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Two Hundred Years of Land Use and Vegetation Change in a Remnant Coastal Woodland in Southern Australia

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Abstract

Post-settlement changes in vegetation and land use were examined in a reputedly undisturbed woodland remnant at Ocean Grove, southern Victoria, the site of earlier ecological studies. The vegetation has passed through at least three structural phases since European colonisation: an open grassy woodland dominated by *Allocasuarina* and *Eucalyptus* species and *Banksia marginata* Cav. with few shrubs; an open scrub of *Acacia pycnantha* Benth.; and a closed scrub of *Allocasuarina littoralis* (Salisb.) L.A.S.Johnson, which now dominates the reserve. Tree and shrub density has progressively increased, from perhaps less than 20 trees ha^{-1} in the early 1800s, to over 3000 trees ha^{-1} in 1996. Most large *Allocasuarina* trees established in the late 1930s or early 1940s, and *Allocasuarina littoralis* appears to have invaded rapidly thereafter. Surprisingly, *A. littoralis* was not recorded in an 1894 plant census, and might have been locally rare last century. Vegetation changes over the past 200 years can be attributed to the long-term absence of fire. The abundant recruitment of *Acacia* species in the mid- to late-1800s may have been a rapid response to the curtailment of Aboriginal burning, and the more recent invasion of *A. littoralis* a longer-term response to fire exclusion. The importance of active vegetation management for biodiversity conservation in the future is stressed.

Introduction

As elsewhere in the world, any comprehensive account of vegetation ecology in Australia must incorporate the impact of people—not only to accommodate over 40 000 years of Aboriginal life, but also to explain the substantial changes wrought since European occupation. Native grasslands and woodlands have suffered gross destruction and fragmentation over the past 200 years, and small remnants now tenuously persist in many agricultural regions of temperate Australia (Kirkpatrick *et al*. 1988; McDougall and Kirkpatrick 1994; Prober and Thiele 1995). Many studies have demonstrated that their composition reflects land-use history as well as underlying environmental factors, such as geology and soils (Stuwe and Parsons 1977; McIntyre and Lavorel 1994; Prober and Thiele 1995; Lunt 1997*a*). Consequently, past land uses must be elucidated accurately, to provide a firm basis for future conservation.

In the early 1970s, the ecology of a remnant woodland at Ocean Grove (38°15′S, 144°31′E), on the Bellarine Peninsula in southern Victoria, was intensively studied by Withers and Ashton (1977) and Withers (1978*a*, *b*, 1979*a*, *b*). Withers and Ashton (1977) described succession from an open woodland dominated by *Eucalyptus* species, to a closed scrub dominated by *Allocasuarina* species (principally *A. littoralis* (Salisb.) L.A.S.Johnson), and attributed this to the long-term absence (> 90 years) of fire and other major disturbances. They predicted that *A. littoralis* would totally dominate the site, and that eucalypts would become extinct, if the site remained undisturbed (Withers and Ashton 1977). Quoting Garnet (1961)—who stated that the ‘only interference with natural processes within the area … was grazing by Cobb and Co. horses a very long time ago’—Withers and Ashton (1977) believed that the Ocean Grove reserve had remained undisturbed by large-scale disturbances such as burning, stock grazing and logging for over 90 years.

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The present study provides a comprehensive account of the vegetation and land-use history of the Ocean Grove Nature Reserve, and surrounding areas on the Bellarine Peninsula. It was undertaken for two reasons. First, Withers and Ashton (1977) made an important contribution, not only to our understanding of woodland dynamics, but also to the ongoing debate over the role of fire in Australia during the past 40 000 years (Singh and Geissler 1985; Ladd 1988; Crowley 1994). Second, many coastal and sub-coastal conservation reserves in south-eastern Australia are now managed in a similar way to the Ocean Grove site. Consequently, an accurate historical record from the Ocean Grove reserve is directly relevant to the conservation management of many important reserves in south-eastern Australia.

Materials and Methods

Historical information on vegetation patterns on the Bellarine Peninsula was searched for in the accounts of early European explorers and settlers, local histories, regional natural history journals and land-use reports. More specific information on the Ocean Grove Nature Reserve was obtained from elderly residents and naturalists, unpublished theses by Withers (1971, 1976), and files at the Geelong Office of the Victorian Department of Natural Resources and Environment. All plant names follow Ross (1996).

Microfiche reproductions of historical maps held at the Central Plans Office of the Department of Natural Resources and Environment in Melbourne were examined. All old plans in the ‘put-away’ series were examined for the four parishes on the Bellarine Peninsula (Bellarine, Connewarren, Moolap and Paywit). More recent maps of the Bellarine parish (which contains the Ocean Grove reserve) which included soil or vegetation annotations (according to the parish map index) were also examined; since the recent maps contained little information of value, they were not examined for the adjoining parishes. A composite map was compiled to illustrate all vegetation annotations on the old survey plans (some detailed plans of small areas near Portarlington, Swan Bay and Point Lonsdale were not used in this study, owing to the small areas mapped).

Some historical maps included tables showing the distance and compass bearings of marked trees from allotment corners. These allowed a quantitative assessment of species frequencies (e.g. 60% oak, 28% gum, 12% honeysuckle) and enabled tree densities to be calculated, using the plotless, closest neighbour method of Cottam and Curtis (1956). By this method, the average tree density can be obtained using the formula: density = 0.25 × (mean distance)$^{-2}$ (Cottam and Curtis 1956; Lunt 1997*b*). This method requires that corner-to-tree distances were measured at all allotment corners, regardless of the practicality to the surveyor of measuring long distances in sparsely treed areas. In practice, no distances were listed at many corners in some areas. Where trees could not be marked, the corner was instead marked by a stake and trench, or a ‘cut in turf, mound and trench’. This more laborious, and less conspicuous, alternative was presumably adopted when trees were too far distant to usefully mark the allotment corner. Treeless points were treated in two ways to obtain maximum and minimum density estimates. Maxima were obtained by ignoring treeless points, thereby resulting in an over-estimation of actual tree densities. Minima were obtained by assuming an arbitrary corner-to-tree distance, 5 m longer than the maximum corner-to-tree distance which was recorded on the map sheet. Both methods were used on all maps, and density data are presented with and without the inclusion of treeless points. Often, more than one tree was blazed at the same corner (one in each adjacent allotment). In such cases, only the tree closest to the corner was used in density calculations, although all trees were used in assessments of relative frequencies of tree species.

