# The nature of pre-European native vegetation in south-eastern Australia: a critique of Ryan, D.G., Ryan, J.R. and Starr, B.J. (1995) *The Australian Landscape – Observations of Explorers and Early Settlers*

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**Abstract**

*Benson, J.S.[1] & Redpath, P.[2] ([1]Royal Botanic Gardens Sydney, Mrs Macquaries Road, Sydney, NSW 2000; [2]New South Wales Department of Land and Water Conservation, PO Box 3720 Parramatta NSW 2150) 1997. The nature of pre-European native vegetation in Australia: a critique of Ryan, D.G., Ryan, J.R. and Starr, B.J. (1995)* The Australian Landscape — Observations of Explorers and Early Settlers Cunninghamia *5(2): 285–328*. Based on a selection of quotes from early European explorers and settlers, and modern authors including Flannery (1994), Ryan et al. (1995) suggest that, at the time of European settlement of eastern Australia: the vegetation was mainly composed of grassland and grassy woodland; Aborigines burnt most of the country every year or so; and a lack of fire after European settlement led to thick regrowth that was subsequently ringbarked and cleared by settlers for agricultural expansion. Ryan et al. (1995) present one line of evidence in trying to explain pre-European vegetation and overlook the extensive scientific literature on past and present vegetation, and on fire ecology in Australia. By referring to the scientific literature, and by re-examining the same historical sources used in Ryan et al. (1995), we examine the views of Ryan et al. (1995) and also question hypotheses put forward in *The Future Eaters* by Tim Flannery (1994) and the views about pre-European tree density in *A Million Wild Acres* by Eric Rolls (1981).

The quotes used in Ryan et al. (1995) mainly cover parts of south-eastern Australia between Tasmania and Brisbane, but do not deal with particular regions in a systematic way. They generally refer to one type of vegetation formation — grassy woodland, which mainly occurs on clayey soils in drier coastal valleys, on non-siliceous soils on the undulating tablelands and on the western slopes. The explorers may have favoured travelling through these areas because they occur near rivers (water), had an open understorey and because some explorers were employed to seek out suitable grazing lands. Using three historical estimates of tree density in grassy woodlands, we estimate there was an average of 30 large trees/ha spaced about one tree width apart. This contrasts with Rolls' estimate of 4 large trees/ha and the perceptions of Ryan et al. (1995) about the structure of a woodland. We found frequent references in the explorers' journals to vegetation containing a dense understorey including coastal heath, shrublands, rainforest and dense eucalypt forests. We found no evidence that most of south-east Australia's vegetation was annually burnt by Aboriginal people and provide examples where explorers' notes about fire have been misinterpreted or inappropriately extrapolated by Ryan et al. (1995) and Flannery (1994).

While some journal entries reveal that Aboriginal people used fire for cooking and burning the bush, the extent, frequency and season of their use of fire is largely unknown, particularly for southern Australia. Vegetation types such as rainforest, wet sclerophyll eucalypt forest, alpine shrublands and herbfields, and inland chenopod shrublands, along with a range of plant and animal species, would now be rarer or extinct if they had been burnt every few years over the thousands of years of Aboriginal occupation. Furthermore, Ryan et al. (1995) and Flannery (1994) ignore much evidence that points to climate as being the main determinant in vegetation change over millions of years, with major changes occurring since the onset of aridity in the Miocene but continuing through the last ice age, which coincided with the occupation of Australia by Aboriginal people.

The adaptation of many plant species to aridity, drought, low nutrient soils and fire does not imply a requirement for them to be frequently burnt. South-eastern Australia's native vegetation is now highly fragmented, after 200 years of clearing, stock grazing and weed invasion. Management of what remains of this vegetation should be based on a scientific understanding of the functioning of ecosystems and the population dynamics of a range of plant and animal species.

## Contents

## Introduction

In 1995 a 20-page booklet *The Australian Landscape — Observations of Explorers and Early Settlers*, prepared by D.J. Ryan, J. Ryan and B. Starr, was published under the name of the Murrumbidgee Catchment Management Committee of Wagga Wagga on the South West Slopes of New South Wales. The authors (p. 1) state that they produced the booklet in order to 'minimise our impact on and improve our management of the environment'. The booklet included a bibliography that contained 97 references of which 25 were cited.

Based on a selection of quotes from the journals of some early explorers and settlers, and from recent treatments including *The Future Eaters* by Flannery (1994), Ryan et al. (1995 p. 1) state that:

> *There is a common belief that Australia was a vast expanse of thick forest before the arrival of European settlers more than 200 years ago and that there has been massive clearing of that forest land ever since. Unquestionably, the Australian landscape has changed over the last two centuries. But what was it like before then and how has it changed? It is becoming more evident that before European settlement most parts of Australia burnt more or less on an annual basis producing vegetation communities markedly different to that of common belief.*

The booklet does not stipulate who holds this 'common belief', as it is clear that 200 years ago most of Australia was covered by semi-arid shrublands, mallee and woodlands, with dense forest restricted to the wetter parts of the eastern coast and tablelands, Tasmania and south-western Western Australia (AUSLIG 1990). Also, while the title of the booklet includes 'Australian landscape' the historical quotes used in the booklet refer mainly to forests and woodlands in New South Wales where European settlement began in 1788.

Ryan et al. (1995) is divided into three main themes: **Fire regimes, Forest land** and **Regrowth**. The authors attempt to show that great tracts of the pre-European Australian vegetation were dominated by open, park-like woodland or grasslands. They postulate that these open grassy woodlands and grasslands were created and maintained by 'fire stick practices' of the Aboriginal people (first mooted by Jones 1969). They also argue that regrowth proliferated after European settlement as a result of the lack of frequent fire, and that the massive ringbarking and clearing over the last century was mainly of this regrowth and that this clearing re-established the landscape's 'original' grazing capacity.

Ryan et al. (1995) have been quoted by those opposed to vegetation clearing control regulations, particularly State Environmental Planning Policy 46 (SEPP 46), which was introduced in New South Wales in August 1995. It has also been used to support more frequent and widespread prescribed burning of vegetation in state forests, national parks and wilderness areas. One of the authors stated verbally that clearing has restored the structure of the vegetation to a similar state to what it was in 1788 (J. Ryan on ABC Radio National *Earthbeat* program, 30 March 1996).

These ideas have been further promulgated in the media. O'Kane (1996) writing in *The Land* newspaper used the booklet to expound such notions that land clearing by farmers is returning the landscape to an original condition of well spaced trees with

a grassy understorey. In another article on this subject published in the *Canberra Times* (O'Reilly 1996), the authors Tim Flannery and Eric Rolls were quoted as stating there are 20% more trees now than in 1788 due to regrowth and cessation of frequent fire.

In light of the public exposure of Ryan et al. (1995) and its possible influence on policies involving the management of native vegetation in Australia (particularly New South Wales), we consider the booklet requires scrutiny as it appears not to have been critically reviewed before its publication. We investigated the validity of its main propositions about fire frequency and vegetation change. This has involved re-examining the accuracy and context of the quotes used by Ryan et al. (1995), examining other reports from the same historical journals, and reviewing the scientific literature on fire ecology and vegetation change in Australia. We also comment on Rolls (1981) views of the pre-European tree density in the Pilliga Scrub and some of the hypotheses in Flannery (1994) about the nature and cause of vegetation change in Australia since Aboriginal occupation and subsequently European settlement.

This critique is divided into the three main themes of the booklet: 'fire regime', 'forest land' and 'regrowth'. An examination of some of the quotes used in the booklet is followed by a brief review of the scientific literature on each theme.

Our definitions of closed forest, open forest, woodland and open woodland follow Walker and Hopkins (1990): 'closed forest' — tree crowns touch or overlap as with most types of rainforest; 'open forest' — tree crowns are either touching or less than one quarter of a crown-width apart; 'woodland' — tree crowns are separated by between one quarter and one crown-width; 'open woodland' — trees are separated by between 1 and 20 crown-widths.

Note: Historical quotes used in Ryan et al. (1995) and re-stated by us are placed in italics, bolded and encased by inverted commas e.g. '***historical***'; original text of Ryan et al. (1995) that we have quoted is placed in italics and bolded e.g. ***historical***; other historical quotations we have used that are not in Ryan et al. (1995) are placed in italics only e.g. *historical*. We have quoted from historical journals with the original spelling. This differs from modern spelling for some words and in the names of some plant species.

## Fire regime

Ryan et al. (p. 1) hypothesise that:

> ***… before European settlement most parts of Australia burnt more or less on an annual basis producing vegetation communities markedly different to that of common belief.***

On page 2 the authors continue:

> ***Nearly every early navigator or explorer mentions fire or comments on the amount of smoke seen. The letters, diaries and journals all indicate that Aborigines always carried a lighted fire-stick and never put a fire out. Consequently, the Aborigines did not just burn now and again, or only in***

> ***autumn, or when the birds were not nesting. They burnt all the time. Many thousands of fires were lit across the countryside on a daily basis. In addition there was nothing to stop these fires from spreading when conditions were suitable.***
>
> ***To Aborigines fire was seen as necessary to clean up the country. They regarded unburnt forest or grassland as being neglected. Apparently for most, if not all groups, every part of grassland, savanna and eucalypt woodland of their territory would be burnt regularly, annually, or at least once every three or four years. It was seen as doing duty by their land.***

We suggest that the explorers' descriptions of Aboriginal fire practices were not quoted or interpreted in a balanced way by Ryan et al. By examining the same explorers' journals, alternative interpretations can be made about the type and abundance of fire in the landscape. Early navigators such as Cook noted 'smooks' [*sic*] because he was trying to work out which parts of the land were inhabited as he had instructions to take possession of the land with the consent of the natives (Cook 1770) (see below). Ryan et al.'s statement that all Aboriginal groups burnt regularly implies there were homogenous Aboriginal burning practices across Australia. This will be shown to be false.

