic zones: montane, subalpine and alpine, which are strongly correlated with altitudinal/climatic gradients and which contain distinctive vegetation communities (Costin 1954; Good 1992).

The montane zone occurs between ~500 m and ~1500 m (Good 1992) and is dominated by Eucalyptus pauciflora alliance woodlands in association with other Eucalyptus species. Construction and maintenance of dams, powerlines, buildings and both sealed and gravel roads are the primary sources of anthropogenic disturbance in the montane zone, associated with a major hydroelectric scheme and tourism (ISC 2004).

The subalpine zone occurs between the lower winter snow line at ~1500 m and the climatic limit of tree growth at ~1850 m. There is continuous snow cover for at least one month per year. The dominant vegetation type is Eucalyptus niphophila woodland interspersed with areas of bog, fen, heath and subalpine grasslands. Visitor
Table 1. Details of the 10 sites sampled along the Kosciuszko Road in the central region of the Snowy Mountains, Australia.

<table>
<thead>
<tr>
<th>Site #</th>
<th>Vegetation zone</th>
<th>Northing</th>
<th>Easting</th>
<th>Altitude (m)</th>
<th>Aspect (°)</th>
<th>Slope (°)</th>
<th>Road type</th>
<th>Distance from road surface to adjacent plot (m)</th>
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<td>275</td>
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<td>2020</td>
<td>120</td>
<td>11</td>
<td>gravel</td>
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</table>

* Distance from edge of plant colonisation on road surface of physical roadside disturbance in alpine plots.

Traffic (vehicular, skiing and trampling), ski resort infrastructure and maintenance of roads and ski slopes are major sources of disturbance in this zone (ISC 2004).

The alpine zone occurs above the climatic treeline at ~1860 m to the top of continental Australia’s highest mountain, Mt Kosciuszko, at 2228 m and covers an area of approximately 250 km² (Costin et al. 2000). The largest contiguous alpine area in the park, and indeed Australia, is the 100 km² around Mt Kosciuszko (Costin 1954; Costin et al. 2000). There is snow cover for more than four months per year with a few permanent snowbanks in some years. Low growing shrubs, grasses and herbs characterise the alpine zone (Costin et al. 2000; McDougall and Walsh 2007). The main sites of human disturbance in the alpine zone are gravel access roads and gravel, paved, raised steel mesh and informal walking tracks (Worboys and Pickering 2002).

Data on exotic species
Mallen-Cooper surveyed cover and species richness of exotic species in roadside vegetation and in paired adjacent natural vegetation plots at 10 sites located every four km along a 1000 m elevation gradient from the montane zone to the alpine zone in the Snowy Mountains in Kosciuszko National Park in November and December 1983 (Table 1).

All sites were along the Kosciuszko Road, with the lower eight sites along a public access sealed section of road and the two highest sites along a gravel section of the road which was closed to public vehicles in 1976 and subsequently used as a walking track and for maintenance vehicles (Worboys and Pickering 2002, Fig. 1). As the potential for spread of exotic species is greatest on the downslope of the road (pers obs.) all plots were located on the downslope side of the road.

At each site, one plot was established on the roadside and a paired plot established in the adjacent vegetation. Roadside vegetation was surveyed in 120 m² plots measured from the edge of the road surface (20 m parallel to road x 6 m perpendicular to road) for the lower eight sites, and 30 m parallel to the road x 4 m perpendicular to the road for the two higher sites. Paired plots of the same dimensions were located 5 m from the edge of physical roadside disturbance (as indicated by clearing/cutting etc. of vegetation, presence of foreign material such as gravel etc.) in relatively natural vegetation, ranging from 11 m to 28 m from the road surface itself (Table 1). This distance ensured the potential for weed seed to disperse into the adjacent plots, but was far enough away to minimise the level of direct physical disturbance associated with the road.

For each plot the following variables were recorded:
(1) presence of all exotic species;
(2) overall exotic species richness;
(3) cover of each exotic species estimated
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<thead>
<tr>
<th>Family</th>
<th>Frequency</th>
<th>Average cover (%)</th>
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Research Report

Table 2. (Contd.)

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<td>2</td>
<td>0</td>
<td>0.020</td>
<td>0.02</td>
<td>0.02</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rosa rubiginosa</td>
<td>Rosaceae</td>
<td>4</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0.025</td>
<td>0.00</td>
<td>0.05</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


using the Braun-Blanquet cover-abundance scale. Cover estimates were converted into the approximate mid point value of each scale for statistical analysis e.g. Braun-Blanquet values of 1, 2, 3, 4 and 5 were given percentage cover values of 0-1, 0-5, 3-0, 15-0, 37-5, 62-5 and 87-5 respectively (Barbour et al. 1987, Liddle 1997); and

(4) total percentage overlapping cover of exotics (e.g. sum of cover of each exotic species). From the data for each plot,

(5) the frequency of each exotic species (measured as the number of plots in which the species was recorded) and

(6) the altitude of the highest of the 10 sites in which the species was found (maximum altitude) was calculated.

Statistical analysis
To determine if species richness and cover of exotics varied with disturbance and altitude, a series of one-way ANCOVA were conducted (in SPSS 12.0) with "treatment" (roadside vs adjacent plots) as the independent variable, and altitude as the covariate. Dependent variables were:

(1) exotic species richness;
(2) percentage overlapping cover of exotics;
(3) species richness of exotic perennial forbs;
(4) overlapping cover of exotic perennial forbs;
(5) species richness of exotic annual/biennial forbs;
(6) total overlapping cover of exotic annual/biennial forbs;
(7) species richness of exotic perennial grasses;
(8) total overlapping cover of exotic perennial grasses;
(9) species richness of exotic annual/biennial grasses; and
(10) total overlapping cover of exotic annual/biennial grasses.

ANCOVA in SPSS 12.0 were initially run with an interaction term between altitude and disturbance term included. If there was no significant interaction the ANCOVA was repeated without an interaction term. The form of the relationship between altitude and the dependent variables was tested separately for roadside and adjacent plots using linear regressions.

To determine if there were differences in mean frequency, cover and maximum altitude between those exotic species recorded in the earliest general vegetation surveys of the Snowy Mountains and those recorded more recently, one-way ANOVA were conducted in SPSS 12.0. The independent variable was the date of the earliest publication of a species in the region, a surrogate mea-
Table 3. Results from one-way ANCOVA with the interaction comparing the effect of altitude (the covariate) and disturbance (the independent variable) on species richness (in 120 m² plots) and percentage overlapping cover (~mid-point of Braun-Blanquet cover values) of exotics in paired roadside and adjacent plots surveyed in the Snowy Mountains, Australia. Due to the large number of analyses performed on data from the same sites, a more conservative alpha < 0.01 level of significance was used. F and P values for the interaction were only included for significant interactions.

<table>
<thead>
<tr>
<th>Interaction</th>
<th>Disturbance</th>
<th>Altitude</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F</td>
<td>P</td>
</tr>
<tr>
<td>Species richness</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total exotic species richness</td>
<td>33.477</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Perennial exotic forbs</td>
<td>21.282</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Annual/biennial exotic forbs</td>
<td>7.980</td>
<td>0.012</td>
</tr>
<tr>
<td>Perennial exotic grasses</td>
<td>25.737</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Annual/biennial exotic grasses</td>
<td>17.031</td>
<td>0.004</td>
</tr>
<tr>
<td>Percentage cover</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total for all exotics</td>
<td>38.870</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Perennial forbs</td>
<td>29.096</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Annual/biennial forbs</td>
<td>1.759</td>
<td>0.202</td>
</tr>
<tr>
<td>Perennial grasses</td>
<td>11.942</td>
<td>0.003</td>
</tr>
<tr>
<td>Annual/biennial grasses</td>
<td>1.609</td>
<td>0.222</td>
</tr>
</tbody>
</table>

Sure for the length of time the species has been present in the region. It had four levels: 1898 (7 species), 1954 (20 species), 1981 (26 species) and 1990 (data were collected in 1983, but published in 1999, 12 species). The dependent variables were the frequency (total number of plots in which a species was found), percentage overlapping cover and maximum altitude. Differences between means were examined using Tukey’s post-hoc tests.

Assumptions of homogeneity of variance and normal distributions were tested prior to analysis. Frequency (converted to a proportion) and percentage cover data were arcsine transformed. Due to the large number of analyses performed on data from the same sites, a conservative significance of α < 0.01 of was used for all tests.