A dendrochronological study was undertaken in 1996 to identify the age of the largest *Allocasuarina* trees, and to see whether they carried fire scars. Cross-sections were obtained from six large *Allocasuarina verticillata* (Lam.) L.A.S.Johnson and two large *A. littoralis* which had recently died. All were over 0.7 m GBBH (girth over bark at breast height). Unfortunately, few large dead *A. littoralis* were available for sampling, and many sampled trees were rotten, resulting in only two *A. littoralis* samples being successfully obtained. Selected radii were fine-sanded, and rings were counted and widths measured under a magnifying glass. A plot of rings widths against annual rainfall data at Barwon Heads (Bureau of Meteorology, unpublished data) showed a good concordance of wide growth rings with high annual rainfall years, which allowed ring sequences to be synchronised. This increased the confidence in the estimated ages from growth ring counts, and enabled samples which had died some time earlier than the sampling date to be aged accurately. To identify whether large trees reproduced in discrete cohorts or continuously, the girths of all large *A. littoralis* and *A. verticillata* (> 60 cm GBBH and excluding short-boled, woodland-form *A. littoralis*) were counted in a 1.4-ha plot in the Ocean Grove reserve (data from Lunt 1998), to calculate the density of large trees in 1996. The resultant girth-frequency plot was compared against the tree ages obtained from the dendrochronological samples, to assess the timing of the main pulses of recruitment.

Results

Early Descriptions, 1802–1836

The first informative European account of the vegetation on the Bellarine Peninsula was by Captain Matthew Flinders in April 1802, who noted:

> *Indented Head, at the northern part of the western peninsula, had an appearance particularly agreeable; the grass had been burned not long before, and had sprung up green and tender; the wood was so thinly scattered that one might see to a considerable distance; and the hills rose one over the other to a moderate elevation, but so gently, that a plough might every where be used. The vegetable soil is a little mixed with sand, but good, though probably not deep, as I judged by the small size of the trees.*
>
> *The most common kinds of wood are the casuarina and eucalyptus, to which Mr. Grimes adds the banksia, mimosa, and some others; but the timber is rarely sound, and is not large.* (Flinders 1814, p. 219.)

Contemporary accounts by Flemming and Tuckey (who both visited in 1803) provide similar descriptions, as do accounts by later settlers, such as Batman, Gellibrand and Wedge, who entered in the 1830s. John Batman provided the most detailed and ecstatic description of the country in 1835:

> *We then went into the bush for about four miles* [from Indented Head], *and passed over some beautiful land, and all good sheep country; rather sandy, but the sand black and rich, covered with kangaroo grass about ten inches high, and as green as a field of wheat. We then went in another direction for about four or five miles over very good sheep land, gentle rises, with wattle and oak, with stunted gum. None or very little, of this timber would split. We made the bay* [Indented Head] *again, and crossed before we came to a beautiful plain, about 300 to 400 acres of as rich a land as I ever saw, with scarce a tree upon it; the grass above our ankles. We saw several forest kangaroos, but … could not catch any ... We then came down the bay, which consists of excellent land—rich black sand the worst of it; the other black soil, but all covered alike thickly with grass of the best description. We saw some bare hills about six miles off, which appear grassy to the top.* (quoted in Bonwick 1883, p. 179.)

Batman's ship followed the shore towards Corio Bay and anchored near Point Henry. Batman went ashore, and later wrote:

> *I went on shore* [near Point Henry] *to look at the land, which appeared beautiful, with scarcely any timber on. On my landing I found the hills of a most superior description—beyond my most sanguine expectations. The land excellent, and very rich—a light black soil, covered with kangaroo grass two feet high, and as thick as it could stand. Good Hay could be made, and in any quantity. The trees not more than six to the acre, and those small sheoak and wattle. I never saw anything equal to the land in my life. I walked over a considerable extent, and all of the same description. This land forms an isthmus, which is about twenty miles long by ten miles across it—upwards of 100 000 acres of good land or more. I could see five or six miles in every direction. Most of the high hills were covered with grass to the summit, and not a tree, although the land was as good as land could be. The whole appeared like land laid out in farms for some 100 years back, and every tree transplanted. I was never so astonished in my life.* (quoted in Bonwick 1883, pp. 179–180.)

In another version of this day's journey, Batman wrote that the land was 'covered with kangaroo and other grasses of the most nutritive character, intermixed with herbs of various kinds' (Batman 1983, p. 25) and, 'the gently rising eminences were adorned with wattle, banksia, native honeysuckle, and the she-oak, whose short, straight, stumpy buts and round heads resembled a number of pins sticking in a ladies pincushion.' (Batman 1983, p. 26).

The accounts of Flinders (1814), Flemming (in Shillinglaw 1879), Tuckey (1805), Batman (in Bonwick 1883; Batman 1983), Wedge (in Bonwick 1883) and Gellibrand (in Bride 1898) all describe an open woodland landscape, with scattered small trees of *Eucalyptus* species ('gum'), *Allocasuarina* species ('sheoak' and *Casuarina*), *Banksia marginata* Cav. ('honeysuckle') and *Acacia* species ('wattles'), and no noticeable shrub layer, above a sward of kangaroo grass (*Themeda triandra* Forssk.) and unnamed inter-tussock herbs. Three accounts (by Flinders, Flemming and Tuckey) note recent fires, and Flemming noted the impact of fire on controlling tree recruitment, and thereby keeping the landscape open: 'the timber … [consisted] of gum, oak, banksia, and mimosa, some small pine, one half of it dead by the country being lately burnt.' (Shillinglaw 1879, p. 33). Wedge's pencil sketches, drawn in 1835, provide some of the earliest illustrations of the peninsula landscape (Todd 1989). All show very open landscapes, with scattered trees and a grassy ground cover.

1850s–1900

The most useful accounts from the latter part of the 19th century exist not in diaries, but in maps and reports by government officers. Annotations from old plans (Fig. 1) reiterate a general theme from earlier explorers' accounts—namely dominance by oaks, gums and honeysuckle—but also show some broad (albeit simple) geographic patterns across the peninsula. The most notable variations from the general theme of 'oak, gum, honeysuckle' woodland were north-east of Clifton Springs, described as 'rich black soil very lightly timbered with gums, blackwood, native box, myrtle and she oak' and, south of Drysdale, described as 'grass tree hills, gum scrub and heath' (Fig. 1). The species concerned are likely to be *Eucalyptus* species (gums), *Acacia melanoxylon* R.Br. or *A. implexa* Benth. (blackwood), *Allocasuarina* species (sheoak) and *Xanthorrhoea australis* R.Br. (grass tree). Some uncertainty surrounds the identity of 'native box' and 'myrtle'. One of the two is likely to be *Bursaria spinosa* Cav., which was called 'prickly native box' and 'French Island myrtle' by Guilfoyle (1894). The other might perhaps be the coastal *Alyxia buxifolia* R.Br., called 'heath box' by Guilfoyle (1894). The area around the present Ocean Grove Nature Reserve was mapped as 'honeysuckle' in the 1850s and 'thick timber' in 1913 (Fig. 1).