### Cook (1770) and White (1790)

During his exploration of the east coast of Australia in May 1770, James Cook (1770) observed many Aboriginal fires or what he termed 'smooks'. Ryan et al. (1995) quote Cook's journal as the explorer passed Cape Howe when he noted:

> ***'In the afternoon we saw smook in several places by which we knew the country to be inhabited.'***

As Cook sailed up the east coast of Australia after leaving Botany Bay he made other references to fire. On Tuesday 8th May, 1770, just north of Broken Bay near Cape Three Points, Cook (1770 p. 313) noted:

> *In the pm saw some smooks upon the shore and in the evening found the Variation to be 80° 25' East, at this time we were about 2 or 3 miles from the Land and had 28 fathom of wat*er.

and again on Friday 11th, near Port Stephens Cook writes (p. 314):

> *We saw several smooks a little way in the Country rise up from the flatland, by this I did suppose that there were Lagoons which afforded subsistence for the natives such as shell fish &c for we as yet know nothing else they live upon.*

And on the following day, near Port Macquarie (p. 315):

> *In the pm as we run along shore we saw several smooks a little way in land from the sea and one upon the top of a hill which was the first we have seen upon elevated ground since we have been upon the coast.*

It was from Sunday 13th May, 1770, that Cook appears to detail a larger fire as opposed to the smoke from smaller camp fires. He writes:

> *At Noon we were by observation in the Latitude of 30° 43' S and Long^de^ 206° 45' west and about 3 or 4 Leagues from the land (15–20 km), the northermost part of which bore from us N 13° West and a point or headland on which were fires that caused a great quantity of smook which occasioned my giving it the name of Smooky Cape, bore SW distant 4 Leagues. It is moderately high land, over the pitch of the point is a round hillock, within it two others much higher and larger and within them very low land. Latitude 30° 51's, Longitude 206° 54' West. Besides the smook seen upon this Cape we saw more in several other places along the Coast.*

This large fire at Smoky Cape may have either been a bushfire, a controlled burn by Aboriginal people, or merely a large gathering of people. Two days later near Byron Bay, Cook notes (p. 317):

> *At 9 O'Clock being about a League from the land we saw upon it People and smook in several places.*

While near Indian Head in south east Queensland, Cook notes fires on the 20th May;

> *We saw people in other places besides the one I have mentioned, some smooks in the day and fires in the night.*

Further north on 23rd May at a place now named '1770', near Bundaberg, Cook noted (p. 325):

> *As yet we had seen no people but saw a great deal of smook up and on the west side of the Lagoon which was all too far off for us to go by land excepting one; this we went to and found 10 small fires in a very small compass and some cockle shells laying by them but the people were gone.*

Of at least 12 references to fire over the month of May 1770, and a distance travelled of some 2000 kilometres, Cook did not refer to widespread burning of the landscape by Aboriginal people. Most of the smooks seen by Cook were probably camp fires used for cooking, as evidenced in the last quote. This point was overlooked by Ryan et al. who portray his observations as proof that Aboriginal people extensively burnt the landscape. Cook's observations are more important in providing evidence that the east coast of Australia was well occupied by Aboriginal people in 1770. They provide little information on the nature of Aboriginal burning practices.

John White (1790), the surgeon on the First Fleet, is quoted on page 2 of Ryan et al. observing a large fire at Storm Bay in Tasmania on 7 January 1788. However, the authors did not refer to an entry by White (1790) when, on the 25th April (White 1790 p. 129), he mentions the role of lightning strikes in causing wildfire:

> *Near this we saw a tree in flames, without the least appearance of any natives; from which we suspected that it had been set on fire by lightning. This circumstance was first suggested by Lieutenant Ball, who had remarked, as well as myself, that every part of the country, though the most inaccessible and rocky, appeared as if, at certain times of the year, it had been all on fire. Indeed in many parts we met with very large trees the trunks of which and branches were evidently rent, and demolished by lightning.*

The following quote from White (1790 p. 129) suggests that Aboriginal people were selective in using fire for hunting. Without some control of the intensity and extent of fire they could have damaged their food resources.

> *26th. We still directed our course westward, and passed another tree on fire, and others which were hollow and perforated by a small hole at the bottom, in which the natives seemed to have snared some animal. It was certainly done by the natives, as the trees where these holes or perforations were, had in general many knotches cut for the purpose of getting to the top of them.*

Ryan et al. contains several quotes from Governor Arthur Phillip about Aboriginal burning around the early settlement at Sydney. Several interpretations are possible. Aboriginals used fire as a weapon by burning settlers huts and crops during early years of conflict with European settlers (Reynolds 1981 pp. 108–109). Some fires could have been used as a defence against the expansion of European intruders. Fensham (1997 p.12) lists incidents in Queensland where explorers (including Leichhardt) noted Aboriginal people setting grass alight as they fled from the European intruders. Flannery (1994 p. 221–222) refers to several early explorers who encountered fire being used by Aboriginal people for offensive or defensive purposes. However, with no supporting data, he discounts such fires as being a minor proportion of those witnessed by the early explorers.

**Fire and the vegetation of Sydney**

Peter Cunningham (1827 p. 43) describes the heath and wildflowers that grew on sandy soil in what is now Sydney's eastern suburbs:

> *… this spot, where low undulating hills (of rock and sand) lie scattered about in disorderly array, garnished with shrubs in liveries of the freshest green, and flowers of the liveliest hue, cannot fail to impress its beauty on the heart too deeply to be readily forgotten.*

The eastern suburbs were covered in heath because their soils are low in nutrients and sandy. There is no evidence the area was dominated by a grassy woodland kept open in its understorey by frequent fire as Ryan et al. (p. 6) suggest covered most of south-eastern Australia at the time of European settlement. Similar heath vegetation occurs today in the sandstone-dominated national parks in and around Sydney (D. Benson and Howell 1990, D. Benson and Howell 1994). This vegetation type is a product of low nutrient soils combined with moderate–high rainfall, an environment that produces shrub-dominated vegetation at temperate latitudes throughout the world (Specht 1979). We discuss the fire ecology of this vegetation below.

It is highly unlikely that a horse could have been galloped through the sandstone vegetation of Royal National Park at the time of European settlement (even after a fire) as purported by a NSW Farmers representative (ABC Radio National *Earthbeat* program March 16 1996). Such a statement is not credible evidence of the historical state of either the vegetation or of the fire regime. This notion was probably derived from Mitchell (1838) where he discusses regrowth 'nearest to Sydney' after settlement. Mitchell does not refer specifically to the land now reserved as Royal National Park. Nevertheless, it may have been possible to gallop a horse through the grassy woodland of the Cumberland Plain to the west of Sydney because this vegetation type, growing on a shale substrate, contains a lower density of shrubs than the Sydney sandstone flora (D. Benson 1992). Aboriginal people may have burnt grassy woodlands such as the Cumberland Plain fairly regularly in patches to attract game

and to ease travel, but at the same time they probably protected rainforest and wet sclerophyll forest from frequent fire to protect food resources such as the yam (Kohen 1996).

**Explorations north of Sydney by Oxley (1818) and Leichhardt (1842–44)**

The wet sclerophyll forests described by John Oxley (1820) in his traverse of the Hastings River Valley would not have existed if so called widespread clean up burns were as prevalent as suggested by Ryan et al. On the 23rd September Oxley (1820 p. 310) notes:

> *Numerous smokes arising from natives fires announced a country well inhabited, and gave the whole picture a cheerful aspect, which reflected itself on our minds; and we returned to the tents with lighter hearts and better prospects.*

This observation is not that of widespread torching of the landscape, but of individual camp fires.

In a letter to his brother-in-law Schmalfuss Esq. dated 2/2/1844, Ludwig Leichhardt (1842–1844 pp. 718–719), discussed the species diversity of the Australian vegetation and bush fires in south-eastern Australia. Ryan et al. selectively quoted a section of this letter (bolded text).

> ***'When you consider how few different kinds of trees go to make up our German woods and indigenous forests, you'll no doubt be astonished when I say that about 120 of these trees are to be found within the radius of a quarter of a mile. 100 of these belong to the dense, rich mountain and river brushes, whilst 20–25 form open forest'.*** *This forest, unlike ours, can't be named after any predominating tree, the way we speak of pine or fir forest, oak or beech forest, for the 25 kinds of trees are evenly mixed, except where the soil favours some rather than others.* ***'The ground under the trees, which would be covered with blueberry and whortleberry bushes in our oak forests, is mostly covered with kangaroo grass here,'*** *so called either because it's the favourite food of the kangaroos or because it grows like wheat and oats, and just gets high enough for them to peep over when they sit up on their hind legs and tails whilst they're browsing.* ***'This grass ripens in October and November, when the ground under the trees looks like an even, sweeping field of oats. In November and December the weather gets dry and the bushfires break out.'*** *They're often a mile wide, and they clear the ground of grass and dead wood as they sweep through the bush. The ashes left behind are like manure to the sweet, tender grass that shoots up as soon as it rains and is eagerly consumed by kangaroos, flocks of sheep and herds of cattle. During the hot months fire can range over hundreds of [square] miles.* ***'It starts [either] where the blacks have been camping for the night, as all they do when moving on is to pull a brightly burning stick out [of the fire] and keep it smouldering against a piece of bark, so that they can light a fire at the next camp;'*** *or [where] white men have set the dry grass on fire [when] passing on; or [where] settlers have been systematically burning off the old grass to obtain young pasture for their sheep and cattle. I've been told that fire is sometimes caused by the friction between trees and boughs rubbing together in the wind, but I've never seen it and it must happen rarely if at all.* ***'The blacks know how to produce fire by friction,'*** *particularly by rapidly rotating one stick in a hole in another;* ***'but it takes too much trouble, so they prefer always to carry fire-sticks with them…'.***

Ryan et al. (p. 12) have selected passages that do not convey Leichhardt's complete observations of fire in the landscape — notably his reference of the use of fire by early settlers.

Leichhardt (1842–44 p. 544) wrote another letter while travelling north of the Hunter River, New South Wales in October 1842. Ryan et al. (p. 11) quoted from part of this letter:

> ***'During my excursions in the bush my interest in bush fires has often been aroused'.*** *Some people maintain that friction between boughs rubbing together in hot winds sets them on fire, and that falling embers fire the grass.* ***'Others ascribe them entirely to the blacks,'*** *the timber-getters and the sawyers,* ***'who light fires all over the place to cook their food and leave them unextinguished'.***

In this instance Ryan et al. have omitted the reference by Leichhardt to the timber-getters and sawyers being equally responsible for the setting of fires as the Aboriginal people. The Europeans may or may not have used fire in a similar way as the Aborigines. However, there is evidence from fire scars and historical accounts from the Snowy Mountains (Banks 1989, Pulsford 1991), and charcoal deposits from the Robertson Plateau (Kodela 1997) that fire frequency increased after European settlement.