Results
Characteristics of exotic species
A total of 67 exotic species were recorded in the 20 plots surveyed (Table 2). Most were annual/biennial forbs (31 species) with just one species of shrub and one tree (Table 2). The families with the highest species richness were the Poaceae (19 species), Asteraceae (12 species) and Fabaceae (nine species). Many species were recorded infrequently (e.g. each of 17 species were found only once) and at low cover. Only seven species occurred in 10 or more sites: the perennial forbs *Acetosella vulgaris*, *Hypochoeris radicata*, *Taraxacum officinale*, *Cerastium spp.* and *Trifolium repens*, and the perennial grasses *Agrostis capillaris* and *Dactylis glomerata* (Table 2).

Effect of altitude
With increasing altitude, the total cover and species richness of exotics decreased on both roadside and adjacent plots (Fig. 2, Tables 3 and 4). The rate of decline was similar between the two plots (no significant interaction, Table 3), although the total number of exotic species was lower on the adjacent plots (Fig. 2, Tables 3 and 5).

How exotic species richness and cover changed with increasing altitude differed depending on the life form/life history of the exotics. For perennials there was either a linear decline or no significant effect of altitude. The only significant linear regressions were for species richness and cover of perennial exotic forbs on adjacent plots (Fig. 3a, Tables 3 and 4). For perennial grasses, and perennial forbs on roadsides, there was no significant effect of altitude (Fig. 4, Table 4).

For annual/biennial exotic forbs and grasses, in contrast, there appeared to be a threshold effect of altitude for both roadside and adjacent plots, with very low cover values and species richness values above 1510 m altitude (Figs 3b and d, 4b and d). Although there were significant linear regressions with altitude (Tables 3 and 4), the distribution of values appear more
Table 4. Linear regressions testing the effect of altitude (in m asl x 10^3) on species richness (in 120 m^2 plots) and percentage cover (mid-point of Braun-Blanquet cover values) of exotics in paired roadside and adjacent plots surveyed in the Snowy Mountains, Australia.

<table>
<thead>
<tr>
<th>Species richness</th>
<th>Plots</th>
<th>Formula</th>
<th>F</th>
<th>P</th>
<th>r^2-adj.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total exotic species richness</td>
<td>roadside</td>
<td>d = 89-634 -43-143 x a</td>
<td>69-390</td>
<td>&lt;0-001</td>
<td>0-884</td>
</tr>
<tr>
<td></td>
<td>adjacent</td>
<td>d = 48-109 -25-452 x a</td>
<td>33-010</td>
<td>&lt;0-001</td>
<td>0-781</td>
</tr>
<tr>
<td>Perennial exotic forbs</td>
<td>roadside</td>
<td>d = 10-112 -4-520 x a</td>
<td>14-600</td>
<td>0-005</td>
<td>0-602</td>
</tr>
<tr>
<td></td>
<td>adjacent</td>
<td>d = 47-030 -27-026 x a</td>
<td>49-438</td>
<td>&lt;0-001</td>
<td>0-843</td>
</tr>
<tr>
<td>Annual/biennial exotic forbs</td>
<td>roadside</td>
<td>d = 25-377 -1-213 x a</td>
<td>19-556</td>
<td>0-002</td>
<td>0-673</td>
</tr>
<tr>
<td></td>
<td>adjacent</td>
<td>d = 14-914 -7-781 x a</td>
<td>37-403</td>
<td>&lt;0-001</td>
<td>0-802</td>
</tr>
<tr>
<td>Perennial exotic grasses</td>
<td>roadside</td>
<td>pc = 2-070 -0-818 x a</td>
<td>10-166</td>
<td>0-013</td>
<td>0-505</td>
</tr>
<tr>
<td></td>
<td>adjacent</td>
<td>pc = 1-279 -0-641 x a</td>
<td>26-873</td>
<td>0-001</td>
<td>0-742</td>
</tr>
<tr>
<td>Annual/biennial exotic grasses</td>
<td>roadside</td>
<td>pc = 0-343 -0-117 x a</td>
<td>26-624</td>
<td>0-001</td>
<td>0-740</td>
</tr>
<tr>
<td></td>
<td>adjacent</td>
<td>pc = 0-994 -0-476 x a</td>
<td>27-639</td>
<td>0-001</td>
<td>0-747</td>
</tr>
<tr>
<td>Perennial exotic grasses</td>
<td>roadside</td>
<td>pc = 0-889 -0-444 x a</td>
<td>15-784</td>
<td>0-004</td>
<td>0-622</td>
</tr>
<tr>
<td></td>
<td>adjacent</td>
<td>0-683</td>
<td>0-432</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annual/biennial exotic grasses</td>
<td>roadside</td>
<td>pc = 0-951 -0-465 x a</td>
<td>17-787</td>
<td>0-002</td>
<td>0-628</td>
</tr>
<tr>
<td></td>
<td>adjacent</td>
<td>pc = 0-861 -0-434 x a</td>
<td>69-390</td>
<td>&lt;0-001</td>
<td>0-884</td>
</tr>
</tbody>
</table>

adj. = adjusted, d = species richness, pc = overlapping percentage cover, a = altitude (in m asl x 10^3)

Table 5. Mean species richness ± Standard Error (in 120 m^2 plots) and overlapping percentage cover (mid-point of Braun-Blanquet cover values) of exotic species in paired roadside and adjacent plots surveyed in the Snowy Mountains, Australia.

<table>
<thead>
<tr>
<th>Species richness</th>
<th>Species richness</th>
<th>Average overlapping cover (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total for all exotics</td>
<td>Total</td>
<td>Roadside</td>
</tr>
<tr>
<td>Perennial forbs</td>
<td>68</td>
<td>20-8 ± 4-4</td>
</tr>
<tr>
<td>Annual/biennial forbs</td>
<td>15</td>
<td>6-5 ± 0-9</td>
</tr>
<tr>
<td>Perennial grasses</td>
<td>31</td>
<td>7-1 ± 2-6</td>
</tr>
<tr>
<td>Annual/biennial grasses</td>
<td>9</td>
<td>4-5 ± 0-7</td>
</tr>
<tr>
<td>Shrubs</td>
<td>11</td>
<td>2-5 ± 0-8</td>
</tr>
<tr>
<td>Trees</td>
<td>1</td>
<td>0-2 ± 0-4</td>
</tr>
</tbody>
</table>

consistent with a threshold effect (Figs. 3 and 4). For example, out of the 31 annual/biennial forbs, only six species (Cirsium vulgare, Medicago lupulina, Polygonum spp. Spergularia rubra, Tragopogon dubium, and Verbascum virgatum) occurred in any roadside plot above 1510 m and only one species on the adjacent plots (Verbascum virgatum). Similarly, of the 11 species of annual/biennial grasses, only three species (Bromus hordeaceus, Bromus sterilis, and Poa annua) were found on roadside plots above 1510 m, and only one species (Bromus sterilis) in the adjacent plots. In the alpine plots the only annual exotics recorded were Spergularia rubra and Poa annua each in one roadside plot with cover of only 0-5%.

Effect of human disturbance
Roadside plots had higher frequency, percentage overlapping cover and total species richness of exotics than plots in the adjacent native vegetation (Tables 2 and 5). Thirty-two species were only recorded on roadside plots while, just three species were limited to plots in adjacent natural vegetation where they were found only in one plot, each at low cover (0-5%).

There were significantly more species of exotic perennial forbs and grasses and exotic annual/biennial grasses in roadside.
Fig. 2. Total (a) exotic species richness (in 120 m$^2$ plots) and (b) overlapping percentage cover for all exotic species on paired roadside (circles) and adjacent natural vegetation (squares) plots at 10 sites along an altitudinal gradient in the Snowy Mountains, Australia. The lines are for significant linear regressions for roadside plots (solid line) and adjacent plots (dotted line).

Fig. 3. Total species richness (in 120 m$^2$ plots) of (a) exotic perennial forbs (b) exotic annual/biennial forbs (c) exotic perennial grasses and (d) exotic annual/biennial grasses on paired roadside (circles) and adjacent natural vegetation plots (squares) along an altitudinal gradient in the Snowy Mountains, Australia. The lines are for significant linear regressions for roadside plots (solid line) and adjacent plots (dotted line).
plots than adjacent natural vegetation (Tables 3 and 5). The number of annual/biennial forbs did not significantly differ between habitats although in nearly all sites there was higher species richness on the roadside plot (Fig. 3b). The percentage cover of perennial forbs and grasses was significantly higher on roadside plots (Fig. 4, Tables 3 and 5), but there was no significant effect of disturbance detected for cover of annual/biennial forbs and grasses (Fig. 4). Exotic species richness was significantly higher on roadsides (11 species) compared to adjacent plots (8 species, Fig. 2a, Tables 3 and 5, P < 0.001). Total cover of exotics was also significantly higher on roadside plots (53%) compared to natural plots (9%) (Fig. 2b; Tables 3 and 5; p < 0.001).