A valuable map from 1850 (map P/A B331, re-drafted in 1869 as P/A B329) coded every allotment across the central peninsula into one of three categories: A, good soil, lightly timbered; B, tolerable forest soils; and C, heathy. Allotments in Category A were to the north-east of Clifton Springs, in the area of 'rich black soil' described earlier. Most of the peninsula—including the area now occupied by the Ocean Grove Nature Reserve—was allocated to Category B (tolerable forest soils), and Category C soils (heathy) were restricted to the central part of the peninsula, in an area north of the Ocean Grove Nature Reserve, and bounded by Drysdale (to the north-east), Wallington (to the west), and the Geelong to Point Lonsdale Road to the south (Fig. 2). The three zones correspond broadly with major geological changes on the Bellarine Peninsula: zone A (lightly timbered vegetation) occurred on Tertiary basalt; zone B (tolerable forest soils) was on Tertiary non-marine sediments (which occupy most of the Bellarine Peninsula); and zone C (heathy vegetation) was on Recent windblown sands which overlie Tertiary sediments (Land Conservation Council Victoria 1985).

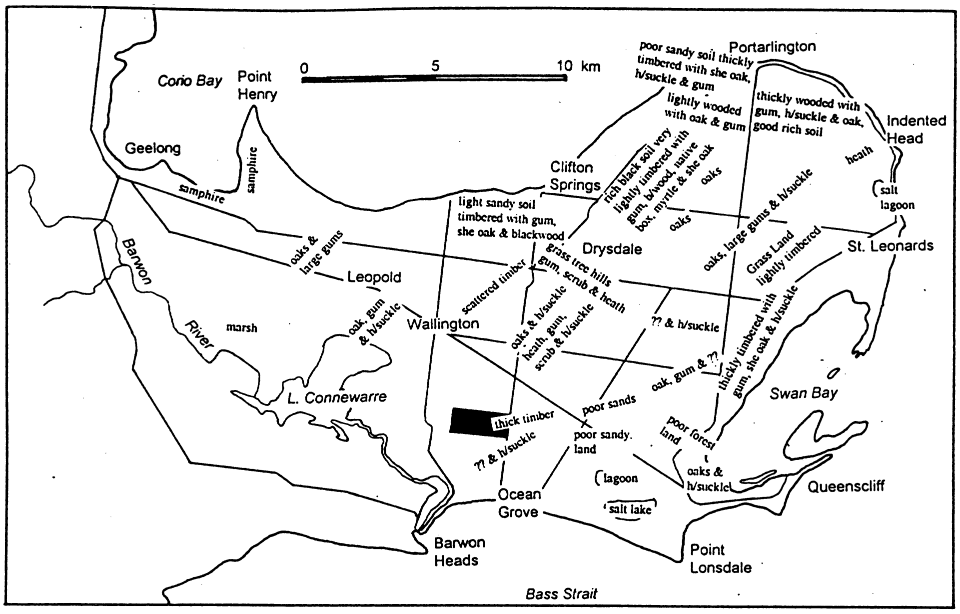

Fig. 1. Vegetation annotations on the Bellarine Peninsula compiled from 19th century survey plans. '??', undecipherable annotation; 'h/suckle', honeysuckle; 'b/wood', blackwood. Location of the Ocean

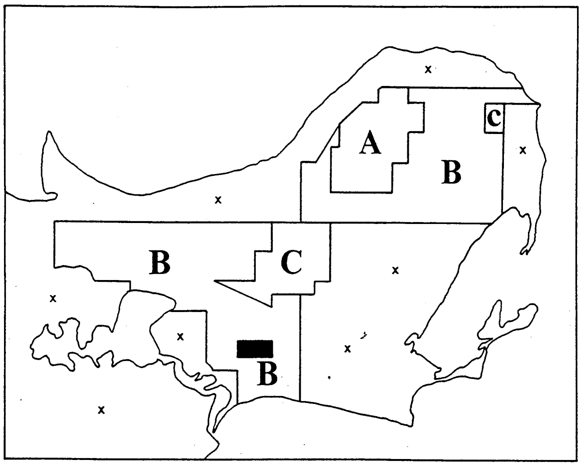

Fig. 2. Three vegetation zones shown on an 1850 survey plan (P/A B328). Zone A, 'good soil, lightly timbered'; Zone B, 'tolerable forest soils'; Zone C, 'heathy'. Areas marked 'x' were not assessed on the early plan.

Two maps from the 1850s (P/A B328 and P/A329) listed the distance of the closest tree to each allotment corner, permitting calculations of species composition and tree densities. Overall, seven species were recorded in these lists (box, oak, gum, honeysuckle, wattle, cherry (*Exocarpos cupressiformis* Labill.) and myrtle), the most

Table 1. Percentage frequency of species in various zones on the Bellarine Peninsula, calculated from historical plans

Zones: A, good soil, lightly timbered; B, tolerable forest soils; C, heathy (all from map no. P/A B329). Zone D is between Clifton Springs and Portarlington (from map P/A B328)

	Zones			
Species	A	B	C	D
Box	14	5	–	7
Oak	53	31	38	58
Gum	33	60	62	28
Honeysuckle	–	1	–	2
Wattle	–	2	–	–
Cherry	–	1	–	–
Myrtle	–	–	–	5

abundant being gum and oak (Table 1). Despite its frequent appearance in map annotations, ‘honeysuckle’ was rarely listed in these tables: just 4 of 382 records (1%) of trees on allotment corners were of honeysuckle (cf. Table 1 and Fig. 1). There were some differences in percentage composition between the three zones (A–C) on map P/A B331. Oaks predominated in the lightly timbered zone north-east of Clifton Springs (and in adjacent area on map P/A B328), whereas gums were recorded most frequently in all other areas (Table 1). Only two species were recorded from the heathy zone: gum and oak (Table 1). Tree densities ranged from a maximum of 16 trees ha^{-1} in the heathy zone, to 6–10 trees ha^{-1} (depending upon the calculation method used) in areas of ‘tolerable forest soils’, and 3–8 trees ha^{-1} in the ‘lightly timbered’ zone north-east of Clifton Springs (Table 2). The general impression is again of an extremely open woodland, as described earlier by European explorers and settlers.