Similarly, the remainder of the quote was very selectively used. In full it read:

> ***'During the hot summer the grass dries out and becomes highly inflammable, and the leaves of the myrtaceous plants, which are full of essential oils, also get very dry. The consequence is that bushfires quickly spread over enormous areas, though without becoming a danger to human beings'.*** *Because the wind brings a steady stream of fresh air and oxygen, and the smoke extinguishes the flames to leeward, the fire always advances to the wind. I have often watched a red line of fire, which may have been several 1000 paces in length, greedily consuming the dry grasses bowing towards it in the wind, and blazing up with a crackling sound through the Eucalyptus saplings that were in its way. It strips the trees of their foliage but rarely kills them. And, although it leaves a blackened, desolate, wintry, burnt-out area behind it, its effects are quickening, for after the next rains fine young grass springs up, and tender foliage begins to clothe the denuded boughs. I was told that the Aborigines burn the bush over limited areas in order to attract wallabies and kangaroos to the fresh pasture. Others even said, though I think wrongly, that they do it in order to kill snakes, as they've got a great appetite for roasted snake.*

This passage contains evidence contrary to the Ryan et al. thesis. Firstly, the reference by Leichhardt to the fire blazing up with a cracking sound through the *Eucalyptus* saplings indicates that a multi-aged vegetation structure was present, rather than a simple 'park-like' stand of large well-spaced trees as suggested by Ryan et al. Some saplings must survive to maturity for a forest to be sustained. Secondly, Leichhardt refers to Aboriginal people using fire on limited areas to promote green pick growth, and thus attract game for hunting. This statement does not indicate that all of the landscape was burnt 'all of the time' or within a season.

## Scientific research on fire regimes and their impacts on vegetation and plant species

The spectacular scenes of fire in the Australian bush would have been especially noted by the explorers who came mainly from northern Europe where forest fire would have been a rarer event. However, these records provide poor evidence of the fire regimes (season, frequency and intensity) that existed at the time of European settlement in Australia. There was little or no scientific measurement, or even consistent observation, of Aboriginal burning practices during the early years of settlement.

There are several other sources of information that should be used when reconstructing a past fire regime including:

- Palynological studies, for example, a study of the changes in vegetation in north-east Queensland (Kershaw 1970);
- The study of tree rings (dendrochronology) that provides an insight to fire frequency through charcoal scars, for example, a study of fire scars in subalpine trees in Kosciuszko National Park (Banks 1989);
- A combination of fine-resolution pollen analysis and dendrochronology, for example the study of palaeoecology and palaeoclimatology of the Southern Tablelands of New South Wales (Green et al. 1988);
- Geomorphology, see a review of this evidence for south-eastern Australia in Tulau (1996);
- Ethno-history, for example, a study of Aboriginal fire regimes in relation to food supply in Central Australia (Latz and Griffin 1978);
- Studying the population dynamics of native plants and animals in various habitats to gain an understanding of their tolerance to certain fire regimes over time (Keith 1996), for example, the study of the demography of the shrub *Angophora hispida* which occurs on sandstone ridges near Sydney (Auld 1987).

Drawing on the scientific literature, the popular books *The Greening of Gondwana* (White 1986) and *After the greening: the browning of Australia* (White 1994) summarise changes in Australian vegetation over millions of years and point to climate and edaphic factors as the main determinant in vegetation change. Strong evidence to support this comes from pollen records from cores in the Lachlan River Valley in south-eastern Australia (Martin 1996). These show that rainforest species such as *Nothofagus* became extinct in the inland by the end of the Miocene (5.1 million years before present) and grasses, daisies and some myrtaceous groups increased in abundance during the drier ages of the Pliocene (5.1–2 m.y.b.p.) and Pleistocene (2 m. 10 000 y.b.p.), suggesting expansion of grassy woodland vegetation. Charcoal deposits in these cores increased markedly in the Pliocene suggesting an increase of wildfires well before Aboriginal people arrived in Australia, and indeed, before the evolution of human beings.

Attempts have been made to re-establish Aboriginal burning regimes in Central Australia to assist wildlife conservation (Morton and Andrew 1987, Allan & Baker 1990) because knowledge could be gained from Aboriginal people still living on the land in the region. In contrast, it has not been possible to establish what the Aboriginal fire regimes were in most parts of south-eastern Australia because the Aboriginal people living there were rapidly displaced soon after European settlement.

There has been a long running debate about the relative roles of climate change and Aboriginal burning in changing Australian vegetation over the last 120 000 years — see pages 344–345 in J. Benson (1991), Martin (1996), Kohen (1996) and Tulau (1996). A discussion on the evidence of pre-European fire regimes is provided on pages 28–30 in Williams and Gill (1995).

We consider that Ryan et al., Flannery (1990 & 1994) and Rolls (1981) over-emphasise the role of past Aboriginal burning in determining the structure and species composition of Australian vegetation. A majority of the scientific literature on climate change and Aboriginal burning supports the position first suggested by Clark (1983) that Aboriginal burning may have affected the rate, but not the main direction, of changes in the nature of Australian vegetation during the Pleistocene. At the height of the last ice age, 18 000 y.b.p., temperatures were lower and annual rainfall was half of what it is today (Dodson 1991). Such climatic conditions led to a retreat of rainforest and wet sclerophyll eucalypt forests to refugia and much of south-eastern Australia would have been dominated by grassy woodlands or grasslands until conditions changed after the ice age ended (around 10 000 y.b.p.). *Eucalyptus* forests and rainforests expanded again after that to more or less their current distributions with minor permutations due to fluctuations in rainfall over the last 6000 years. The extreme climatic change of the last ice age may also be the primary cause of the extinction of the megafauna (Horton 1982, Wright 1986) rather than hunting and altered fire regimes as proposed by Flannery (1990, 1994) (see the discussion on Flannery's hypotheses below).

Some evidence from coastal New South Wales supports increased fire frequency over recent millenia. Increased sediment deposition rates (Hughes and Sullivan 1981) and more frequent charcoal deposits in the top layers of sediment cores at Kurnell Peninsula (Martin 1994) support the view that Aboriginal burning may have increased over the last few thousand years — possibly due to technological change in Aboriginal society and/or due to an increase in the Aboriginal population (Kohen 1995). However, the importance of Aboriginal burning on sedimentation is questioned in a review of the literature in Tulau (1996). He considers that there is no conclusive evidence that 'fire stick farming' (Jones 1969) was the main cause of changes in sedimentation and that it is difficult to compare fire regimes and consequent geomorphic response before and after European settlement. Caution is required in interpreting changes in the quantity of charcoal in deposits because much of the work in Australia has not been corroborated by other evidence (R. Bradstock pers. comm.). In a definitive study in a catchment in Minnesota in the United States, Clark (1990) derived corroborated evidence by comparing charcoal lake deposits with 750 years of dendrochronological data (tree fire scars). This research revealed that changed fire regimes are tightly correlated to climate changes in that region.

Pollen samples dating from 6000 y.b.p. taken from a core in a swamp in Ku-ring-gai Chase National Park on the northern outskirts of Sydney (Kodela and Dodson 1989), indicate there has been little change in the floristic composition of sandstone flora in that region over that time. Changes in pollen composition over 3500 years in the region of Wildes Meadow Swamp near Robertson, on the Southern Tablelands of New South Wales, indicate that fire activity and *Eucalyptus* declined about 3000 y.b.p. and rainforest expanded but fire increased again after European settlement (Kodela 1997 pp. 103–105). Settlers may have increased fire frequency and intensity to help clear the land.

Kohen (1996) suggests there may have been a 'struggle' between climate and Aboriginal burning over the last 6000 years as rainfall increased, but as rainforest has expanded during that period in north Queensland (Neldner and Clarkson 1995), Robertson Plateau in New South Wales (Kodela 1997) and in Tasmania (Jarman et al. 1984), it appears that climatic factors have been the main determinant of vegetation composition over that period. However, different factors may have varied in their importance in different places.

One of the weaknesses of Ryan et al. and Flannery (1990, 1994) is that they predicate their hypotheses about vegetation change on the assumption that pre-European Aboriginal fire regimes were more frequent than those used by early settlers. At least for some regions, there is evidence of an increased fire frequency due to the burning practices of the early settlers (Wakefield 1970, Kodela 1997, Pulsford 1991).

## Critique of Ryan et al. (1995) views on 'fire regime'

Over thousands of years, Aboriginal people burnt much of Australia's vegetation — there is little argument about that. However, the biological evidence suggests that the frequency of fire (Aboriginal or other) must have varied for different types of vegetation. This point has not been discussed by Ryan et al.

While we agree with Ryan et al. that the explorers' recordings and some scientific studies (for example, Lunt 1991) indicate that Aboriginal people burnt grassy woodland and grassland habitats, there is a lack of detail in the historical journals about the extent and frequency of burning. On available evidence, it is most likely that Aboriginal people burnt in a mosaic fashion for 'green pick' to attract game as recorded by Leichhardt (1842–1844), therefore a patch of grassland or grassy woodland may not have been re-burnt for some time.

If the fires were so frequent across the Australian landscape (a notion initiated by Jones (1969), re-iterated by Flannery (1990, 1994) and strongly portrayed in Ryan et al.), in order 'to clean up the country', then it is highly likely that many of the small to medium-sized fauna that existed in 1788 would not have survived due to a lack of hollow logs and dense ground cover. The extensive literature on the habitat requirements of animals was not canvassed in Ryan et al. Examples include:

- The requirement of Red-necked wallabies, swamp wallabies, bettongs and hare wallabies for ground cover to survive as it contains food resources and provides protection from native and introduced predators (Lunney & O'Connell 1988, Christensen 1980);

- The requirement of the threatened eastern-barred bandicoot for a dense ground cover to build nest sites and to protect it from predators (Mallick et al. 1997);
- The conclusion of Hadden and Westbrooke (1996) that increased complexity in the shrub layer (diversity, cover and height) reflected species richness in the herpetofauna in buloke remnants in north-western Victoria;
- The preference of the western ring-tailed possum for forests where trees are touching so it can avoid travel on the ground that would expose it to predation (Jones et al. 1994).