**Discussion**

In our study there was a decline in exotic species richness and cover with increasing altitude. There appeared to be a threshold around the montane-subalpine boundary (~1450-1500 m in the Snowy Mountains) for annual/biennial forbs and grasses, with few if any of these species present above this altitude even in the more favourable roadside plots. This is consistent with the distribution of native annual/biennial forbs and grasses, with very few native annuals in the alpine zone due to the short growing season (Pickering 1997; Costin et al. 2000). In contrast, there was no clear pattern for the species richness and percentage cover of perennial grasses with increasing altitude. To determine if the lack of effect of altitude on perennial grasses was not just due to a power effect.

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**Fig. 4.** Total percentage overlapping cover of: (a) exotic perennial forbs (b) exotic annual/biennial forbs (c) exotic perennial grasses (d) exotic annual/biennial grasses on paired roadside (circles) and adjacent natural vegetation (squares) plots along an altitudinal gradient in the Snowy Mountains. The lines are for significant linear regressions for roadside plots (solid line) and adjacent plots (dotted line).
in the analyses, sampling at a larger number of sites along more transects, using a more precise measure of cover is recommended.

There are other observational studies that have examined patterns in species richness of exotics with increasing altitude in mountain regions (Pauchard and Alaback 2004; Becker et al. 2005; McDougall et al. 2005). These studies also have found declines in total exotic species richness with increasing altitude on roadsides (Pauchard and Alaback 2004; Becker et al. 2005) or in natural vegetation in the Australian Alps (McDougall et al. 2005). However, unlike our study, they have not compared the patterns between annual/biennials and perennial species to determine if the patterns they found may be due to a lack of exotic annual/biennial species above certain altitudes, as was found here.

There are three possible explanations for a decrease in the species richness and cover of exotics as found here with increasing altitude (Pauchard and Alaback, 2004). First, the decrease in species richness and cover is an ecological effect of the increasing severity of conditions such as climate at high altitude. This is supported by the possible threshold effect of altitude on annual/biennial exotics in this study. It is also supported by a decrease in the species richness of native species in paired native vegetation plots at the same sites (Mallen-Cooper 1990), and in some other mountain regions for native species richness/diversity (Austrheim 2002; Grytnes 2003). This appears to be the most likely explanation for the current pattern.

The second explanation is that extensive human disturbance may have occurred less frequently, less intensively or later at higher altitude sites. This might be the cause of the current pattern with the potential for lower levels of disturbance on roadsides at higher altitude sites. Certainly for the two highest alpine sites, the road is gravel and it has very limited vehicle traffic. Again, additional sampling on this and other roads including ranking different levels of disturbance, and/or manipulative experiments may assist in determining the possible causes of the current patterns in exotic species richness found in this study.

The third explanation is the pattern could be a lag effect, due to exotics dispersing from lowlands to highlands in mountain regions. Decreasing weed diversity and cover along roads within national parks from lowland to highland sites, or along peninsulas, have been found in other studies (Pauchard and Alaback 2004). Further sampling combined with comparing time when first recorded in the region based on herbarium records, would assist in determining if the pattern was due to a lag effect.

**Disturbance favours weeds in mountain regions**

This study found more exotic species and greater cover of exotics in disturbed plots compared to adjacent plots. The effects of disturbance partly offset the decline in species richness and cover with increasing altitude. For example at the highest site (2020 m altitude), there were no exotics in the natural vegetation, while on the roadside there were *Agrostis capillaris*, *Taraxacum officinale* and *Acetosella vulgaris*.

In this and other studies it is clear that increasing provision of infrastructure for tourism such as roads, tracks and ski resorts favours the establishment and potential spread of exotics (Jesson et al. 2000; Johnston and Pickering 2001; McDougall 2001; Johnston and Johnston 2004; Pauchard and Alaback 2004; McDougall et al. 2005; Hill and Pickering 2006). However, as seen in this study, natural vegetation, even that adjacent to sites subject to human disturbance, tends to have low cover and diversity of exotics particularly at higher altitude sites (Johnston and Johnston 2004; Hill and Pickering 2006; McDougall et al. 2005; Johnston 2005; Bear et al. 2006).

The species in this study that were common on roadsides (*Acetosella vulgaris*, *Hypochoeris radicata*, *Taraxacum officinale*, *Cerastium spp.* and *Trifolium repens*, and the perennial grasses *Agrostis capillaris* and *Daectylis glomerata*) are among the most common exotic plants in other surveys of the Snowy Mountains (Mallen-Cooper 1990; Johnston and Pickering 2001; Godfree et al. 2004; McDougall et al. 2005). They are also part of an international weed flora and can be found in
mountain regions around the world (Jesson et al. 2000; Austheim 2002; Pauchard and Alaback 2004; Parks et al. 2005).

Limitations of this study
There are three main limitations to this study:
(1) it only examined diversity and cover of exotics along one transect at 10 sites along one road in the Snowy Mountains;
(2) only one site at each altitude was sampled; and
(3) current patterns of disturbance were not consistent over the transect.
It is likely that vehicle usage decreases with increasing altitude on this road, and the highest two sites were a closed gravel road. However, the general pattern of decreasing species richness with increasing altitude in this study is supported by the results of a more extensive parallel study examining changes in the species richness of native and exotic plants over altitudes on several main roads (16 sites), minor roads (23 sites) and at adjacent native vegetation (25 sites). With a greater number of sites, negative linear relationships were still found for total exotic diversity, supporting the results reported here (Mallen-Cooper 1990, Mallen-Cooper and Pickering, unpublished data). The parallel study, however, did not examine changes in vegetation cover, or examine if there were differences in the patterns depending on the life histories and life forms of the plants.

Climate change and alien plants
Alpine systems are considered to be among the most vulnerable communities to climate change in Australia and overseas (Körner 1999; Hughes 2003; Root et al. 2003). There are already data indicating that there has been an increase in species richness, and upward movement in the distribution of native plants in Europe (Grabherr et al. 1994). For the Australian Alps, the latest climatic predictions indicate an increase in temperature of between +0.6, and +2°C, resulting in between 38-96% decrease in the area receiving at least 60 days of snow cover by 2050 (Henessey et al. 2003).

If climate is limiting species richness and abundance of alien plants in the Snowy Mountains, then predicted declines in snow cover and increasing temperatures will result in more weeds in Australian mountain regions. This is consistent with predictions made in other studies of exotic plants in the Australian Alps (Pickering and Armstrong 2003; Pickering et al. 2004; McDougall et al. 2005; Bear et al. 2006). The potential for an even greater range of weeds with climatic warming emphasises again the need to limit human disturbance in these regions of high conservation value.

Acknowledgements
We gratefully acknowledge the support of Jane Mallen-Cooper’s PhD supervisors, Alec Costin and Nigel Wace for the original research. We thank Michael Arthur for statistical advice, as well as Wendy Hill and others who have provided comments on this manuscript. Our thanks also go to the New South Wales National Parks and Wildlife Service for access to the sites and research facilities in Kosciusko National Park.

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One Hundred and One Years Ago

TIMBER AND TREES

By Ernest Lees, Teacher of Woodwork, Continuation School, Melbourne

The tea-tree (Leptospermum laevigatum), on account of its gnarled and twisted trunk, is of little use as timber, but is splendid for fuel, and much sought after by bakers for heating their ovens. It is extremely useful as a break-wind along the coast, and as a sand-binder.

From The Victorian Naturalist XXIII, p. 226, March 7, 1907
Killer Whale *Orcinus orca* sightings in coastal Victoria

Simon Mustoe

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Abstract
The web-based casual sightings network ‘Auscetnet’ receives an average 13 records of Killer Whales per year, mainly from coastal locations of southeast Australia. These data combined with data from the Atlas of Victorian Wildlife are presented to illustrate the pattern of monthly sightings. Sightings peak in late June/early July and again between September and November. There is a distinct decline in sightings between late July and the end August. One individual Killer Whale has been seen twice off the central coast of Victoria and twice off southern New South Wales since 2002, suggesting some Victorian Killer Whales occupy home ranges that extend into NSW waters, although the vast majority of sightings are from south of about 36°S. Sighting frequency is unlikely to reflect the species’ true abundance and despite frequent records off Victoria and southern NSW, they may be uncommon. There is no evidence to characterise movement patterns but Killer Whales are likely to respond to changes in prey availability, influenced partly by the East Australian Current. Killer Whales have been observed feeding on sharks, sunfish, Humpback Whales and Australian Fur Seals in the region. (*The Victorian Naturalist* 125(3), 2008, 76-81)

Introduction
Development of the web-based sightings network ‘Auscetnet’ in recent years has increased capacity to document casual records of Killer Whales *Orcinus orca* and we find the species is frequently present and a notable component of Victoria’s coastal environment.