Botanical Census

A census of the vascular plants of the Bellarine Peninsula between Ocean Grove and Clifton Springs was published in 1894 by the Director of the Melbourne Botanical Gardens, William Guilfoyle (1894). The list, compiled ‘during a few days sojourn in the district’, contained 250 species, including 211 natives and 39 exotics. Guilfoyle’s article

Table 2. Tree densities in various zones on the Bellarine Peninsula, calculated from historical plans

Zones A to C are from historical map no. P/A B329 and Zone D from map P/A B328. The ‘no. of points’ column shows the number of allotment corners used to calculate mean tree densities. The first value shows the number of corners at which trees were recorded, and the second shows the number of additional corners where no trees were listed

Zone	Density (trees ha^{-1}) maximum	Density (trees ha^{-1}) minimum	No. of points
Zone A—good soil, lightly timbered	8	3	49 + 35
Zone B—tolerable forest soils	10	6	189 + 31
Zone C—heathy	16	16	23 + 0
Zone D—Clifton Springs – Portarlington	10	6	53 + 7

is arranged taxonomically, and does not describe the landscape or vegetation structure. Nevertheless, it provides an invaluable early record of plant diversity on the peninsula. One species in particular is notable by its absence, *Allocasuarina littoralis*:

> *The* Euphorbia, *nettle, and* Casuarina *families, can each claim only one species, so far as could be discovered by the writer during a few days sojourn in the district. The Sheoak* (Casuarina quadrivalvis [now called *Allocasuarina verticillata*]) *attains to large size in some places.* (Guilfoyle 1894, p. 31.)

The omission of *A. littoralis* is either an extraordinary oversight or, more probably, given the comprehensiveness of Guilfoyle's species list, must reflect a surprising sparsity in the region at the time. In 1996, a century later, *A. littoralis* exceeded 3 500 plants ha^{-1} in the Ocean Grove Nature Reserve (Lunt 1998), and the species could not nowadays be missed by any competent naturalist 'sojourning' for 10 min on the Bellarine Peninsula.

The Wattle Bark Industry

The Bellarine Peninsula was settled and developed for agricultural and pastoral pursuits from the late 1830s onwards, when the original Aboriginal landowners, the Wathaurong, were evicted. In the latter half of the 19th century, extensive scrubs developed in many areas, dominated by *Acacia* species, principally *Acacia pycnantha* Benth. (golden wattle). Guilfoyle (1894) listed eight species of *Acacia*, of which 'several kinds grow in dense thickets', and noted that *Acacia pycnantha* was 'one of the most common round Ocean Grove' (Guilfoyle 1894, p. 26). The wattle thickets formed the basis of an intensive wattle bark industry in the late 1800s and early 1900s. However, by the late 1870s, amidst concern that wattle bark supplies were diminishing in many areas of Victoria (owing to waste and over-cutting), the 'Wattle Bark Board of Inquiry' was formed in 1878. Evidence to the committee from a Geelong tannery owner, and landowners and wattle bark harvesters on the Peninsula, provides invaluable descriptions of the region in the late 19th century (Dixon *et al*. 1878).

The scale of the wattle bark industry was enormous. The Geelong tanner Joseph Brearley stated that 'I am a large consumer of bark, my establishment on the Barwon River, three miles from Geelong, absorbing on an average 1 300 tons per annum.' This bark was sourced from throughout central and western Victoria, including the Bellarine Peninsula. Edward Harvey of Portarlington attested that 'During the present season [1878] about 500 tons of bark have been shipped from Portarlington, and as much more, I believe, has been sent by road to Geelong.' Some respondents claimed that wattle thickets had increased in size and density since European colonisation of the peninsula. Robert McDonald, of Swan Bay, stated:

> *I own about 3,000 acres at Swan Bay, from which I have repeatedly tried to keep the wattles down; they grow like weeds, and all my efforts to extirpate them were unavailing ... For every wattle that was growing on my land twenty years ago there are at least a score now ... The wattles have multiplied in this district wonderfully; and there are many thousands now growing where they were unknown only a few years ago.* (Dixon *et al*. 1878, p. 54.)

Another resident, P. H. Ryan, 'corroborated this statement from his own personal experience of thirty years' residence in the locality' (Dixon *et al*. 1878, p. 54). A Mr James Dickinson of Portarlington presented an obsessively thorough appraisal of the abundance of the wattles in the district:

> *I went five days into the forest to make sure that my observations were correct. My desire was to elicit how many trees would be found upon an acre provided they were kept free from the intrusion of cattle, and left to the natural state of growth for a certain time. I measured ten square yards, counted the trees upon that surface. The number at the different ages I found as follows, where they had been kept preserved.*

Now, bear in mind, I don't suppose that there is one consecutive acre bearing the number, in consequence of the ravages of enemies. My estimate, especially of the younger plants, is therefore the maximum produce, provided the plants had been properly preserved up to the year old of stripping at any of the lower ages….
A patch of 2-year old trees, 5 to 6 feet high, contained 12 in the yard … 60 000 per acre
A patch of 3-year old trees, 10 to 12 feet high, contained 5 in the yard … 25 000 per acre
A patch of 4-year old trees, 15 to 18 feet high, contained 4 in the yard … 20 000 per acre

I need not go any further as I am convinced of my accuracy …. I was as much surprised as you at the number when I came to calculate. This compelled me to go into the forest again and again to make certain.

The development of dense wattle thickets was clearly a post-settlement phenomenon, and descriptions of dense thickets provide a stark contrast to the accounts of early white explorers like Tuckey who noted, 'the country is entirely free from underwood' (Tuckey 1805, p. 161). The abundant shrub recruitment may have arisen after the cessation of burning by Aborigines, as the local tribes were usurped in the 1830s. Curiously, even though some respondents described the development of the wattle thickets, nobody questioned *why* they developed, or why they were absent in the early 1800s when the region was first settled. In another interesting observation on changing perceptions of the local landscape, a recent observer (Bound 1964) interpreted the dense wattle thickets as representing the original vegetation of the peninsula at the time of European colonisation, rather than a post-settlement phase:

The eastern half [of the Bellarine Peninsula] *appears to have been in the main, thickly timbered* [originally], *with golden wattle* (A. Pycnantha) *predominating, and an early report (about 1879) describes how a party of reverend gentlemen returning to Geelong from a mission at Point Lonsdale turned south and went crashing and stumbling through the thick bush, finally reaching the Barwon River at what is now Ocean Grove.* (Bound 1964, p. 20.)