The last point illustrates that some arboreal animals require dense forest to survive rather than open woodland with sparsely spaced trees. Additionally, the early explorers did encounter dense understorey and fallen logs as revealed from Oxley (1820) describing a forest on the north coast of New South Wales:

> *We therefore continued along the edge of those valleys, our progress much impeded by the vast trunks of fallen trees in a state of decay, some of which were upwards of one hundred and fifty feet long, without a branch, as straight as an arrow, and from three to eight and ten feet in diameter.*

Ryan et al. do not present a review of the scientific literature about the post-fire recovery times of many vegetation types that require decades, or even centuries, between fires to maintain their species composition (Turner 1986, Interim Reference Areas Committee of Victoria 1977). This is particularly relevant for the maintenance of rainforest and wet sclerophyll forests. Different Aboriginal burning practices may have applied to different vegetation types, such as postulated by Clark and McLoughlin (1986) for Sydney sandstone vegetation compared to the grassy woodlands growing on shale on the ridge tops of the Lane Cove Valley or on the Cumberland Plain in western Sydney.

Ryan et al. overlook most of the substantial scientific literature on fire ecology including the dynamic interaction of plants and animals with differing fire regimes. Important sources of literature on fire such as Gill et al. (1994) which contains over 2000 references, are not referred to in the booklet. Also, they do not refer to the numerous scientific papers on fire ecology of the predominantly sandstone vegetation in National Parks near Sydney (for example Auld 1987a, Bradstock 1990, Bradstock & O'Connell 1988). The scientific evidence for the Sydney sandstone flora suggests that repeated, widespread burning at intervals of less than a few years will cause the extinction of a number of shrub species and that recolonisation from unaffected sites occurs extremely slowly (Keith 1996). The Aboriginal people did not burn extensive areas of this vegetation type annually, or even every few years, because if they did many plant species would not now be present. Shrubby sandstone vegetation has not spontaneously appeared during the last 200 years because of a lack of burning. As a generalisation, these shrubby sandstone forests and woodlands require occasional intense fires between 10 and 25 years apart, but with variable inter-fire periods (Bradstock et al. 1995). To maintain species diversity and populations of plant species, fire intervals should be long enough to allow seedlings to mature and seed to be built up in the seedbank before another fire (Auld 1997).

While the 'appropriate' fire regime to maintain all species in a given area is difficult to achieve, modern bushland fire management should take a landscape approach aimed at maintaining species diversity in patches by applying varied fire regimes (Keith 1996).

## Forest land

Under the 'Forest land' section of Ryan et al. the authors have interpreted explorers' journals to indicate that the landscape was a continuum of open grassy woodland or grassland. They postulate (p. 6) that:

> ***It seems that much of the tall mixed eucalypt forest with a developed understorey that is a common occurrence these days did not exist at the time of European settlement. Contrary to what is often stated, dense forests did not cover large areas of Australia and the first settlers did not set to and ringbark huge areas. There was no need to. Most of the country was woodland, grassland, savannah or open forest. Grazing was plentiful and there for the taking. Many areas could be readily ploughed.***

No explanation is provided for the above assertion made by Ryan et al. that it is 'often stated' that dense forests covered Australia. If the northern savanna of Australia is included in estimates of original vegetation cover, woodland was more common than open forest or rainforest (AUSLIG 1990), and it still composes two thirds of the remaining 156 877 000 ha of tree-covered land remaining today (Commonwealth of Australia 1997). However, south-eastern Australia (about which Ryan et al. concentrate their discussion) contains a higher proportion of dense forest than the remainder of the continent. A key point we make is that there was and still is a range of vegetation types — some containing a shrubby understorey, others with an open understorey.

In our re-examination of the same historical literature we found there are numerous instances where the explorers recorded encounters with dense vegetation, not just grassy woodland.

### Cook (1770) and White (1790): vegetation of the coast and Sydney

Ryan et al. (p. 6) use the following quote from James Cook on Tuesday 1st May 1770 (Cook p. 307) to argue that little undergrowth existed around Botany Bay in 1770:

> ***'After this we made an excursion into the country which we found diversified with woods, Lawns and Marshes; the woods are free from under wood of every kind and the trees are at such a distance from one another that the whole Country or least a great part of it might be cultivated without being oblig'd to cut down a single tree; we found the soil every where except in the Marshes to be a light white sand and produceth a quantity of good grass which grows in little tufts about as big as one can hold in ones hand and pretty close to one another, in this manner the surface of the ground is coated in the woods between the trees'.***

White (1790) stated that the First Fleet settlers could not find the areas Cook had described at Botany Bay, even though they searched extensively for them. White commented (White 1790 p. 110):

> *… The fine meadows talked of in Captain Cook's voyage I could never see, though I took some pains to find them out; nor have I ever heard of a person that has seen any parts resembling them.*

Cook's observations are open to interpretation. He provides no measurement of the distance between trees and the tufts of grass he observed may have been the less palatable non-grass genera *Juncus* or *Lomandra*. Additionally, it would appear that Cook's observations were often based on seeing vegetation from a distance out at sea, rather than recording at close range. For example, he labelled as 'lawns' the heaths on the coast of what is now Nadgee Nature Reserve on the south coast of New South Wales. This may explain why what Cook recorded and what was actually found by White with the First Fleet at Botany Bay were so different. A possible but unlikely explanation could be that Cook observed the vegetation immediately after it had been burnt and by the time White arrived it had changed. On page 7 of Ryan et al. the authors state:

> ***'Many of the early accounts and journals of the first settlers in NSW made comment, similar to Cook. Only scattered trees and very little scrub understorey existed beneath the tall forests along with grass and fern'.***

They proceed to quote from an account by John White (1778 p. 122) of a visit to Dee Why on the 15 April 1788 during the early days of the Sydney colony:

> ***'We rounded this lagoon, and proceeded four or five miles westward, along the banks of a small fresh-water river, which emptied itself into it and had for its source only a swamp or boggy ground. After we had passed this swamp we got into an immense wood, the trees of which were very high and large, and a considerable distance apart, with little under or brush wood. The ground was not very good, although it produced a luxuriant coat of a kind of sour grass growing in tufts or bushes, which, at some distance, had the appearance of a meadow land, and might be mistaken for it by superficial examiners'.***

The understorey 'sour grass' was probably a combination of grasses and other grass-like plants such as *Lomandra longifolia* or species of *Xanthorrhoea* (grass tree). Many of these species are unpalatable to stock and this may explain the term 'sour grass'.

Earlier on the same day, White (1788 p. 121) describes a wetland near Manly Cove:

> *His excellency, attended by Lieutenant Ball of the Navy, Lieutenant George Johnston of the marines, the judge advocate, myself, three soldiers, and two seamen, landed in Manly Cove (so called from the manly conduct of the natives when the governer first visited it), on the north side of the entrance into Port Jackson harbour, in order to trace to its source a river which had been discovered a few days before. We, however, found this impracticable, owing to a thicket and swamp which ran along the side of it.*

On the 17th of April, after hiding their tents and the remains of their provisions, White's expedition made a forced march in a westerly direction (White 1788 pp. 124–125):

> *.... of about fourteen miles, without being able to succeed in the object of our search, which was for good land, well watered. Indeed, the land here, although covered with an endless wood, was better than the parts which we had already explored. Finding it, however, very unlikely that we should be able to penetrate through this immense forest, and circumstanced as we were, it was thought more prudent to return.*

Later on the 22nd April, quoted in Ryan et al. (p. 7), White mentions traversing through a forest of enormous trees, free of underwood and then being blocked by 'brush-wood' somewhere west of Sydney. When taken together, these descriptions of the vegetation by White reveal that the vegetation around Sydney contained a mosaic diversity of vegetation with areas of heavily wooded forests (with both dense and open understoreys) and thickets of scrub and swamps. It is not possible to understand precisely what White meant by 'well spaced trees' without measurements.

**Anthill (1815): vegetation of the Blue Mountains and Bathurst New South Wales**

On page 7 of Ryan et al., Henry Anthill (1815) is quoted describing the landscape near modern-day Bathurst on May 4 1815:

> ***'The country we rode over this day ... was beautiful and open, large tracts of land, without timber or underwood ... At present we saw it to great disadvantage, the greatest part of the herbage of the plains having been destroyed by fire'.***

On the way to Bathurst, however, Anthill describes a broader range of vegetation types. For example, on Monday May 1 1815, referring to their passage through 'Clarence's Hilly Range' via Mount Blaxland and 'Wentworth's and Lawson's Sugar Loaves,' Anthill (1815 p. 8) describes *this range is clothed with thick timber and has good feeding for cattle.* On May 2 (p. 8) he describes the country from Cox's River to Sydmouth Valley as red and black granite, *hills heaped upon hills, and rocks upon rocks, with deep gullies between, some with streams running through them, and clothed with woods to their very summits.* On May 3 Anthill (1815 p. 10) describes coming to an extensive plain (O'Connell Plains) after riding approximately 8 miles which Anthill cites as, *a considerable tract of land without a tree, fit for both pasture and cultivation.* He goes on: *Continuing along the banks of the river about 2 miles, we came to another extensive plain called Macquarie Plains,* which he stated *is the more extensive of the two, and equally good for pasture and cultivation.*

While the land around Bathurst was a natural treeless plain of about 12 000 ha (Croft et al. 1997), Anthill and his party traversed through a number of vegetation formations on their expedition. The ranges to the east of Bathurst were densely forested in 1815, yet Ryan et al. only quote Anthill's description of the open plains near Bathurst.

Croft et al. (1997) compare explorers' descriptions of the vegetation in central western New South Wales with that contained on modern vegetation maps. In a majority of cases there is compatibility between them. They conclude that in the early 1800s there

was a range of vegetation types in the region determined mainly by climate and substrate. Woodland was widespread but its understorey varied from open/grassy to dense shrubs depending on the soil. 'Thick brush' was present in 1813 when Europeans first cross the Blue Mountains, as it is today.