Auscetnet has been active since 2002 receiving an average 13 records of Killer Whales per year (5–13% of all postings). Almost half of the 66 sightings (28) are from Victorian coastal waters and the rest from the immediately adjacent Sapphire Coast of New South Wales. They include five records of beached animals from Museum Victoria archives (Dixon and Frigo 1994).

Records are presented from between Merimbula, NSW (36° 53’S, 149° 56’E) and Portland, Victoria (38° 21’S, 141° 38’E), a distance of approximately 1000 km. Other records from the Atlas of Victorian Wildlife and the author’s own observations bring the total to 161 records since 1933. Auscetnet sightings are submitted to the Southern Oceans Orca Database (Morrice 2006), which comprises approximately 1000 records, although about 62% of these are from Macquarie Island (Morrice et al. 2003).

This paper presents graphs and maps showing the locations of sightings and monthly frequency distribution in coastal Victoria and immediately adjacent waters of southern New South Wales. Most observations are from land or from vessels within sight of the coast. Mammal taxonomy is referred to Menkhorst (1995) and fish taxonomy to Hutchins and Swainston (1986).

Sighting Trends
Sightings have occurred along most of the Victorian coast (Fig. 1) with a paucity of records between Wilsons Promontory and Lakes Entrance, most likely due to the poor coastal access and absence of human habitation along Ninety Mile Beach.

Data since 2002 provide the most consistent basis for discussion, as the number of annual reports has varied relatively little (mean 13; range 11–17). In this period, Killer Whales have been recorded throughout the year, though there have been only 1–2 sightings per month between December and May. Peaks in sighting frequency centre on June–July (30% of records) and September–November (42% of records) and there is a distinct lull in sightings in August – since the first observation in 1933, there have been only six records.

Peak sighting frequency since 2002 has been in July, which is similar for earlier records; however, data from 1933–2001 indicates a peak in June (Fig. 2a). Closer inspection (Fig. 2b) shows nine records...
Contribution

Fig. 1. Sightings of Killer Whales off southeast Australia. Apart from single records in 1933 and 1966, all other records are since 1970.

Fig. 2. Frequency histograms of Killer Whale sightings. from the first two days in June. Six of these records are from just two separate days: three for 1 June 1951 from Seal Rocks (central Victoria), Cape Nelson and Cape Sir William Grant (western Victoria); and three for 2 June 1988 from Wilsons Promontory. In the latter case, it is likely these were repeat sightings of the same pod. In the former case, the sites are geographically separate so either it is coincidence or, more likely, the precise date was unknown and 1 June is a default, derived from only writing June into an Excel spreadsheet.

Closer inspection of the Atlas of Victorian Wildlife data indicates three similar duplications but none alters the pattern presented as monthly sighting frequency in Fig. 2a. Hence, these data are presented without amendment. Figure 2b is enough to indicate that Killer Whales are mostly seen in late June and early July indicating that sightings are in decline through late July as well as August.

Individual resighting
Killer Whales were reported on 7 July 2005 at Port Phillip Heads, Victoria. One individual, identified by a uniquely disfigured dorsal fin (Fig. 3) has been observed twice off Eden, New South Wales (October 2003; November, 2004); once off Mallacoota in far-east Gippsland (July, 2003); and possibly offshore southeast Australia south of Gabo Island in May 2006 (David Donnelly, observation reported in AES 2007). A record from 1990 (Robert Warneke, in litt.) may be the same animal:

29.10.1990, Bushranger Bay, Cape Schanck (38° 20'S, 144° 54'E), pod of about 10. One
of the two larger individuals had a split dorsal with the two halves flopping on either side.

This is the first evidence of a Killer Whale resighting in Australian coastal waters. It indicates that individuals may occupy home ranges that include the coasts of both southern NSW and Victoria. At Port Phillip Heads the animal was observed with a small pod (estimated four individuals) but was with 10–12 individuals off Eden.

**Pod Size**

Mean pod size is significantly greater (p<0.05) in New South Wales compared to Victoria (Table 1) but has a much greater level of variance. On average, pod in New South Wales are observed to be almost twice the size of pods in Victoria.

**Seasonal Sighting Effort**

Since 2002, all sightings from the southern coast of New South Wales have been provided by whale-watching operators or fishing vessels that from to time, also run whale-watching. This activity occurs daily during the southerly Humpback Whale Megaptera novaeangliae migration season between September and December (DEW 2005). This effort-bias could explain the peak in sightings off NSW in spring/early summer. Nevertheless, fishing charter operators out of Eden and Merimbula, many of whom operate whale-watching vessels, are well aware of cetaceans, and report sightings of various species throughout the year.

Reporting frequency off the Victorian coast is not subject to similar bias as there are no significant whale-watching operations in the state, and monthly sightings for central Victoria, excluding NSW (145–147°E), similarly exhibit peaks in June-July and October–November. A reduction in winter sightings would be expected when the weather is colder and there are fewer people walking on the coast or fishing from recreational boats. There is nevertheless a peak in sighting frequency in mid-winter (June–July), whilst for most of the summer and autumn months (December–May), there are relatively few sightings. If anything, seasonal bias would be expected to reduce the difference between winter and spring/summer, suggesting the relative decline in sightings in late July/August may be even more significant.

**Conservation Status and Protection**

Killer Whales are protected in Victoria from interference, killing or injury by the *Wildlife (Whales) Regulations 1997* (Victoria) in state waters out to three nautical miles offshore. They are also matters of national environmental significance on the *Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth), which protects them as 'migratory' species, pursuant to Australia's commitments under the *Convention on the Conservation of Migratory Species of Wild Animals*. If there is a 'real or not remote possibility' of an impact that would be 'important or notable' (the Act's definition of significant), an environmental assessment would be required, even in Victorian waters. Whether an impact is significant would depend on the...
intensity of the effect and the status of Killer Whales.

The Killer Whale population of Australia is presumed to be secure (Bannister et al. 1996), hence the species is not listed as vulnerable to extinction under Commonwealth legislation. Unfortunately, sighting frequency does not reflect true abundance and, although they are commonly observed (Morrice et al. 2003), they may be a relatively uncommon species (Warneke 1995; Ross 2006). Cetaceans have evolved to maintain relatively stable population sizes at or near carrying capacity (Wade 2002), but Warneke (1995) suggests that disastrous depletion of local populations of seals and migratory whales in Australian waters might have indirectly caused a decline in Killer Whales in the 19th century. If this is true, we have no way of telling how large the population used to be and to what extent the remaining population could cope with any intense environmental impact.

It is important therefore that sightings continue to be documented so they can contribute to the Southern Oceans Orca Database. Researchers can then keep a watching brief on the situation by better understanding Killer Whale ecology and identifying important conservation objectives (Morrice 2006; Ross 2006).

Discussion and Conclusion

These data show that casual sightings networks are important, particularly in the case of a charismatic species that occurs at very low-density. Killer Whales are readily identified and popular, so it is not surprising Aus cetnet receives a relatively high percentage of postings on this species.

Although the sample is relatively small, there is a consistent pattern of monthly abundance in Victoria evident from Atlas of Victorian Wildlife data pre-2002 and records from Aus cetnet since 2002. A similar pattern is also shown by data from the Southern Oceans Orca Database combining records between 25-50°S (Morrice et al. 2003; Morrice 2006). Evidence indicates a predictable seasonal occurrence along Victoria’s coastline.

Killer Whales from Victoria almost certainly occupy home ranges that extend into southern NSW, but sightings from northern NSW are rare. There are occasional sightings from Narooma (36°15’S), less frequently Newcastle (33°57’S) and hardly ever from further north, e.g. Coffs Harbour, where there is considerable Humpback Whale-focused whale-watching. Given an average swim speed of about 120 km per day (Fish 2002), the coastline of the study region in Fig. 1 (about 1000 km) could be traversed in just over eight days, so it is possible that Victorian Killer Whales range further both to the east and west. Given the almost year-round sightings and lack of data in central and northern NSW, it is likely that the Killer Whale population found in Victoria mostly ranges south of 36°S.