The 'early report' presumably refers to the wattle bark inquiry (Dixon *et al*. 1878). However, no mention of this event was found in the Geelong evidence to the inquiry (Dixon *et al*. 1878, pp. 50–54), and the story may be apocryphal.

The Nature Reserve, Late 1800s–1960

The area now occupied by the Ocean Grove Nature Reserve was owned by the Cuthbertson family from the late 1800s. Their property occupied a square mile, of which the northern half is now reserved, and the southern half subdivided for housing. Garnet's (1961) account, quoted by Withers and Ashton (1977), forms the basis of the accepted history of the reserve: 'During the long continuous ownership by the [Cuthbertson] family, about the only interference with natural processes within the area was when Cobb and Co. grazed horses there—a very long time ago.' Garnet also noted that 'Quite evidently [the reserve] has suffered no damage from fire during the past thirty or forty years—which is something almost unique in Victoria's settled places.' (Garnet 1961, p. 47). A more comprehensive, early description of the Cuthbertson's property was provided in a local history text by Edwards (1952):

[Cuthbertson's] *land … has never been cleared, and in parts fallen trees and rotting vegetation make walking impossible ... While the property to the east* [of Cuthbertson's] *was being stocked with sheep and that to the north with cattle, the Ocean Grove area was kept only for the value of its wattle bark, used extensively for leather tanning. The bark in this area has always been preferred by the tanners and fetches a good price … These wattles are very fast growing and the cleared areas soon regain their beauty.* (Edwards 1952, pp. 8–9.)

In contrast to Garnet's account, which implies that the Cuthbertson family didn't utilise the bush property, Edwards (1952) unambiguously describes its utilisation for wattle bark harvesting. Elderly Ocean Grove residents confirmed that Mr Cuthbertson cut the wattle bark on his own property ‘every year’ until the late 1940s, when ‘he was too old’ (E. Fox, pers. comm.; P. Mitchell, pers. comm. to Ray Hodge, Jan. 1997). The bark was cut from wattles about 10 years old, and the continual regrowth of younger wattles provided a constant resource for future years. The following winter, the dead wattle timber was sent to bakeries in Geelong. Whilst people ‘didn’t bother’ cutting sheoaks (E. Fox, pers. comm.), eucalypts were felled for wood, and the resprouting stumps were re-cut. According to Edwards (1952, p. 22), ‘Cuthbertsons had about forty bullocks on their property, mostly used for carrying the wattle bark into Geelong’, which suggests that very large quantities of wattle bark were removed from the reserve and surrounding areas every year. Stock grazing was apparently restricted to brief periods in the 1930s or 1940s, when the reserve was grazed by sheep (E. Fox, L. Hockley, P. Mitchell, pers. comm., Jan. 1997).

The appearance of the reserve earlier this century was described as ‘all gum trees, lots of grass trees and scrub … you could walk right through it’ (E. Fox, pers. comm.), and ‘mixed gums … [with] an odd sheoak tree’ (L. Hockley, pers. comm.). An early article by Waterhouse and Lyell (1913), which describes a new species of butterfly (the small ant-blue butterfly, *Acrodipsas myrmecophila* Waterhouse & Lyell, now a threatened species: Jelinek and White 1996), provides a vegetation description which is thought to refer to either the Cuthbertson’s property or Kingston Park (0.5 km south-east of the Ocean Grove Nature Reserve). They noted:

> *The ova of the* Pseudodipsas [an earlier name for *Acrodipsas*] *we found ... upon small dead tree stumps within a plantation of golden wattle,* Acacia pycnantha. *Some of these patches of eggs were deposited upon stumps at least ten yards distant from the nearest* A. pycnantha *tree …* (Waterhouse and Lyell 1913, p. 156.)

From this brief description it seems that the area concerned was dominated by an open stand of *A. pycnantha* at the time. The reference to a ‘plantation’ implies that the stand was harvested (for wattle bark, presumably) and contained few trees of other species.

Despite its regional importance at the turn of the century, the now-obsolete wattle bark industry was rapidly forgotten, and is not mentioned by Garnet (1961), Withers and Ashton (1977) or other commentators (Department of Natural Resources and Environment, unpublished data). Nevertheless, given the large quantities of bark harvested and the number of trees removed, the industry must have had a considerable impact on vegetation structure, by continually extracting large trees and maintaining open areas for future re-colonisation.

1960s–Present

A successful campaign to acquire part of the Cuthbertson estate as a conservation reserve was initiated by the Geelong Field Naturalists’ Club in the early 1960s, spurred by the almost complete destruction of the original woodlands of the Bellarine Peninsula, and expanding residential development in the neighbouring town of Ocean Grove (Garnet 1961). The resultant compulsory acquisition of part of the estate in 1966 set a precedent at the time (Department of Natural Resources and Environment, unpublished data).

The site was inspected by staff of the Forests Commission and National Parks Service in 1960, prior to the acquisition of the reserve. In an unpublished internal report, they described the area as, ‘flat lightly timbered country with an understorey of native grasses and small shrubs’ (Landy 1960). Furthermore, they believed, ‘the present stand [of dominant trees] to be second growth between 80 and 100 years old. The prolific growth of Sheoke [*Allocasuarina* spp.] and golden wattle [*Acacia pycnantha*] in some places may be the result of fires.’ (Landy 1960). Landy (1960) noted, ‘The only damage in recent years has resulted from the removal of timber, but this has been restricted to small sections of the forest and few of the larger trees have been felled.’ Interestingly, there was, at that time, no mention of widespread *Allocasuarina* invasion, or of any obvious impacts of past wattle bark harvesting.

Eleven years later, in 1971, Withers and Ashton began the field work for their comprehensive ecological and physiological studies. They described the vegetation as:

> *a fairly mature layered woodland of* Eucalyptus, Casuarina [= *Allocasuarina*], Acacia *and* Banksia, *in which both eucalypts and acacias are dying out.* [*Allocasuarina*] *forms dense scrub with thick litter accumulation. Regeneration of* Eucalyptus *species is virtually absent, whilst that of* [*Allocasuarina*] littoralis *is relatively prolific* (Withers and Ashton 1977, p. 623.)