Early explorers may have under-reported on vegetation types where the understorey was dense because such reports may have met with less approval (Croft et al. 1997). Often their reason for exploration was to find new grazing land, so they concentrated on describing land that was 'favourable'. Earlier paintings of open woodlands by John Lewin (referred to on page 8 of Ryan et al.), who travelled to Bathurst in 1815, may be an example of this. Also, it is likely that the early explorers would have preferred open, grassy routes for ease of travel — sometimes following the same travel routes as Aboriginal people along grassy plains adjacent to rivers. An example is the journey of Alan Cunningham from Bathurst to the Liverpool Plains on 15th April 1823. Upon departure from Bathurst, Cunningham (1825 p. 142) stated:

> *The exceedingly broken sub-mountainous structure of the country at N.E., N. and N.N.W., obliged me to commence my route from the plain of Daby, on the Cugeegong, considerably west of north, in part over a rising forest land, tolerably well watered, lightly timbered, and occasionally interspersed with confined brushes…*

Linked to the above point is that most of the early explorers and squatters were mainly concerned with seeking out land suitable for grazing stock, not giving objective descriptions of the look of the landscape and vegetation types. This is illustrated in a quote from page 77 of Curr (1841–1851) while squatting near the Murray River:

> *But we were just intent on sheep-feed, and not on scenery*

**Oxley (1820): vegetation of the central-west and north coast of New South Wales**

One of the earliest recorders of vegetation was John Oxley (1820) who was assisted by the botanist Allan Cunningham. Oxley and his party trekked from Wellington in central-west NSW, north west along the Macquarie River into the Macquarie Marshes and then east towards the coast at Port Macquarie. On page 8 of Ryan et al. (1995) part of Oxley's journal is quoted as the bold text in the following passage:

> ***'The country we passed through is what is generally known in New South Wales as open forest land,'*** *with occasionally small flats on the river, and north and south of us were detached ranges of a similar description.* ***'The whole face of the country was abundantly covered with good grass, which having been burnt some time, now bore the appearance of young wheat. Six miles down the river it was joined by a fine stream from the southward, apparently watering a spacious valley. We crossed this and named it Ellenborough River,'*** *in honour of the Chief Justice of England.* ***'We proceeded about three miles further before we halted at the edge of a thick detached brush'*** *which came nearly down to the waters edge. In this brush was a quantity of fine red cedar trees, affording us reason to hope, that this valuable wood might, as we advanced to the coast, be found in yet greater abundance. This timber generally might be termed heavy, consisting of blue gum, stringy bark, and iron bark, with fine forest oaks…*

The following extracts have been taken from the portion of Oxley's journal pertaining to his travels from east of Walcha to Port Macquarie, which roughly follows the present day Oxley Highway.

On September 17, Oxley (1820 p. 301–302) comments on different vegetation types:

> *We proceeded on an easterly course during this day's journey; and seven miles from Crocker's River crossed a smaller stream running to the north-east. For the first ten miles the country was very poor and badly timbered, with barren stony hills; but from the last mentioned stream, to our halting place, at the end of twelve miles, though the land was hilly the soil was excellent, consisting of rich, dark mould. The hills were particularly rich and thickly clothed with fine timber, blue gum, and stringy bark.*

And on 18th September Oxley (p. 303) comments on the transition from open forest to wet sclerophyll forest/rainforest with shrubby understorey:

> *Proceeding on our course to the east north-east, we did not advance above a mile and a half before a small stream running to the north-east through a very steep and narrow valley obliged us to alter our course more southerly, which we did, and soon entered a forest of stringy bark and blue gum trees of immense size and great beauty. The soil on which they grew was a rich vegetable mould covered with fern trees* [* Alsophila australis* of Brown] *and small shrubs. We found that this part of the country was intersected by deep valleys, the sides of which were clothed with stately trees, but of what kind we were ignorant: creepers and smaller timber trees all of a species not previously noticed by us, grew so extremely thick that we found it impossible to penetrate them. We therefore continued along the edge of those valleys, our progress much impeded by the vast trunks of fallen trees in a state of decay, some of which were upwards of one hundred and fifty feet long, without a branch, as straight as an arrow, and from three to eight and ten feet in diameter. The forest through which we travelled appeared to be an elevated level or plain, and at three o'clock in the afternoon, after proceeding three or four miles to the westward, we cleared the truly primeval forest, and descended into a small valley of open ground, through which ran the stream we had crossed in the morning. Indeed we were not more that two miles south of the place we had quitted. Our hope of proceeding without much interruption was thus disappointed: the gloominess of the weather, and the constant showers that fell, so impeded our view and distorted its objects, that what appeared plain and practicable at a distance of two or three miles, when approached was found impassable. I think it probable, however, that our most serious obstructions will be the thickness of the timber, rotten trees, and creeping plants; the soil is so rich and free from rocks, that I do not think the steepness of the descents will greatly endanger us. The wind, which had been extremely violent all day, was now accompanied by heavy showers; and we thought ourselves extremely fortunate in not being obliged to encamp in the forest.*

As a result of a change in the weather, Oxley (1820 p. 306) noted on the 21st September:

> *We accomplished seven miles on a south-east by east course, through a very heavily wooded country; the timber generally of the best description, and the soil, with some partial exceptions, was equally good and rich. It was, however, so thickly covered with ferns and bushes among the trees, with vines running from them, that in many places we found it difficult to pass. Our course was accidentally such as to avoid all the deep valleys but two, the descents of which were extremely difficult.*

Again, on September 22, due mainly to the ruggedness of the terrain and vegetation, Oxley comments (p. 307):

> *We had no choice in the route we pursued this day, taking that which appeared most practicable for men and horses: it was a continued ascending and descending of the most frightful precipices, so covered with trees and shrubs and creeping vines, that we frequently were obliged to cut our way through.*

On the same day, Oxley also referred to a barrier of thick vines in what could be considered to be a gully rainforest surrounded by wet sclerophyll forest (p. 311):

> *After the provisions were brought up, all hands were sent to cut a road for the horses through the brushes which surrounded the bottoms of the steepest ascents, and without which it would have been impossible for them to pass laden; the vines which crossed each other in various directions forming an almost impenetrable barrier. It may seem superfluous to speak of soil and timber among such mountains as these; yet I will say that except where the rocks presented a perpendicular face, and among the highest ridges, the soil was light and good. The timber consisted of blue gum and stringy bark, and forest oak (Casuarina torulosa) of the largest dimensions.*

The preceding extracts from Oxley (1820) describe a range of vegetation types varying in both their floristic composition and their structure. They included woodlands, wet sclerophyll forest, rainforest ('brush') and gallery rainforests. Much of the vegetation contained dense undergrowth. Ryan et al., however, only include one quote from Oxley that describes a grassy woodland on the Northern Tablelands. Excluding the impact of clearing and stock grazing, the vegetation patterns described by Oxley match those present today in the Hastings Valley on the North Coast of New South Wales (NSW National Parks and Wildlife Service 1981).

**Peter Cunningham (1827): vegetation of Sydney, Southern Tablelands, Hunter Valley**

Although Peter Cunningham (1827) was an agronomist, he gives insightful accounts of the vegetation around Sydney. He describes the vegetation of Mrs Macquaries Road in Sydney as a 'closely wooded point.' He goes on to describe the road to South Head Lighthouse where he states (p. 43):

> *Midway, a road to the left carries you to a rising ground named Bellevue, level at top, and commanding an extensive view of the ocean and all the surrounding wild natural scenery. The country on the route will afford few charms to the mere agriculturalist, alive to no other attractions save fertility of soil; but to the admirer of untamed nature, in all her primeaval variety, this spot, where low undulating hills (of rock and sand) lie scattered about in disorderly array, garnished with shrubs in liveries of the freshest green, and flowers of the liveliest hue, cannot fail to impress its beauty on the heart too deeply to be readily forgotten.*

In this passage Cunningham is describing a heathland on low fertility soils. This contrasts with statements made in Ryan et al. (p. 6) about the dominance of grassy woodlands, some of which could be ploughed.

On page 47, Cunningham (1827) refers to the county of Cumberland and describes the differences in the vegetation between the coast and the Cumberland Plain west of Parramatta:

> *... the land immediately bordering upon the coast is of a light, barren, sandy nature, thinly besprinkled with stunted bushes; while, from ten to fifteen miles interiorly, it consists of poor clayey or ironstone soil, thickly covered with our usual evergreen forest timber and underwood. Beyond this commences a fine timbered country, perfectly clear of brush, through which you might, generally speaking, drive a gig in all directions, without any impediment in the shape of rocks, scrubs or close forest. This description of country commences immediately beyond Parramatta on the one hand, and Liverpool on the other; stretching in length south-easterly obliquely towards the sea, about forty miles, and varying in breadth near twenty.*

It appears that while a gig could be driven through the Cumberland Plain the coastal vegetation was much denser.

Heading further west, Cunningham (1827 pp. 62–63) describes the vegetation of protected aspects of the lower Blue Mountains:

> *The moment you reach the foot of the mountain, an entire new scene opens upon your view, the country being quite distinct in its general features, as well as in the trees, shrubs, and even birds it produces, from any thing you have seen before in the colony. The tall fern, cedar and cabbage trees; the numerous creeping vines, climbing up and throwing their fragrant tassels of flowers downwards from the tops of the less lofty trees; the luxuriant growth of every vegetable product; with the red-crested black cockatoos, and large-crested blue pigeons peculiar to this district, make you fancy yourself transported to some far-distant tropical region; to which the temperature, as well as the general features of the spot, bear a much closer resemblance than to the moderate latitudes wherein it is placed.*

Again, Cunningham (1827 p. 68) outlines the variation in vegetation cover as he moved across the Southern Tablelands of New South Wales. He states:

> *Lake George is near to the summit of the range dividing the eastern and western waters, being but about twelve miles from the south Fish river, a branch of the Lochlan [sic] running into the great interior marshes. Beyond this lake is the fine open forest of the Argyle, and stretching on south-westerly, beyond the dividing range, much good grazing forest land and downy open country are passed through, until you reach Monaroo Plains.*
>
> *These are most extensive downs, clear of timber, which from their fertile limestone soil, seem well adapted for agricultural purposes, while their great elevation and southerly latitude must give them a cool climate, every way suited to European constitutions.*

Letter VIII in Cunningham (1827 pp. 75–88) describes the vegetation in the Hunter River valley north of Sydney.