The record of an individual off central Victoria and southern NSW involved different pod sizes, suggesting a varying association with animals at each location. Pod sizes in Victoria are relatively small compared to southern coastal NSW, and it is possible groups come together to feed or mate in the east of their range. If this resighting is indicative of an overall trend, the number of Killer Whales occupying the Victorian coastline may be a lot smaller than indicated by sighting frequency.

Monthly sighting frequency of Killer Whales is very similar to the pattern of north-south migration of Humpback Whales. Corkeron et al. (1999) made a case for evolution of migration in Humpback Whales as a mechanism to avoid predation by Killer Whales but this does not necessarily imply that Killer Whales specifically target migrating Humpback Whales as prey. Killer Whales certainly predate Humpback Whales, par-

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Table 1. Comparison of mean pod sizes in Victoria and New South Wales

<table>
<thead>
<tr>
<th>Location</th>
<th>Mean</th>
<th>Variance</th>
<th>95% confidence</th>
<th>n</th>
<th>P*</th>
</tr>
</thead>
<tbody>
<tr>
<td>New South Wales</td>
<td>5.70</td>
<td>26.40</td>
<td>2.15</td>
<td>22</td>
<td>0.02</td>
</tr>
<tr>
<td>Victoria</td>
<td>2.99</td>
<td>5.50</td>
<td>0.47</td>
<td>95</td>
<td></td>
</tr>
</tbody>
</table>

*P = two-tail probability of no difference in mean values
particularly calves on migration, and there have been two documented cases reported to Auscetnet off Eden since 2000 as well as various other reported cases, mainly in the Southern Ocean (Naessig et al. 2004; Mehta et al. 2005: ). We do not know how severe or otherwise such predation may be, other than that such events are no more commonly observed than foraging on other species. For instance, since 2002 Killer Whales have twice been observed feeding on Southern Ocean Sunfish Mola ramsayi off Eden NSW and once on a School Shark Galeorhinus galeus or Gummy Shark Mustelus antarcticus in Port Phillip Bay, Victoria. Almost annually, they are seen in close proximity to Australian Fur Seal Arctocephalus pusillus doriferus colonies at Seal Rocks in central Victoria, and they have been observed eating seals off the coast of Eden, NSW.

It is quite likely that seasonal movements of Killer Whales in Victoria are influenced by the East Australian Current (EAC). Anti-cyclonic (warm-core) eddies sweep surface-water offshore, creating coastal upwelling off southern NSW. This is weakest in the winter months and extends furthest south in the spring and summer, when it creates phytoplankton blooms and drives marine surface productivity (Marchesiello et al. 2000). This is likely to explain the higher incidence of Killer Whale sightings in southern NSW between September and November. These data cannot provide more clarity on movement patterns and whether this is linked to any particular prey or oceanographic condition, though both are likely.

Killer Whales have been studied extensively in some parts of the world where they exhibit varied social and foraging ecology, and there is a suggestion that these traits may be linked. Groups are roughly divided into residents comprising discrete matriarchal groups with little or no immigration/emigration that feed mainly on fish; and transients whose offspring mostly disperse but continue to use their natal range and are more likely to exploit marine mammal prey (Baird 2000). There is no clear evidence of localised populations that could be considered ‘resident’ in Victoria (Warneke 1995).

The data provide evidence for peaks in sightings off Victoria in winter (late June-early July) and spring / early summer (September- November) whilst sightings for the rest of the year are less frequent but the species has been recorded in all months. For reasons unknown, there are very few Killer Whale sightings between late-July and the end of August. Observer effort does not appear to be biasing results in Victoria and, if it did, fewer sightings might be expected between June and July. Explanations could include movement of animals offshore, into waters off South Australia — where they were recorded on average three times per year between 1982 and 1990 (Ling 1991) — or perhaps aggregation into larger groups off southern NSW. Here, sighting bias could affect the pattern of reports. Between June and August there is little whale-watching activity in southern NSW, and larger pods moving into the area at that time of year would mean a lower encounter probability due to dilution effects.

Acknowledgements
I wish to particularly thank all those who have contributed data for the development of this paper: Ross and Gordon Butt of Cat Balou (Eden), John Smith of Freedom Charters (Eden), Bob McPherson, Matt Edmunds (Australian Marine Ecology), Peter Constable, David Donnelly, Chris Hywrd, Craig Dickman, the Dolphin Research Institute, John Joubert (Gone Fishing Charters), Jon Hall, Liz Allen, Martin O’Brien, Paul Bazinas, Rob Tirelli and Roger Kirkwood. Thanks also to Kelvin Aitken of Marine Themes and Ros Butt for generous permission to use their photos of the split-fin animal, to Bob Warneke for reviewing early text for this paper, and to Adrian Purdy and Graeme Russell for details of their sighting of a split-fin individual from 1990.

Notes
1Auscetnet is a Yahoo group community listserv establish to provide a forum for sharing information on cetaceans around Australia and for discussing cetacean-related issues. http://groups.yahoo.com/group/auscetnet
2Low sustained speed is described as 1.8-13.0 kph. A distance of 120 km could be covered by an animal swimming at approximately 5 kph or 2-3 knots.

References
Continent of curiosities: A journey through Australian Natural History

by Danielle Clode

Publisher: Cambridge University Press, 2006, xii + 212 pages, hardback; ISBN 0521866200. RRP $59.95

During her time as the Thomas Ramsay Science and Humanities Fellow, the author of this book chose a dozen specimens from the collection of Museum Victoria and used each of them as a peg on which to hang a discussion about modern biological concepts. As its title implies, the Fellowship, funded by bequest, fosters research and writing across both the sciences and humanities. The twelve chapters in this book are evenly clustered into four time slices: 500 years; 250 000 years, 250 million years and 4-5 billion years. A di-
special reference to Dutch and Portuguese involvement. The Lesser Bilby heads up a
discussion of early collectors in Australia and the use of indigenous knowledge to
expand our understanding of former distributions. The chapter on Melbourne’s pro-
tected water catchments and development of sewerage treatment in the early colony
is headed by an aquatic beetle and leads into the 250 000 year section. Coventry’s
Skink seems a strange example to intro-
duce Mountain Ash ecology, succession
and fire adaptation, but different lizard
species occupy individual niches within the forest ecosystem. A mounted skin of
Leadbeater’s Possum prefaces the chapter	hon the historical discovery and biology of
Leadbeater’s Possum and the Mountain
Pygmy-possum.
The third section of the book is titled
Fossils and Bones and starts with
Neotrigonia margaritacea, from a family
of shells known by European palaeontolo-
gists only as Miocene fossils until discov-
ered by the French expedition on
l’Astrolabe in 1802. The author takes this
opportunity to weave in the debate about
creation and evolution. A fossil imprint of
the brain of a dinosaur from Dinosaur
Cove on the Victorian coast was unusually
large for the animal’s size, with a clear
imprint of a pineal body and a large optic
tectum. This raises the possibilities of ther-
moregulation, nocturnal activity, migration
and prey preference. The famous Ape Case
of mounted Gorillas, introduced into the
Melbourne Museum by Frederick McCoy,
gives an opportunity to describe Thomas
Huxley’s championship of Charles
Darwin’s later work The Descent of Man.
The final section in this eclectic collect-
ion has a picture of a Red Bird of
Paradise, collected by Alfred Wallace, fol-
lowed by his musings on biogeography
with his famous ‘line’ and that of similar
alternatives. Spalaeogrphacea, a crus-
tacean from an ancient order with a
Gondwanan distribution, is a fine example
to introduce the geologist Lyell, Alfred
Wegener’s continental drift and the con-
cept of vicariance. Finally, the Murchison
meteorite leads on to the canals on Mars,
possible traces of bacteria in meteorites,
and extra-terrestrial life.
The theme of the book is the develop-
ment of biological and geological thinking
and its expression in the natural history art
of collecting, using Australian examples
from the Melbourne Museum. The discus-
sion is broad, well referenced and illus-
trated with many historical plates and pho-
tographs. Within the text are boxed topics
of ancillary explanation; my only criticism
of these is that they interrupt the flow of
the main text, a poor book design feature.
Also I would warn that proof-reading of
scientific names has missed a few errors.
Nevertheless, it is a nice summary of nat-
ural history exploration and discovery in
this enigmatic country.

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Australian Seeds:
A Guide to their Collection, Identification and Biology

edited by Luke Sweedman and David Merritt


Australia is going through perhaps the most important phases of land rehabilitation and landcare in its 200 years of European occupation. This is a timely book that addresses most aspects of Australian native plant seed.