The decline of *A. pycnantha* was patchy, and restricted to areas of closed *Allocasuarina* scrub; elsewhere it formed, 'developing stands in large grassy gaps in the woodland' (Withers and Ashton 1977, p. 625). The death of many mature eucalypts shortly before their study was attributed to competition for water against the invading scrub of drought-tolerant *A. littoralis* (Withers 1971, 1976). Eucalypt deaths were thought to have occurred in the severe drought of 1967–1968:

> *Another feature of the changing vegetation pattern is the dieback of young mature* Eucalyptus. *Much of the dieback occurred fairly recently as many trees still have fine twigs on the branches. These usually drop off after the tree has been dead a long while. An aerial photograph taken on December 13, 1964, does not show any dead* Eucalyptus *tops projecting above the canopy, which suggests that much of the dieback may have occurred within the past six years. This could have been due to the severe drought of 1967–68. It is possible that sufficient moisture could be available to support the smaller crowns of the younger trees but not to satisfy the demands of more mature individuals.* (Withers 1971, p. 30.)

After a series of detailed, ecophysiological studies (Withers and Ashton 1977; Withers 1978*a*, *b*, 1979*a*, *b*), Withers and Ashton (1977, p. 623) concluded:

> *Ultimately, the poor regeneration of the eucalypt woodland is almost certainly due to the absence of fire …* [*Allocasuarina*] littoralis *is an aggressive species which is vigorously invading* Eucalyptus *woodland and establishing a dense stratum. Since the* [*A.*] littoralis *scrub is self-regenerating, even in quite small gaps, it is considered to be a climax condition at the present time in the long-continued absence of fire.*

Continued fire suppression was predicted to lead to increasing development of a monocultural *A. littoralis* scrub, gradual extinction of eucalypts, loss of open gaps (and any species dependent upon open areas), and a decline in the diversity of ground plants beneath the dense scrub. These trends were confirmed by repeat monitoring in 1996 (Lunt 1998).

Ages of Dominant Allocasuarina *Trees in 1996*

The 1996 dendrochronological study showed that tree ages varied from 50 to 91 years (Table 3). No fire scars were observed, which supports the general history of no major fires this century. The two sampled *A. littoralis* trees were of similar girths (0.76 m and 0.78 m) but different ages (52 and 72 years). By contrast, older trees of *A. verticillata* were generally larger (Fig. 3). There was no indication that older *A. verticillata* were slowing their annual growth increment before their death (Fig. 3).

Structural data from the 1.9-ha plot in the Ocean Grove reserve showed no evidence of discrete size classes amongst large (> 0.6 m GBBH) *A. littoralis* (Fig. 4*a*), which suggests that large trees of *A. littoralis* may have recruited continuously. The aged samples of *A. littoralis* were considerably smaller than the largest trees in the plot (0.76 m and 0.78 m GBBH c.f. a maximum of 1.38 m GBBH: Fig. 4*a*), suggesting that the largest *A. littoralis* in the reserve are far older than the 50–70 years indicated by the samples. By contrast, many size-class cohorts of *A. verticillata* may be discerned: (1) 0.6–0.7 m

Table 3. Estimated ages from tree ring counts of eight large *Allocasuarina* trees in the Ocean Grove Nature Reserve in 1996

GBBH = girth over bark at breast height. In calculating tree ages, it was assumed that all fallen trees died in 1996, although some may have died some years earlier

Species	GBBH (m)	Year of recruitment	Age (in 1996)
A. littoralis	0.78	1944	52
A. littoralis	0.76	1924	72
A. verticillata	0.90	1946	50
A. verticillata	0.96	1934	62
A. verticillata	1.26	1915	81
A. verticillata	1.26	1910	86
A. verticillata	1.17	1905	91
A. verticillata	1.35	1905	91

GBBH, (2) 1.0–1.1 m GBBH, (3) 1.3 m GBBH, plus two larger trees (1.58 m and 1.87 m GBBH: Fig. 4*b*). By extrapolating from the aged samples, the 1.0–1.1 m GBBH size class may be 50–60 years old (i.e. 1930s–1940s recruitment) , and the 1.3 m GBBH class, 80–90 years old (1900–1915 recruitment). The two largest *A. verticillata* presumably exceed 100 years. Despite the presence of some trees far larger than the aged samples, most of the large, dominant *A. littoralis* and *A. verticillata* were within the same size classes as the aged samples (Fig. 4), indicating that the great majority of the large, dominant *Allocasuarina* trees have recruited this century, and are less than about 90 years old.

In 1996, large *Allocasuarina*, *Banksia* and *Eucalyptus* trees (> 0.6 m GBBH) occurred at a density of 198 trees ha^{-1} in the 1.4-ha monitoring plot (the inclusion of dead trees raises this total to 259 trees ha^{-1}, Table 4). Similar densities occurred in the rest of the reserve, beyond the monitoring plot. The majority of these trees were *A. littoralis*, and there were relatively few large *B. marginata*, *A. verticillata* or *Eucalyptus* species (Table 4). It is assumed that most (if not all) of these large trees are at least 50 years old, and recruited before 1945, at the latest.

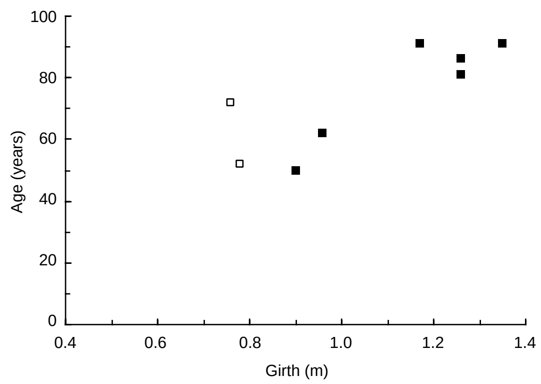

Fig. 3. Relationship between girth (GBBH) and tree age (from growth ring counts) for eight large *Allocasuarina* trees. ■, *A. verticillata*; □, *A. littoralis*.