> *Small settlers occupy patches of ground along the alluvial banks of Hunter's River, for about a mile onward; when you come to a thick vine brush of the richest soil, through which the road winds, the ground becoming firm, and the country beyond it of the open forest description.*

Continuing, Cunningham comes upon:

> *the rich alluvial plains called Twickenham Meadows, which consist of a series of rich alluvial flats, dotted lightly over with trees (with good forest land behind) extending through a distance of twelve miles and upwards along both banks of the river, and averaging from half a mile to one and a half broad.*

It is from this section of Cunningham's letter that Ryan et al. (p. 8) take their quote (the bold text) when they are justifying their interpretation of the Australian landscape as being like an 'open parkland'. Further describing Twickenham Meadow Cunningham (1827 pp. 80–81) continues:

> *On disentangling yourself from among the undulating hills and ridges which bound these beautiful meadows,* ***'one of the richest natural prospects that can well be witnessed presents itself, the flat alluvial lands spread out before you being matted with luxuriant herbage; branching evergreens scattered singly or in irregular clumps; the river winding through the midst; whilst dark foliaged swamp-oaks, bordering with a deep green fringe its steep and grassy banks, and the gently rising hills beyond, thinly clothed with wide-spreading forest-trees, extend in diversified magnificence as far as eye can reach…'.***
>
> ***'.... In all these luxuriant plains there is scarcely a superfluous tree to be seen, not often above a dozen to the acre; and patches of acres here and there met with destitute even of one, and only requiring the instrumentality of the plough to produce an abundant crop. It is this freedom from the superfluous timber, which among other things, gives so decided a preference to New South Wales over America, where your capital is often exhausted in making land fit for the plough;'*** *whereas here, you will often meet with enough to serve your purpose, without a farthing of previous outlay on account of clearing.*

While it appears that the floodplain and adjoining plain sections of the Hunter River valley were covered with a grassy open woodland, more undulating country was probably covered with a denser open forest. Cunningham would have traversed the less dense vegetation on the valley floor — the path with the least possible resistance. Cunningham's descriptions of the landscape must be interpreted in the light of his intention as he was employed to evaluate the land for pastoralism. So his words probably present an idealised view of what he was trying to sell to future potential landholders and the Government.

In letter VIII of Cunningham (1827 p. 83) refers to the vegetation of the Liverpool Plains:

> *These plains occupy a space of about sixty miles square, besides branching out among the hills in various directions, all fine rich grassy soil without a tree, excepting where a small woody hill occasionally rises from the bosom of the plain to vary and beautify the prospect. In looking down upon this extensive tract from the summit of one of the overhanging ridges, the country appears to be spread out like a green ocean, of unbounded extent, with clusters of woody islands bespangling its surface.*

These treeless plains described by Cunningham above, were mainly restricted to brown and black cracking clay and alluvial soils derived mainly from basalt (Banks 1995) which occur in a small proportion of the southern part of the Northern Tablelands. Surrounding areas would have been forested to varying degrees.

**Lhotsky (1835): vegetation on Southern Tablelands of New South Wales**

The journals of the botanist explorer Lhotsky (1835) were also consulted by Ryan et al.. Lhotsky travelled south-west of Sydney in January 1834. He had camped at Long Bridge near Liverpool (now an outer suburb of Sydney) on 11th January, from where he commented (pp. 70–71):

> *The vegetation near the Long Bridge, began already to be very different from the coast vegetation near Sydney. The experience I have as yet obtained, during my Australian travels, enables me to distinguish five systems of vegetation in this country. The coast vegetation from Sydney, South to Illawarra; in these extensive sandy levels and hills, the Epacris, Borronia, Dalvinia, Gompholobium, Xantorrhoa, Hakea, Grevillea, Personia, and such like, are prevalent and characteristic, when of the higher forest trees, scarcely any other than the Eucalyptus are visible. However, I must observe, (as far as I can do on the present occasion), that even this coast vegetation, has a subdivision of very striking character; and this is the vegetation of our rocky gullies. Here, although few springs appear, which feed the small number of creeks we possess, and the periodical or permanent moisture, elicits a series of plants not to be seen any where else in the same geographical localities. In such gullies, or small flats surrounded by such gullies, is the spot where the two sole species of palms we possess, are to be found. Here the Corypha Australis projects its annulated stem, of a hundred feet high; here the Seafortia Nobilis ascends to an equal height, but with a thicker and smoother trunk. The second sort of vegetation which I shall here mention, is the Argyle vegetation, or that with which the grassy hills, flats, and plains of that County, and all congenial places in the Colony abound. Here, almost all the families of the Coast are wanting, and a certain number of others appear, which begin to be mixed with the tribe of the Compositae, the vast quantity of which characterises the extensive downs of the Menero.*

In the above passage Lhotsky notes the major botanical differences between the coast and the inland Cumberland Plain. On the 20th January, after camping on the flats near a chain of ponds at Lockyer's Farm, near Mittagong Lhotsky (pp. 90–92) continues:

> *We started, and proceeded silently through a serene fresh air, surrounded by the beautiful forest land of the Argyle. After a few miles, we passed a number of fine large ponds, around which the forest was more dense, the dark shadow of which reposed like a mystic dream, upon the surface of the quiet limpid waters. We soon reached a place where the road approaches the Wollondilly a second time … we entered a rather wild forest, from which a lofty range of hills was visible to the N.E., of at least 600 feet in height, and covered with timber. The expectation to reach Goulburn Plains (here commonly called* ***the plains****) increased every moment. We reached a little flat at the foot of the above ranges, where two small, but well cultivated farms are situated, and plenty of vegetables were growing about. We again entered the bush, and reached the Wollondilly, whose course was visible to a long extent through a fine open forest land, the verdure of which, contrasted agreeably with the placid waters of the limpid steam … The plain I saw stretches about five miles in length, and two and a half in breadth, and being an almost perfect level, the very few undulations being unimportant, it is visible to the whole of that distance, extending from N.N.E. to S.S.W. A long range of wooded mountains, about 600 feet high, girt them from N.E. towards S.W. To the S.S.W. another large one of nearly 2000 (feet) in height is visible at a distance of about 40 or 50 miles, and at the S. W. some lower ones appear at near 25 miles distance.*

In the above passage Lhotsky is describing a traverse through open forests between modern-day Mittagong to modern-day Goulburn where he recorded a five miles long by two and a half miles wide grassy plain. This reveals that natural treeless grassland was not abundant in the Sydney to Goulburn region. The region was dominated by open forests most of which have now been cleared.

Further south on Lhotsky's expedition he did encounter a large area of treeless plains on the Monaro tableland on the Southern Tablelands of New South Wales (quoted on page 9 of Ryan et al.). This is an important record of what was one of the largest natural grasslands in south-eastern Australia, of which only a small fraction remains in natural condition today (J. Benson 1994, Kirkpatrick et al. 1995). However, based on other reports from explorers and scientific studies of vegetation history (cited elsewhere in this paper), grassland was atypical of the vegetation of south-eastern Australia 200 years ago. It persisted on the Monaro after the last ice age due to the presence of a dry, cold climate combined with heavy clay or clay-loam soils as these conditions are prerequisites for grassland vegetation worldwide (J. Benson 1994). It is unnecessary to invoke fire or herbivory in order to explain such open vegetation formations that develop under these conditions, as Flannery (1990) and Ryan et al. have done.

**Leichhardt (1842–44): vegetation in north-eastern New South Wales**

Ludwig Leichhardt described in detail the vegetation of the Mount Royal area on the northern side of the Hunter Valley in a letter to Lt. Robert Lynd dated 19th February 1843 (Leichhardt 1842–44 pp. 632–633):

> *The base of both mountains is covered with forest, the principle tree being the black butt. The westerly flancs are covered with a rich grass, devoid of trees at Piri and with very few ones at Mt Royal. The easterly flancs are covered with a rich brush to the even edge of both mountains; the brush covers even the more expanded top of Mt Royal, though it seems only a loose heap of Ruines. During my stay at the mountain I observed with few exceptions a S Easterly wind. The wind carries the moisture of the sea, which is scarcely more than 50 miles distant to the mountain, and is here the cause of frequent morning mists and of rain. The rain supplies the East side of the mountains with abundant moisture and is so the cause of the rich vegetation, which covers them. At Mt Royal the moisture is perhaps equally attracted and better kept by the loose stones of the top and I explain so the dense brush extending over it. — And oh that you could have been with me in these brushes! A great variety of trees of great height tied together by vines form the body of the brush. Here grows the nettle tree about 80 and 90 feet high with its large leaves, and the noble red cedar (what is its scientific name?) the red Sterculia, the Sassafras, the Ricinus, the Rosewood, the cohiti wood. It will take some time before we find even their real names. It was impossible to get branches from many of them, or to identify bark and leaves. In little gullies, where the waters went down the fern trees grew luxuriantly about 12–15 feet high with long leaves 8–9' (feet) long. [From margin: Underneath it a peculiar plant, if I'm not mistaken a kind of Dorstenia, and Greliola and the common nettle covered the ground.] Polypodium, Asplenium, Aerostichum grew everywhere, mosses hung down in festoons and a species of bird had knowingly made use of them to hide its nest. —*

> *Lichens of various colour covered the rotten and the living trees. The lyre bird, the native Turkey with its peculiar nest of leaves, the Echidna, and many curious animals live here, though I had no means of getting them, I myself being no shot, and having no terrier to find the small quadrupeds out for me.*

The preceding passage aptly describes the subtropical–warm temperate rainforest (Baur 1957) on the eastern slope of Mount Royal that persists today as a consequence of rich basaltic soil, high precipitation and an absence of frequent fire (J. Benson 1983). Leichhardt (1842–44) is quoted on pages 11 and 12 in Ryan et al. but the passages they selected from his journal do not include his many descriptions of wet sclerophyll forest or rainforest vegetation. Leichhardt describes these vegetation types again in a letter to Helenus Scott Esq. on the 24th July 1843 (Leichhardt 1842–44, p. 662):

> *Of all the country from Newcastle to the Condamine, none could be equalled to the Darling Downs, wherever they are sufficiently watered. The country between the Coast Range and the sea which forms a belt about 100 miles wide, has the advantage of plenty of water, though the rather dense forest and the abundance of scrubs renders them less fit for sheep farming. There are however very generally 1500 sheep in a flock which one shepherd is well able to attend to. The vegetation is rich, the turf denser, than in any part of the colony I traversed (you know I did not get to see New England); the grasses are various though the Kangooroo grass (which might perhaps be different in species from that which covers the mountains of the Glendon Estate) pre-dominates.*

In the above passage Leichhardt describes dense forest and rainforest ('scrub') on the coastal strip between the mountains and the sea between Newcastle and Brisbane. Most of the species-rich kangaroo grass grasslands on the Darling Downs have since been replaced with crops and introduced pastures.