Seed is the most important component in any revegetation project and plant nursery seedling production.

A publication that has sound and relevant information towards helping practitioners and researchers in this field is a welcome addition to the many books now available.

Australian Seeds: A Guide to their Collection, Identification and Biology, is an excellent textbook following on from an earlier work, also published by CSIRO researchers.

Until the last decade many rehabilitation and revegetation works in most Australian states were carried out in a somewhat ad hoc manner, although with good intention. One of the main concerns was that people using Australian native plant seed lacked knowledge and understanding of the germination cues required.

With this book comes a wealth of knowledge that will help address this and achieve better outcomes in land rehabilitation projects that help to put back floristic foundations into the Australian landscape.

Those of us involved with native plant seeds are always keen to read up-to-date literature on new techniques in the understanding of breaking seed dormancy, particularly for understorey species, and other related native plant seed biology. The effect of fire and smoke on seed is of importance for many plant genera.

Western Australia, which has some of Australia’s if not the world’s unique flora, has been a leader in floristic research on the many facets of native seed and is an ideal base for such work to be published in book form.

All chapters are thoroughly researched and are of considerable interest. These include Seeds through time; Seed and fruit structure; Seed biology and ecology; Seed collection, drying, cleaning and storage. An excellent chapter on seed collection guidelines for common Australian plant families and genera is of interest as many of these can be found in other states.

This book is complemented by the excellent photography of some 1400 different species of seed in natural colour and size. This alone is worth the price of the book.

While this book is titled Australian Seeds, most photographs of seeds are from the western side of the nation.

Although other states have made good progress in this field with native seed related books and papers, this book has set the national bench mark. It is hoped that other states may embrace similar models in the years ahead.

Australian Seeds is an excellent work, a credit to all contributors. This book will be a welcome addition to the literature, a must for all researchers, plant nursery propagators and revegetation practitioners.

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Vol. 125 (3) 2008
Water – facts, issues, problems and solutions

by David Leaman


This is not a conventional book on hydrology and water resources. It is a passionate account of the mismanagement of the Tasmanian natural environment, with particular regard to water. Many of David Leaman’s concerns, and the strength and feeling in his accounts of his dealings with the Tasmanian Government bureaucracy, will resonate with many readers of The Victorian Naturalist.

The book consists of eight chapters and 15 appendices. There is a list of references, an index, and 14 pages of colour plates at the end of the book. Black and white illustrations are interspersed throughout the text. The first five chapters deal with facts about water and principles of hydrology, water quantity and related flow and allocation issues, water quality and water management. Chapter 6 is a long and rambling case study of water issues in Tasmania. Chapter 7 presents an overview of possible solutions to problems of water supply, and includes some interesting material on matters such as cloud seeding (also discussed in relation to Tasmania in Chapter 6), icebergs, privatisation and aquifer recharge. The final chapter is a set of concluding notes.

It is not clear why the author has chosen to include 15 appendices rather than simply incorporate the material they contain into the body of the text. The appendices, like much of the rest of the text, have a focus on Tasmanian forest management and include some details of the author’s clashes with the bureaucracy. There are some unusual topics such as ‘thermal springs’, ‘aerosols, rainfall and health’, and the text ends with a cautionary note about the use of terminology such as ‘the 1,000 year drought’ which in hydrology never means what it appears to mean.

This book, now in its 3rd edition, has arisen out of the author’s teaching in Adult Education, Schools for Seniors and the University of the Third Age. It has an emphasis on groundwater and surface-groundwater interactions, more detailed than usual in a book of this kind. This arises, no doubt, from his professional interests as a geophysical consultant. The origins of the material as teaching notes is obvious and I found, in some places, the subject matter was not explained in sufficient detail to allow me to follow it easily. For non-specialist readers, some of this will be tough going without the author in front of the class to answer your questions. The photos have been scanned at too low a density with consequent loss of sharpness.

I’ll have to confess that I am not a disinterested reviewer of this book, given its focus on the activities of Forestry Tasmania. My own dealings with Forestry Tasmania and its tame ‘watchdog’, the Forest Practices Board, have led me to conclude that both these organisations are morally and scientifically bankrupt. David Leaman’s writings reinforce this view. If you have ever harboured any thoughts, as I do, that Tasmania is not an appropriate entity to be a sovereign state, then this book will confirm your suspicions.

There is a lot of interesting material in this book and many useful facts and figures. If you are interested in, and concerned about, the ongoing rape of Tasmania’s forest resources, then read this book.

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SGAP: the story of Arthur Swaby and the Society for Growing Australian Plants

by John Walter


The Society for Growing Australian Plants (SGAP) is perhaps Australia’s premier organisation committed to the advocacy of the conservation of Australian plants and their use in horticulture. There can be few people seeking to establish a native plant garden, or simply to grow indigenous plants on their suburban blocks, who have not sought information from the Society and its publications as to what plants are suitable for their circumstances. From its small beginnings in Victoria, the Society has grown to include branches in all states and a vigorous network of study groups, the attention of which is concentrated largely on specific genera. The Society celebrated its fiftieth anniversary in 2007. To mark this milestone it has published SGAP: the story of Arthur Swaby and the Society for Growing Australian Plants, written by John Walter.

This book is more than a history of the Society. It starts with the early enthusiasts of using Australian plants in horticulture, stretching back into the nineteenth century: those who wrote about it, established native plant nurseries and advocated the use of Australian plants in public gardens. Well-known people such as Thistle Harris, Edwin Ashby, Edward Pescott and George Althofer are introduced and their early contribution outlined. The foundation of the Society is thus placed against this background of a dedicated group of people passionate about the merits of Australian plants. In establishing the Society its founders were building on the work of these forerunners. They were also attempting to provide a formal means by which the wider community could be encouraged to grow native plants. The book is not just a history of the Society, but also of the native plant movement in the broader history of Australian horticulture.

The Field Naturalists Club of Victoria was central to the foundation of the Society. Its founders were members of the Club, which was the seedbed of societies that for many years were in the forefront of public activities in the conservation area. Like the Society, both the Victorian National Parks Association and the Native Plants Preservation Society had their origins in committees of the Club. This book is therefore a contribution to that part of the Club’s history and its participation in the wider issues of conservation, the use of Australian native plants in horticulture, revegetation, and other related fields.

In telling the story of the SGAP the author traces the paths by which the founders came to their love of Australian plants and their determination to create a society that would be a home to those who shared their interest in the native flora. While each of the founding members is given their due, the subtitle draws particular attention to Arthur Swaby as the energetic promoter of the Society. The early years, while the Society was feeling its way, were difficult, with auctions particularly over drawing up a constitution. Swaby was vigorous in promoting his ideas, using as a principal means of communication the popular gardening magazine Your Garden. The picture emerges of Swaby’s strong desire to see his ideas carried to fruition, but also of his impatience of restraint and determination to be at the centre of things. His mistrust of office bearers eventually led to his resignation from the Society.

This is a book rich in detail. The author charts the Society’s progress from its first meeting in July 1957 and its early upheavals, through the establishment of branches across Australia and the linking federal council, to the formation of the
Australian Plants Society, a nation-wide organisation with regional branches and 31 individual groups specialising in specific groups of Australian plants or aspects of their use in horticulture. (It was, in fact, Swaby’s dream that the Society should be constituted with such special interest groups.) Along the way much space is devoted to the publications produced by the Society, particularly the journal Australian Plants and the monographs that came from both the study groups and regional groups.

In writing this book the author has made extensive use of records, particularly of the Field Naturalists Club and the Australian Plant Society, and made a detailed study of Swaby’s published papers. These sources are clearly a rich lode for the historian. Walter also, by judicious use of extracts from transcripts of interviews with the people involved in the story, and their friends and family members, has brought their ‘voice’ to the fore and given immediacy to the narrative. There are copious illustrations from a wide variety of sources, including reproductions of letters and photographs of key people. There are six appendices, five of which contain the sort of information that is often difficult to find elsewhere: lists of office bearers; con- tact details of state and local groups together with times and places of meetings; award winners; and active study groups. Some of Swaby’s ‘poetic lines’ about the Grampians constitute the sixth appendix. The index is limited to names of people and some organisations. No list is provided of the archival material consulted or of the publications cited (although these can be discerned by reference to the extensive footnotes). In a work of this kind such a list of source material is considered a necessity.