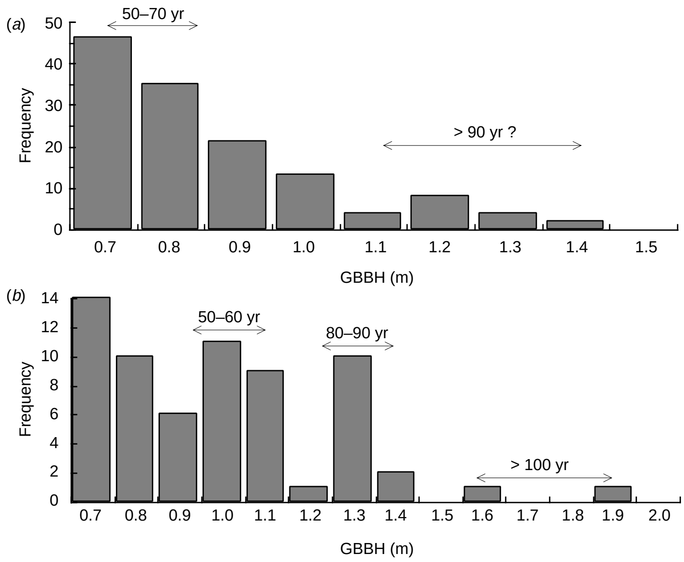

Fig. 4. The number of large trees (> 0.6 m GBBH) of (*a*) *Allocasuarina littoralis* and (*b*) *Allocasuarina verticillata* in the Ocean Grove Nature Reserve in 1996 (short-boled, multiple-stemmed, woodland-form *A. littoralis* are excluded). Tree ages are extrapolated from aged samples.

The density of large trees in the reserve pales into insignificance, compared to the dense growth of younger saplings and seedlings. In 1996, there were 5648 trees ha^{-1} (including 2224 small saplings < 3 cm GBBH) in the monitoring plot: 63% of these trees were *A. littoralis* (Lunt 1998). The reserve now supports, not an open grassy woodland, but an increasingly dense scrub dominated by *A. littoralis* (Fig. 5).

Discussion

The results of this historical study support the earlier conclusions of Withers and Ashton (1977), in relation to the long-term absence of fire at the Ocean Grove reserve, and the dramatic increase in tree densities since European settlement. However, the historical perspective reveals a more complex history of land use and vegetation change

Table 4. Density (number of trees ha^{-1}) of large trees (> 60 cm GBBH) in the Ocean Grove Nature Reserve in 1996
The 'all' column includes dead trees. *A. littoralis* data includes old, short-boled, woodland-form trees < 60 cm GBBH

Species	All	Alive
Allocasuarina littoralis	142	133
Allocasuarina verticillata	46	33
Banksia marginata	10	5
Eucalyptus species	61	27
Total	259	198

Fig. 5. A typical view of *Allocasuarina littoralis* dominated scrub in the Ocean Grove Nature Reserve in 1996. Note the closed vegetation structure and abundance of fallen timber.

than was previously realised (Garnet 1961; Withers and Ashton 1977), especially with regard to the rise and demise of *Acacia* dominance and the wattle bark industry. Despite earlier accounts (e.g. Garnet 1961), the reserve did not remain 'undisturbed' over the past century, but was heavily utilised for most of this period.

Pre-settlement Vegetation and Aboriginal Burning

A brief discussion of vegetation composition and aboriginal land management throughout the Holocene provides a valuable, longer-term context in which to view more recent, post-European changes in vegetation. Pollen studies in western Victoria show the stable presence of open grassy woodland vegetation dominated by *Casuarina* species (*sens. lat*), with sub-dominant *Eucalyptus,* during the past 6000–10 000 years (Dodson

1974, 1979; Clark 1983; Head 1983; Lourandos 1983). The region is thought to have been regularly burnt by Aborigines during this period, but no detailed information exists on any elements of Aboriginal burning regimes, such as fire season, frequency or intensity (Clark 1983). Other than charcoal evidence, available information on Aboriginal burning is almost totally restricted to short quotes by early European explorers and settlers, as described earlier. These quotes suggest widespread burning immediately prior to white exploration but again provide no information on fire frequencies (although the abundance of such quotes in the historical literature implies that Aboriginal burning was common and widespread in many coastal areas). However, pre-contact Aboriginal burning regimes may already have been disrupted before the first white explorers arrived. Flemming and Tuckey, the first two European explorers in the region, both recorded smallpox scars on local Aborigines (Flemming 1803, in Shillinglaw 1879, p. 33; Tuckey 1805, p. 176), and it has been cogently argued that a smallpox epidemic had already decimated and greatly disrupted traditional Aboriginal society before the earliest descriptions by white explorers (Butlin 1983).

Recent ecological studies of ungrazed *Themeda* grassland remnants in southern Victoria have shown that very frequent burning, at least every 3 or 4 years, is required to maintain the diversity of native herbs at many sites (Stuwe 1986; Lunt 1994), and Robertson (1985) suggested that burning at least every 6 years was necessary to prevent tree recruitment in an open *Eucalyptus* woodland. Whilst both examples suggest an ecological requirement for very frequent burning, their relevance to pre-European ecosystems remains unknown (Morgan 1994; Lunt 1994, 1995), although it is difficult to conceive of alternative processes which might have acted across broad areas. To summarise, the open woodland vegetation described by the early explorers probably existed in similar form for the previous 6000–10 000 years, and the region is likely to have been regularly burnt by Aborigines during this period. If fires occurred frequently (every 5 years or so), they may well have helped to maintain an open woodland structure. However, no details on Aboriginal burning regimes are available.

Early Tree Densities

Although used overseas (e.g. Cottam 1949), historical maps have rarely been used in Australia for calculating tree densities (Lunt 1997*b*). A similar analysis of historical tree densities in grassy woodlands on the lowland Gippsland plains in eastern Victoria obtained estimates of 2–59 trees ha^{-1}, with the lowest densities in areas surrounding treeless grasslands, and highest densities in riparian zones (Lunt 1997*b*). The results obtained here (3–16 trees ha^{-1}) are of similar magnitude to those from non-riparian areas in eastern Victoria (2–31 trees ha^{-1}, Lunt 1997*b*). Both studies suggest a very sparse tree cover in such grassy woodlands last century, even though some areas were described at the time as being ‘thickly timbered’. However, such descriptions are entirely relative, and can only be interpreted by comparison to the surrounding landscape.

Notions of ‘thick timber’ are likely to have changed over the past 150 years, as tree densities have changed, and early descriptions may have been framed in the context of being ‘thick to chop down’, rather than ‘thick to walk through’. However, the calculation method is prone to under-estimating actual tree densities, especially if the early surveyors did not always select the tree closest to each allotment corner. Since trees were blazed to provide conspicuous markers for allotment corners, conspicuous trees may have been selected over those closest to each corner (although for practical purposes trees must have been selected as close as possible to each corner). Small trees may have been ignored, and some species may have been selected against. *Banksia marginata* appears to have been strongly selected against, since ‘honeysuckle’ was frequently recorded as a co-dominant species on map annotations (e.g. ‘gum, oak and honeysuckle'), but accounted for just 1% of trees on allotment corners, which would suggest that surveyors preferred to mark more distant 'oak' or 'gum' trees before nearby 'honeysuckles'. However, these qualifications are unlikely to affect the order of magnitude of the densities obtained. Even if the calculated densities are doubled or quadrupled, they are still remarkably low by present-day standards. Furthermore, the results obtained accord closely with the low densities described and illustrated by early explorers, e.g. Batman's quote of 'trees not more than six to the acre' corresponds to a maximum of 15 trees ha^{-1}.