Leichhardt was a sagacious recorder of vegetation. His descriptions of the vegetation between the Liverpool Plains on the Northern Tablelands of New South Wales and Brisbane indicate the variety of types of vegetation encountered on that journey (pp. 700–702):

> *The Liverpool Plains are one of those areas that still hold out the hope of something new to the botanist. When I crossed this strange region there were numerous Compositae in flower. I made only a small collection of them because the only paper I had was the newspapers that my several hosts had been kind enough to give me. 'Just imagine your peregrine friend begging for newspapers so that he might collect plants'— The Liverpool Plains have probably been the bed of a chain of lakes that contained numerous islands formed of sandstone and covered with forests composed of many different species of Eucalyptus. The Cypress pine (Callitris) grows here in many places, and the bush huts are built of its timber. I followed the Mokki, the Namoi, the Peel and the Manilla, to spend some time of the source of the Gwider …*
>
> *Between the Peel and the Namoi the [character of the] forest changes, and instead of riding between spotted gums, box and narrow-leaved ironbark you enter a forest of silver-leaved ironbark whose leaves are greenish grey …*

> *Between the Severn and the Condamine the country is flat, covered with forest which is very dense in some places, known to the colonists as brigalow scrub'. The brigalow is a species of Acacia with long, stiff, greyish phyllodes. It is associated with Casuarinas (forest oak), and a good deal of brushwood, [narrow-leaved] ironbark and a species of Banksia — the only one found far from the coast. The soil is very sandy except on small flats near the streams, where it contains more clay and vegetable mould. The apple tree' of the colonists, Angophera lanceolata, grows well on these flats. Just as the brigalow gives character to this part of the country, another species of Acacia, the myall (Acacia pendula) characterises the Liverpool plains and the plains of the Gwydir and the Big River …*
>
> *From the Condamine you are on the Darling Downs, undulating, open country, with rich, black, basaltic soil covered with numerous grasses of which one species of Antistheria, the oaten grass, is the staple food of the numerous flocks of sheep …*
>
> *When you enter the basin of the Brisbane, you are at once aware of the greater vigour in plant growth. Trees are taller and they grow closer together. The flanks of the mountains and the banks of the streams and of river are overgrown by almost impenetrable brush [mountain brush and river brush].*

The above passages describe both open and dense vegetation types in the areas that Leichhardt traversed. Similar vegetation patterns exist today but those on more fertile soils such as Myall *Acacia pendula* and Brigalow *Acacia harpophylla* have been extensively cleared for agriculture.

### Curr (1882): vegetation of the Riverina, south-western New South Wales

Turning to the inland plains, Curr (1882 p. 86) comments on the relationships between rainfall, vegetative production and stocking rates on inland vegetation such as the replacement of chenopod shrublands with grasslands on the Riverina:

> *Originally also, in conjunction with a little grass, large portions of the continent were covered with salt-bush and pigs'-face. In places, as for instance around Mt. Hope and the Terricks, in Victoria, the salt bushes occasionally attained the height of twelve feet, standing twenty or thirty feet apart; in other localities a dwarf variety of this plant prevailed, and grew so close as almost to crowd out the grass entirely. With this class of vegetation great changes have occurred, and at Mount Hope (as in country generally in which it grew), stocking has almost entirely destroyed it. The pigs'-face, once general in that country, has also disappeared, a luxuriant growth of grass having taken its place. The same might be said of the cotton bush and other plants.*

This observation that the original vegetation on the Riverina was mainly composed of chenopod shrubland contrasts with Ryan et al. view that grasslands and open understorey woodlands covered most of Australia prior to European settlement. Curr is quoted in their booklet on fire and grasslands (pp. 12–13) but his reference to the original chenopod shrubland of the Riverina is not included. Chenopods are not highly flammable, but if burnt enough they are mostly killed and only recover slowly from seed (Hodgkinson et al. 1993). If fire was as widespread and frequent before European settlement as suggested by Ryan et al., it is unlikely that chenopod shrubland would have been as abundant and as aged (metres high) as suggested in early observations as documented in Moore (1953).

**Scientific evidence of pre-European vegetation and vegetation change**

The conjecture of Ryan et al. that most of Australia was covered in grassland or grassy forests in 1788 does not fit with scientific evidence about the composition of Australian vegetation since the end of the last ice age 10 000 years ago.

Australia contains a broad range of vegetation types that have evolved over millions of years in response to climatic change, a range of soil types derived from an array of substrates, and the isolation of the continent (although some species from the north did colonise the continent). Most of the soils of Australia contain low levels of nutrients. They have not been renewed through glaciation for 300 million years and only small areas of the east coast have been enriched through volcanism over the last 40 million years (White 1997). Infertile soils, combined with an onset of aridity over the last 15 million years, has led to a dominance of sclerophyllous plant species including *Acacia* and *Eucalyptus*. Rainforest and grassy woodland tend to occur on higher nutrient soils with the former in high rainfall areas protected from fire and the latter in drier areas subjected to fire. The extensive scientific literature on the history of Australian vegetation is summarised in texts such as Groves (1994) and White (1986, 1994). The current vegetation of Australia is described in Beadle (1981) and Groves (1994), and broadly mapped in AUSLIG (1990). In addition, over the last forty years many regional and local vegetation surveys have been compiled at a range of scales to assist with land use decisions and habitat management.

There is no evidence to support the Ryan et al. and Flannery (1994) view that grassland and open woodland covered most of the landscape in 1788, although as mentioned under 'fire regime' above, these vegetation types were more common during the last ice age. Based on studies of pollen from soil cores (for example Ross 1984) grasses appeared to be more prevalent during the last ice age 40 000–10 000 y.b.p. due to cold temperatures and lower precipitation. During the ice age, vegetation change was probably mainly climate-driven and many vegetation types in south-eastern Australia would have retreated to refugia, but have expanded in their distribution again over the last 10 000 years. This includes both rainforests in places such as the Atherton Plateau (Queensland), Barrington Tops (NSW) and Tasmania, and eucalypt forests over the continent generally. Climate change after the last glaciation is probably the main explanation for the rise in eucalypt pollen over grass pollen in many sites after 8000 y. b.p. as trees re-colonised higher altitudes (Singh et al. 1981). This topic is summarised by Dodson (1991), mainly based on studies of pollen in soil cores from a number of regions of Australia.

Aborigines, like the Europeans, favoured some habitats over others, including grassy woodlands and river valleys where water was plentiful. The archaeological evidence suggests that they did not reside in the dense escarpment forests as much as on the coast or on the inland plains (V. Attenborough pers. comm.). During the last ice age the climatic conditions were so severely dry and cold, that Aboriginal impacts on vegetation through burning may have been relatively minor in comparison (White 1997). The topic of Aboriginal burning is discussed above under 'fire regime'. To reiterate, the evidence suggests that climate change was the main determining factor of vegetation change even over the period since Aboriginal people came to Australia.

The vegetation had become physiologically adapted to fire, poor soils and aridity over millions of years. Aboriginal burning may have accelerated the pace of change in vegetation composition in some plant communities, but it is unlikely it initiated the direction of change (Clark 1983).

## Regrowth

Ryan et al. (p. 15) state:

> ***The extracts from letters, diaries and journals of early European settlers, explorers and government officials describe a parklike landscape of grasslands and grassed open forest lands with very few areas of thick forest. The cessation of the regular burning following European settlement allowed the growth of a thick forest of young trees that, together with an increasing shrub understorey, choked out the grasses. The widespread ringbarking that was carried out around the turn of the century was mostly of this regrowth. The landowners were attempting to re-establish the original grazing capacity.***

Ryan et al. cite several early observations about regrowth (Curr 1841–51, Mitchell 1838 & Howitt 1890). Mitchell (1838) observed regeneration of thickets of trees on the Cumberland Plain west of the early settlement of Sydney. He probably did observe shrub species such as Blackthorn *Bursaria spinosa* increase in abundance due to less frequent fire (D. Benson and Howell 1994). With the onset of clearing for grazing and timber extraction from forests, regrowth of young trees would have occurred in places that were not cultivated or re-cleared over the years.

Howitt (1890) referred to sapling growth in the Snowy River valley and in Gippsland after settlement and to regrowth of *Eucalyptus sieberi* (Ryan et al. p. 14):

> ***'giant trees of E. sieberiana now all dead, while a forest of young trees of the same species … which may probably be twelve years, growing so densely that it would not be easy to force a passage through on horseback'.***

It is not surprising that Howitt observed thick regrowth of *Eucalyptus sieberi* as this species proliferates after intense fires which occur from time to time in the forests of Gippsland. Also, reduced competition from grasses due to stock grazing may have led to increased survival of saplings. Howitt's observations were made 60 years after the European settlement of Gippsland, and Wakefield (1970) argues that the settlers burnt frequently — every 3–4 years. This may have been more frequent than previous Aboriginal burning and it led to a more shrubby vegetation. Similarly, Good (1982) demonstrates that frequent burning of sub-alpine vegetation in Kosciuszko National Park increases the abundance of the flammable shrubs *Bossiaea foliosa* and *Daviesia latifolia* but when these shrubs are left unburnt for 40 years the understorey tends to revert to a sward of snow grass. These studies counter the axiom adopted in Ryan et al., Rolls (1981) and Flannery (1990, 1994) that frequent fire leads to a more open understorey and inhibits shrubby regrowth. The studies also challenge the assumption that Aboriginal people burnt the landscape more often than the early settlers.

**Clearing and regrowth in southern Australia**

Given that Ryan et al. dedicate a chapter to what they perceive to be the 'problem' of forest regrowth, it is curious that they hardly mention the problems of vegetation clearance, over-logging and overgrazing by domestic stock over the last 200 years (although they imply that clearing or thinning is returning the vegetation to the 'natural state'). These have been primary causes of soil erosion, acidification, rising water tables and salinisation, decline in abundance of native species and species extinction.

The early settlers sought out pastures that required the minimum removal of trees, thus they quickly occupied natural grassland areas such as the Monaro in New South Wales, the midlands in Tasmania and the Keilor Plains near Melbourne in Victoria. Due to over 150 years of stock grazing, cultivation, pasture improvement and weed invasion, these grasslands are now close to extinction (Kirkpatrick et al. 1995). At the time of European settlement, grasslands were scarce compared to forested land and from an early time the settlers began clearing forest and woodland. The rate of forest clearing became a topic of public debate. For example, while debating the first Forestry Bill for New South Wales in 1909 Mr N.R.W. Nielson, Member of the Legislative Assembly for Yass, said (NSW Parliament *Hansard* 1909):

> *I could take Honorable Members to the country between Narrandera and Barmedman and I could point out thousands of acres of valuable cypress pine which have been ringbarked with no other desire than to grow grass. I have been grieved to observe the enormous quantity of beautiful timber which has been wasted in order that the land might be utilised for pastoral purposes ...*

Reed (1990) estimated that 35 million hectares, or 44%, of New South Wales was ringbarked or cleared in the first 130 years of settlement. A total of 1 550 000 $km^2$ including 52% of the woodlands and forests of Australia's land use zone has been cleared or thinned over the last 200 years (Graetz et al. 1995). There is little evidence to support the views of Ryan et al. that most of the ringbarking was of regrowth. By revisiting sites in inland NSW where the vegetation was described by explorers such as Mitchell, Denny (1992) reveals that at most locations all strata (particularly the understorey) of vegetation have decreased in their biomass due to stock grazing, clearing and logging for fence posts since European settlement. Hundreds of thousands of trees including White Cypress Pine *Callitris glaucophylla* were felled for fence posts in western NSW before steel fence pickets were invented (Denny 1980).