Walter has brought to life an organisation that played a central part in the Australian horticultural world in the second half of the twentieth century. He has woven a story of considerable complexity, following the Society from its early uncertainties to its current pre-eminent position. The Society acted as a catalyst in popularising the use of the indigenous flora in horticulture and in bringing together many people who shared a love of Australian plants. Its publications are recognised for their high quality and authoritative information. Members of the Society advocated the use of native plants as suitable for horticulture in Australia’s climatic conditions long before it was widely recognised among the general public that our traditional gardens, heavily water-dependent, were increasingly unsustainable. Walter’s treatment of the history of the Society is worthy of its successes.

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The Victorian Naturalist
Notes on the post-fire recovery of plants at Wilsons Promontory

After the fire at Wilsons Promontory in April 2005, a group of South Gippsland naturalists volunteered to assist in monitoring the recovery of the vegetation. Monitoring means checking, observing and recording, without interfering (McDonald, 2005). Our aim, like that of Angair after the 1983 wildfire (Wark, 2000), was to document the post-fire recovery of threatened Ecological Vegetation Classes (EVCs), to compare them with unburnt areas of these EVCs and to obtain information for use by Parks Victoria in the planning of conservation management. The EVCs formally being monitored are Coast Banksia Woodland and Coast Dune Scrub Mosaic.

The notes presented here are based on observations made while executing the monitoring program for Parks Victoria, but the paper does not include analysis of the data. Rather, it presents a broad overview of post-fire recovery by plants at Wilsons Promontory.

The observations presented here were obtained in different seasons and at different intervals after the fire, either during the course of walking along the tracks to the Light Station, Windy Saddle or Mt Oberon, along Waterloo or Oberon Tracks or while collecting quadrat data for the monitoring program.

Early colonisers

Immediately after the fire, thousands of seedlings appeared, many crowded along tracks where ashy topsoil had washed down. All our plant knowledge was called on to identify the different species from the shape, colour, texture and arrangement of the leaves. Most of us could identify seedlings of eucalypts and acacias to generic level. Of the seedlings, Hakea were among the most prolific. We had to wait some months before we were able to get to specific level, although we had some ideas because of the mature plants in the vicinity. The Hakea became Bushy Needlewood Hakea sericea, one plant found flowering already in August 2006.

We found it difficult to distinguish between Tree Everlasting Ozothamnus ferrugineus and Dogwood Cassinia aculeata seedlings, both species when small having leaves of similar length and no flowers. She-oak seedlings were probably Drooping She-oak Allocasuarina verticillata; however, we had to take care to find cotyledons to distinguish them from root suckers. Other seedlings found were Dillwynia and Pultenaea species. Sweet Bursaria Bursaria spinosa and Silky Guinea-flower Hibbertia sericea. Along Telegraph Track, amid the burnt Swamp Paperbark Melaleuca ericifolia thickets, there were large areas thick with Golden Spray Viminaria juncea, most flowering in the summer of 2006-07. This is a fast-growing shrub considered to be a good substitute for introduced broom species in gardens.

Annuals, of which we have seen two flushes of seedlings in the first two years, include Shade Pellitory Parietaria debilis, Common Bottle-daisy Lagenophora stipitata, Annual Bluebell Wahlenbergia gracilenta and Jagged Fireweed Senecio biserratus. Unfortunately, the invasive weed Tall Fleabane Conyza bonariensis also has produced two flushes of seedlings. Another weed was the Common Centaury Centaurium minus, but this was not as prolific as Fleabane.

Perennial herbs that covered the ground very quickly were Common Raspwort Gonocarpus tetragynus, Austral Stork’s-bill Pelargonium australe, Cinquefoil Crane’s-bill Geranium potentilloides, Variable Stinkweed Opercularia varia, Running Postman Kennedia prostrata, Hairy Pennywort Hydrocotyle hirta, Swainson-pea Swainsona lessertifolia and violets Viola hederacea, V. sieberiana, V. cleistogamoides and V. betonicifolia. These herbs can be so entangled that distinguishing between individual plants and seedlings or regrowth from perennial rootstock is difficult. It was easier to count individuals of Common Woodruff...
Asperula conferta and Angled Lobelia Lobelia anceps as they were smaller and occurred in smaller numbers.

The dominant understorey plants in the Coast Dune Scrub Mosaic quadrats have been Kangaroo Apple and Gunyang, both Solanum species that have grown very quickly to a metre tall and nearly a hundred percent cover.

Among all these plants were some small climbing plants with heights very dependent on their support. Twining Glycine Glycine clandestina and Blue Love Comesperma volubile are both fine, little plants whose leaves need to be located along the stems for identification. Two species of Clematis, Small-leaved Clematis Clematis microphylla and Forest Clematis C. aristata, have been found as seedlings. Clematis plants produce vast numbers of seeds, and seedlings are always found along tracks, but they seem to have a high mortality rate as the mature plants are not nearly so common. Forest Bindweed Calystegia marginata has grown rampant in the sclerophyll forest along Telegraph Track.

We did record a few unknowns and took specimens for further study. One had only the cotyledons and one small ‘three-fingered’ leaf. A later field trip elsewhere provided the identification: Slender Platysace Platysace heterophylla. Most unknowns were small and probably will only be identified as mature plants. They usually occurred as one or two plants at most and are unlikely to have a significant effect on the recovery of the vegetation.

Species diversity was greatly enhanced by the fire in both vegetation classes being monitored. The key species in these vegetation classes are Coast Banksia Banksia integrifolia and Coast Tea-tree Leptospermum laevigatum. Coast Banksia seedlings were rare; the only site where numerous seedlings were seen was at Oberon Car Park, many months after the fire. Coast Banksias do not require fire to release their seeds, but they are in poor condition, so perhaps seedling numbers were not high before the fire. Coast Tea-tree seedlings were abundant, up to 325 per square metre in burnt areas compared with less than five in unburnt control quadrats. This species has become an invasive weed and its success has been attributed to disturbed topsoil, a temporary increase in soil phosphorus and the release of the accumulated reservoir of seed. Fire is the most likely factor to produce these conditions (Burrell, 1981).

Queries arising from these observations are: Why are the Banksias in decline? and How can the Tea-tree invasion be controlled?

Ferns

Within a month of the fire there were patches of green highlighting the burnt landscape. Some of these were gullies that the fire had swept over, leaving refuges for any animals that were able to escape. Other splashes of fresh bright green were ferns.

The Austral King-fern Todea barbara was conspicuous in fern gullies and beside or in the shelter of granite boulders. This fern is a survivor, a vigorous coloniser, slow-growing and long-lived. It is characterised by a short, black fibrous trunk, often with several crowns; the fronds are large and bipinnate.

Rough Tree-ferns Cyathea australis were scattered through the burnt forest or growing in dense stands in creek beds and damp areas. Remnants of singed fronds were to be seen. In the centre of these, new croziers were visible, bearing shiny scales. In a very short interval after the fire, the fronds formed green umbrellas.

Austral Bracken Pteridium esculentum took longer to recover, but after emergence it grew as vigorously as ever. We were walking through dense, metre-high fronds the year following the fire.

We found only one epiphytic fern, in an unburnt quad of Coast Dune Scrub Mosaic, a Kangaroo Fern Microsorum pusillum.

In August 2006, on the track from Telegraph Track to the Light Station, we found three other ferns: Common Ground Fern Calochlaena dubia, Scrambling Coral-fern Gleichenia microphylla and Screw Fern Lindsaea linearis, all of which grow from rhizomes.

On the way up Mt Oberon in October 2006, we found three Blechnum species. Soft Water-fern B. minus and Fishbone Water-fern B. nudum regenerate from crect
rhizomes that form short trunks, Hard Water-fern *B. wattsii* regenerates from a creeping rhizome; the rhizomes are protected by scales. These ferns normally grow in sheltered damp places, but survive on the edges of forest. After burning, Fishbone Water-fern becomes yellowish and more stunted and new fronds sprout from the trunk.

Ferns are clearly very tough survivors of bush fire. Their thick fibrous trunks or underground rhizomes give them a reliable means of rapid regeneration. For the first year, at least, they were growing in unsheltered, open forest and this second year has been very dry. Until areas of wet forest recover we may not find many of the smaller, more delicate and moisture-dependent ferns.

**Epicormic growth and root sprouts**

Epicormic growth is vegetative growth arising from a swollen stem base containing food material and bearing buds in the axils of scale-like remains of the previous season's growth. The sprouts that appear along the trunks and branches of eucalypts after a fire are epicormic. This immediate response allows the trees to survive while they resume normal crown growth.

It is not only eucalypts that display epicormic growth. We found Blanket Leaf *Bedfordia arborescens* and Sweet Bursaria *Bursaria spinosa* showing the same rapid regrowth.