Perceptions of Vegetation Change

The Ocean Grove Nature Reserve story can be divided into three phases: (1) Aboriginal occupation, involving the use of fire, (2) early European utilisation, including wattle bark harvesting, timber cutting and occasional stock grazing, and (3) recent conservation. The major players in each phase had strikingly different motives and concerns. However, the two European phases both shared a similar conceit: both grossly under-valued the contribution of earlier 'managers' in maintaining the vegetation they so valued.

To John Batman, 'the whole appeared like land layed out in farm for some 100 years back' (quoted in Bonwick 1883, p. 180). It seems most likely that the open grassy woodland of Batman's model 'farm' was maintained by regular burning by the Wathaurong tribe of Aborigines (see above). As elsewhere, the Aboriginal tribes were rapidly 'dispersed', and the fires of the early 1800s were the last landscape fires lit by the Wathaurong tribe on the Peninsula. A probable explanation for the development of dense wattle stands (in both grazed and ungrazed areas) is their emergence after the cessation of frequent burning by the Wathaurong. Withers (1978*a*) demonstrated experimentally that seedlings of *A. pycnantha* (and *Allocasuarina* species) could establish within a thick grass cover of *Themeda triandra* in the absence of fire, grazing or soil disturbance (although seedling growth was enhanced by burning).

More recently, the conservationists who fought an extraordinary battle in the 1960s to preserve the site from destruction (Department of Natural Resources and Environment, unpublished data) both valued and mythologised a history of non-disturbance. The long-term absence of not only grazing stock, but also fire, was promoted as a unique asset of the proposed reserve. The long-term presence of intensive harvesting of wattle bark and timber (for at least 70 years), and intermittent stock grazing were denied, as was Aboriginal burning, over millennia. Instead, Garnet asserted that the reserves 'biological associations have reached a stage of stable equilibrium. They are, in fact, climax communities' (Garnet 1961, p. 47). The structural changes outlined by Withers and Ashton (1977) and Lunt (1998) demonstrate the manifest error in this claim. Ironically, only the *recent* history of the reserve—the preservation phase, from the 1960s onwards—is characterised by an *absence* of disturbance; in this phase, burning, timber harvesting, and grazing and browsing by mammals (both native and exotic) have all been successively eliminated or grossly diminished.

Curiously, the implications of the study by Withers and Ashton (1977) were never incorporated into reserve management. Their studies are mentioned only once in departmental files (which are over 10 cm thick), and then only to corroborate a statement that the reserve has not been burnt for over 90 years. Perhaps, Withers and Ashton's (1977) recognition of the important ecological role of fire sat uneasily with the strong philosophical importance placed on the absence of fire and other human disturbances (Garnet 1961). The preference for fire exclusion continues today, and is encapsulated in a recent 'draft management plan' (prepared as a student project), which reiterates the now-mythologised 'absence of disturbance' to the vegetation: 'The Reserve is the last remnant of woodland on the Bellarine Peninsula, remaining *virtually untouched* since European settlement. Most of the Reserve has not been burnt for over 100 years.' (Aberton 1995, p. 1, italics added). The 'Strategic directions' section of this report states, 'The *natural succession* of the bush will be a high priority' and, 'the Reserve will remain unburnt so that it can be used for research and reduce the risk of weed invasion' (Aberton 1995, p. 3, italics added). The threat of post-fire weed invasions is real and not to be under-estimated (e.g. Molnar *et al*. 1989; Carr 1993), but the 'naturalness' of past management is mythologised, debatable and—more importantly—is perhaps largely irrelevant to biodiversity conservation.

The above appraisal is not intended to criticise the committed conservationists who invested a phenomenal amount of energy in the conservation of the Ocean Grove Nature Reserve. Their efforts were (and still are) directed against impending destruction by urban encroachment, not against utilisation by timber harvesting, which had already ceased. Furthermore, whilst the vegetation structure might have changed dramatically over the past 200 years, the reserve still contains a diverse native biota, much of which has been eliminated from most of the Bellarine Peninsula by agricultural and urban development. From a biological perspective, the chief value of the reserve today is its immense contribution to biodiversity conservation in the region, not its disturbance history.

The Ocean Grove story provides a fascinating example of the problems inherent in conserving dynamic ecosystems. Which vegetation do we want to conserve (or could we possibly conserve) in the future: the present sheoak scrub, a golden wattle stand, or an open savannah of 'gum, oak and honeysuckle'? In reality, the vegetation of the future will probably differ from all previous stages, regardless of the management inputs imposed. However, without an historical perspective, this fundamental question is impossible to ask, let alone address (Lennon 1988; Griffiths 1992, 1996).

The case study also provides a valuable example of changing landscape perceptions over the past 200 years. The 'thickly timbered' reserve of today bears little resemblance to the areas of 'thick timber' mapped a century earlier: tree densities have increased over 100-fold. Such context-dependent perceptions continue to evolve. Withers and Ashton (1977) began their paper with the sentence, 'In the drier regions of Victoria, it is rare to find vegetation which has remained unburnt for substantial periods of time.' In 1996, this context has changed dramatically, as broad areas of coastal and lowland Victoria—including many remnant coastal, heathland, grassland, woodland and riparian ecosystems—are now very rarely burnt (Victorian Government 1983; Lunt 1995). The non-interventionist reserve management which has characterised the Ocean Grove woodland since the 1960s, especially the absence of fire, is now typical of ecosystem management across most of sub-coastal and lowland Victoria. Consequently, numerous instances of shrub encroachment, and declines of threatened species and ecosystem diversity may be attributed, at least in part, to long-term fire exclusion (e.g. Gleadow and Ashton 1981; Day *et al*. 1984; Molnar *et al*. 1989; Offor 1990; Scarlett and Parsons 1990; Bennett 1994; Lunt 1995; Fisher 1996; McMahon *et al*. 1996; Middleton *et al*. 1996). To conserve biodiversity in the future, ecologists and land managers must develop and instil an informed philosophy of active vegetation management, rather than perpetuating a pervasive attitude of passive non-intervention. Biodiversity conservation must involve human interaction, and will not be well served by a nebulous rubric of 'maintaining natural processes'.

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