Roots appear to have a similar potential for regrowth. In some high intensity burn areas where the trees are blackened stumps, root sprouts from several species occurred, including Coast Banksia *Banksia integrifolia*, Drooping She-oak *Allocasuarina verticillata* and some pea species.

**Perennial ground cover species**

Mosses, sedges, grasses and lilies all recovered quickly after the fire, providing early green shoots for grazing animals. They are matt and tussock forming plants, many with underground stems that store food, and can withstand fire, their growing points protected by dried leaves. They often produce hard seeds that germinate readily after a fire.

Many mosses are adapted to dry harsh environments and those we found in the burnt areas seem to have survived. Immediately after the fire it was possible to find moss-covered rocks that were still green, while parts of the nearby rocks had split off in the heat. Most mosses were covered in sporangia in the first year after the fire, but died back during the dry summer months.

Mat-rushes provided early green shoots for grazing animals. We found Spiny-headed Mat-rush *Lomandra longifolia* and Wattle Mat-rush *L. filiformis* mat-rushes in both EVs. During the first winter we found a lot of tough, blackened rhizomes in wet gullies and swamps. These were later identified as Tall Saw-sedge *Gahnia clarkii*, a tall tussocky plant that often forms impenetrable masses in poorly drained areas. Sword-sedges were well represented, the most common being Sand-hill Sword-sedge *Lepidosperma concavum*. A loosely tufted, stoloniferous, perennial herb found in both EVs, was Field Woodrush *Luzula meridionalis*. We found seed heads later in the season.

The most intriguing plants after a fire are the grass trees. Two species occur at the Prom, Austral Grass-tree *Xanthorrhoea australis* and Small Grass-tree *X. minor*. Although the leaves were burnt, they regrew from the centre of the trunk, the length of fresh bright green showing the rapid rate of growth, about 3 cm a week so that by the fifth week after the fire the line between brown and green was 15 cm from the trunk. They all flowered, providing a source of food for returning butterflies and other insects. Some grass trees have since died and the question is: Why? They respond positively to fire, being resistant to burning and responsive to the stimulus of heat and smoke in reproduction. Have they become susceptible to Die-back, Phytophthora root-rot or is there some other cause?

Milkmaids *Burchardia umbellata* were conspicuous. This small lily has a few grass-like leaves with white six-petalled flowers in umbels in spring. It grows from underground tubers that clearly provided protection from the fire and a source for rapid regrowth in the first season. The reddish-brown three-lobed capsules were abundant in the autumn. The Butterfly Flag *Diapiranna moraea* made a spectacular
show against the bare ground, flowering prolifically. It won’t be seen so well until the next fire clears the undergrowth. Another lily found in early spring in the Coast Dune Scrub Mosaic EVC was Early Nancy Warbeka dioica. It grows from a small bulb and is found on the heathlands at the Prom especially after fire.

Only one species of Centrolepis Centrolepis fascicularis occurs at the Prom and we found it in both EVCs. This is a small bright green perennial herb forming dense cushions that die back when conditions become dry, resprouting after rain.

We found several species of grasses: Weeping Grass Microlaena stipoides, Brown-top Bent-grass Agrostis capillaris, Reed Bent-grass Deyeuxia quadririseta and Wallaby-grass Austrodanthonia species. Many of these were obviously new seedlings; others were regenerating from tussocks. Fire may present an opportunity for these perennial species to reproduce sexually and produce new individuals in the space and light created; certainly they all flowered in the first season post-fire.

**Orchids**

One group of plants attracted incidental attention because of their expected response to the fire: the orchids. These plants have declined in numbers and diversity in Victoria as a result of habitat loss, but other threats include rabbits and weed invasion (Coupar and Van Bockel, 1998). The terrestrial orchids have a tuberous root system which allows them to die back to avoid extremes of heat and dryness, but also to respond quickly to fire and rain. The tubers may increase in number, enhancing their ability to colonise suitable habitats. Under favourable conditions they also set seed. Some species flower only after stimulation by fire (Elliot and Jones, 1997).

There are more than eighty species of orchids to be found at the Prom (Flora Information System, Biodiversity and Natural Resources, DSE - May 2005 - © Viridans Biological Databases).

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Botanical Name</th>
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</thead>
<tbody>
<tr>
<td>Mosquito Orchid</td>
<td>Acianthus pusillus</td>
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<tr>
<td>Mayfly</td>
<td>Acianthus caudatus</td>
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<tr>
<td>Pink Fairies</td>
<td>Caladenia latifolia</td>
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<tr>
<td>Small Spider-orchid</td>
<td>Caladenia parva</td>
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<tr>
<td>Caladenia sp</td>
<td>Caladenia sp.</td>
</tr>
<tr>
<td>Thick-lipped Spider-orchid</td>
<td>Caladenia tessellata</td>
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<tr>
<td>Beard-orchid</td>
<td>Calochilus sp.</td>
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<tr>
<td>Spurred Helmet-orchid</td>
<td>Corybas aciniflorus</td>
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<tr>
<td>Slaty Helmet-orchid</td>
<td>Corybas incurvus</td>
</tr>
<tr>
<td>Pelican</td>
<td>Corybas unguiculatus</td>
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<tr>
<td>Small Tongue-orchid</td>
<td>Cryptostylis leptocephala</td>
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<tr>
<td>Donkey Orchid</td>
<td>Dioris orientalis</td>
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<tr>
<td>Waxlip</td>
<td>Glossodia major</td>
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<tr>
<td>Hare Orchid</td>
<td>Leptoceras menziesii</td>
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<td>Onion Orchid</td>
<td>Microtis sp.</td>
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<td>Common Onion-orchid</td>
<td>Microtis unifolius</td>
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<tr>
<td>Horned Orchid</td>
<td>Orthoceras strictum</td>
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<tr>
<td>Tall Leek-orchid</td>
<td>Prasophyllum elatum</td>
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<tr>
<td>Striped Greenhood</td>
<td>Pterostylis alata</td>
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<td>Slender Greenhood</td>
<td>Pterostylis foliata</td>
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<td>Sickle Greenhood</td>
<td>Pterostylis furcata</td>
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<td>Tall Greenhood</td>
<td>Pterostylis melanogramma</td>
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<tr>
<td>Greenhood sp</td>
<td>Pterostylis sp.</td>
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<tr>
<td>Tunstall’s Greenhood</td>
<td>Pterostylis tunstallii</td>
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<tr>
<td>Red Beaks</td>
<td>Pyrorchis nigricans</td>
</tr>
<tr>
<td>Blotched Sun-orchid</td>
<td>Thelymitra benthamiana</td>
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<td>Thelymitra media</td>
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<td>Slender Sun-orchid</td>
<td>Thelymitra pauciflora</td>
</tr>
<tr>
<td>Sun-orchid</td>
<td>Thelymitra sp.</td>
</tr>
</tbody>
</table>

Table 1. Orchids found at Wilsons Prom from July 2005 to November 2006

The Victorian Naturalist
Walking along Biddy’s Track revealed the largest number of species, seven in July 2005 and three more in September. Along Waterloo Track there were numerous Red Beaks, almost all in flower or just past it in October 2005. On a trip to the Light Station in August 2006 another four species were seen. Only single specimens were found of the vulnerable Caladenia tessellata, rare Corybas aconitiflorus, and endangered Pterostylis furcata. Ralph Laby photographed eight other orchids during our work. Other species were found in great numbers when we were measuring and counting individual plants in metre-square quadrats, more than twenty individuals per square metre and most were flowering, e.g. Corybas incurvus, Caladenia latifolia and Pterostylis melagramma. Where only a leaf was visible it was not always possible to identify the species (Table 1).

Overall, we observed about a quarter of all the species recorded for the Prom. Given that we were not searching for the plants and were working in only two EVCs, rather than the full range of habitats where orchids may be found, these results are encouraging. The large number of individuals flowering was probably a response to the fire, whether by direct exposure or the effect of smoke. The immediate effect of the fire has probably been beneficial for the orchids. It will be interesting to see whether the same numbers of species will be observed over the next few years before the vegetation recovers to full growth. Rabbits and weeds remain the principal threats to orchids. There are control programs in place for both at the Prom.

The weed that we have found almost everywhere is Tall Fleabane Conyza bonariensis and it may well represent a threat to orchids because seedlings appeared rapidly and the first seedlings have already produced copious seeds. Reviewing the results in the meantime assists in clarifying the questions we should bear in mind when collecting data. After the profuse flowering, it would be interesting to determine whether next (2007) season’s orchids include any seedlings. How can we measure the effect of Fleabane?
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