Clearing is still occurring. In New South Wales it has been estimated that an average of 150 000 hectares of native vegetation was cleared annually between 1980 and 1995 (NGGIC 1994) with three times this amount in Queensland during the 1990s.

Soil erosion increased soon after settlers and their stock moved onto the land. In a study of erosion rates into Llangothlin Lagoon on the Northern Tablelands of New South Wales using $^{210}$Pb chronology dating techniques, Gale et al. (1997) found that the deposition rate of soil into the lagoon increased many fold after the introduction of stock in 1837. In 25 years most of the topsoil was eroded from the catchment.

At the time of European settlement in eastern Australia there were similar vegetation types as there are today — ranging from rainforest to dense eucalypt forests to open woodlands. The early settlers favoured woodlands where the trees were well spaced and grasses and herbs dominated the ground cover. In south-eastern Australia woodlands grow on relatively rich loamy or clayey soils in drier coastal valleys, the tablelands and western slopes of the Great Dividing Range and parts of the inland plains. Examples include the Grey Box *Eucalyptus moluccana* — Forest Redgum *Eucalyptus tereticornis* woodland of western Sydney (D. Benson 1992) and the grassy box woodlands dominated by White Box *Eucalyptus albens* on the western slopes of New South Wales (Prober 1996). These temperate woodlands of southern Australia have taken the brunt of agricultural expansion — including recent broadscale clearing. Of the bushland cleared during the 1980s, 71% was woodland (World Wide Fund for Nature 1996). Woodlands are also threatened by firewood cutting, overgrazing, weed invasion, rising water tables and salinity.

While large tracts of country have been cleared, cultivated or subjected to pasture improvement, other areas have only been grazed and not cleared, allowing some native species to persist. In some places regrowth of forest has occurred after the initial clearing — often on public lands, poorer soils, steep slopes or in back paddocks distant from the main production zone of a farm. Regrowth after disturbance is more dense than the original forest or woodland but over time it self-thins. In the absence of further major disturbance it eventually becomes dominated by large, spaced trees. An example is Coolibah *Eucalyptus coolabah* — Blackbox *Eucalyptus largiflorens* woodland that grows on the floodplains of western New South Wales. Many of these floodplains have been extensively cleared and others are threatened with clearing or thinning of regrowth as there is a perception among the pastoral community that the 'original forest' was 'park like' and regrowth is unnatural (Maher 1995). Seedlings of Coolibah germinate after floods, so it is possible to age cohorts of trees in relation to flooding history. By counting the number of Coolibah trees in plots placed in different cohorts of trees that germinated after different floods between the 1890s to the 1950s, Maher (1995) found that after 100 years less than 3% of the trees remained. This illustrates that regrowth is a natural phenomenon and the structure of a woodland changes over time through self-thinning. Grazing in these woodlands may actually favour tree seedling survival because it reduces competition from other plants such as grasses if they are grazed in preference to eucalypt seedlings (Maher 1995).

For forests to survive over time it is necessary for young saplings to be recruited to the population of mature trees (eucalypts live 200–500 years). Most eucalypt saplings, however, would not have survived the frequent, even annual, burning regime postulated in Ryan et al. to have been applied across the landscape prior to European settlement.

## Other Contemporary Writers

The popular books of Rolls (1981) and Flannery (1994) appear to have influenced Ryan et al. about the nature and causes to vegetation change in southern Australia since European settlement. Flannery (1994) is quoted several times by Ryan et al. to support their conclusions.

### *A Million Wild Acres* (Rolls 1981)

It would seem that the popular book *A Million Wild Acres* (Rolls 1981), either directly or indirectly, influenced the views of Ryan et al. about pre- and post-European forest structure in south-eastern Australia. Rolls (1981) records his views of post-European history of the 400 000 ha Pilliga Scrub, a forest growing on low nutrient sandy soils in central, north-western New South Wales near the town of Coonabarabran. This case illustrates how generalisations about vegetation structure should not be applied to all parts of a forest or a region, and how popular views should be substantiated by more detailed studies of historical records and species dynamics.

According to Dodson & Wright (1989) climate has been the major cause of change in the vegetation of the Pilliga Scrub. Their analysis of pollen records shows that at the height of the last ice age, 25 000 y.b.p., the Pilliga Scrub probably contained few trees and was dominated by chenopod shrubs, daisies and grasses in a semi-arid environment. The present type of vegetation of *Callitris* and *Eucalyptus* forest established in the Holocene (10 000 y.b.p.–present).

Rolls (1981 p. 1) states that:

> *Australia's dense forests are not the remnants of energetic clearing, they are the product of one hundred years of energetic growth.*

On page 1, Rolls refers to Oxley (1820), who was the first explorer to traverse the Pilliga Scrub region in 1818. Rolls does not directly quote from Oxley's journal, but puts his own interpretation of what the pre-European Pilliga Scrub looked like (Rolls 1981 p. 1): *Most of it, about 800 000 hectares, was a 'forest' of huge ironbarks and big white-barked cypress pines, three or four of them to the hectare.* Rolls (1981 p. 1) continues: *We would not now call it forest. 'But that is open grassland' we would say in bewilderment.*

Again on page 245 Rolls states:

> *When the first squatters sent their stock in, the ridgy country on the east and south carried the same heavy growth as it does now … Not all the growth extended to the flats, not all the ridges were covered. The rest, apart from the great arc of Brigalow in the north, was grassland dominated in the east by three to four big ironbarks (Eucalyptus crebra) to the hectare, and in the centre and west — about half a million hectares — by three to four big pines to the hectare.*

To check Rolls' descriptions we examined Oxley's journal. After leaving the Macquarie River, Oxley traversed eastwards through the present Day Warrumbungle National Park. He climbed Mt Exmouth which forms part of the Warrumbungle Range and lies in the Park today. From its summit he viewed the Nandewar Ranges

to the north east. The Pilliga Scrub lies between these two mountain ranges. Oxley entered the south-western side of the Pilliga Scrub on August 11, 1818 and left its eastern side on about August 24 1818 (Oxley 1820 pp. 264–272). Winter rains impeded his progress and his expedition often became bogged in the loose sandy soil. He describes a variety of vegetation types: apple tree flats with pine, iron-bark and box (p. 265), pine and eucalyptus on rocky crags (p. 266), a vast variety of flowering shrubs (p. 267), a thick forest of small ironbarks that had been burnt (p. 268) — and states *so thick was the forest that we could hardly turn our horses* (p. 269). Oxley complains about the lack of nutritious grass — referring to a lack of feed for his horses on page 269 of his journal — *it was the fourth day that they had been without grass, and they preferred the tender branches of shrubs … to the prickly grass.*

In his descriptions of the Pilliga Scrub, Oxley does not mention that large sections of it were 'grassland' as alluded to by Rolls (1981). On the contrary, Oxley describes the Pilliga as a desolate place with a variety of vegetation types and generally a poor grass cover. As mentioned above he even describes thick patches of small ironbark trees. Oxley (1820) mentions grasslands only when he travels further east onto the northern tablelands, particularly when viewing the Liverpool Plains, which we agree were covered in grassland and open woodland.

Oxley (1820) gives no estimates of the number of trees in a given area. The source of Rolls' (1981) estimate of three or four large trees/ha is not given in his book and appears to be a gross under-estimate of the density of large trees in the Pilliga 200 years ago. We consider Rolls' unsupported figures of tree density in the Pilliga has influenced the perceptions of some modern-day writers such as Ryan et al.

Recent counts of large, old (100+ years) trees in the central section of the Pilliga Scrub reveal that there are more than four large trees/ha (E. Norris pers. comm.). The majority of the early grazing runs in the Pilliga were along the rivers on the forest's edges (Norris et al. 1991) where the soils are more clayey than the central sandstone area. These valleys would have contained a more open woodland than that of the central area. Perhaps Rolls (1981) assumes this type of woodland extended over large sections of the Pilliga Scrub. We contend that, even in these more open woodlands, there would have been more than a few large trees per hectare, given the spacing of trees in woodlands generally in south-eastern Australia (Fig. 1).

Rolls may have refined his 1981 views on the density of trees in the original Pilliga forest. In a newspaper article on the impacts of the December 1997 bushfires (Rolls 1997), that burnt 200 000 ha of the Pilliga forest, Rolls states that under Aboriginal management there were three to four huge, old grey trees to the hectare only, with a dozen or so young trees coming on to replace them. He does not define the size of a 'young' tree, but the statement 'with a dozen or so trees coming on' was not stated in his influential book (Rolls 1981). This is unfortunate because it is a better description of the forest. Given the evidence about the spacing of trees in woodlands as outlined below, we contend that there would have been 30 mature/large trees per hectare in the Pilliga with denser forest in some parts.

Rolls (1981) suggests that dense regrowth of White Cypress Pine *Callitris glaucophylla* is not usual and has been caused by a combination of a lack of Aboriginal burning, loss of native herbivores (rat kangaroos), control of rabbits in the 1950s, above

average rainfalls in the 1880s and 1950s, and large fires that stimulated *Callitris* seeds to germinate. Norris et al. (1991) questions some of these explanations of change in the forest. Old surveyors' maps and Oxley's journal (see above) suggest that the central sandstone area of the Pilliga contained a shrubby understorey and patches of dense forest well before European impacts had affected the area. This area still supports a shrubby understorey today.

Disturbance in the Pilliga Scrub due to logging, and timber stand improvement of selectively removing eucalypts, over the last 100 years has probably established favourable conditions for White Cypress Pine seedling regrowth. The presence of mixed age classes of White Cypress Pine suggests there has been some regeneration between the two main regrowth events. Since seed viability falls to 1% several months after seed-fall (Lacey 1972), some seed must have successfully germinated and grown into trees to have yielded the mixed age classes present in the forest.

The major White Cypress Pine regrowth events in the Pilliga Scrub of the 1880–90s and 1950s coincided with above average rainfall years. These may simply be natural patterns when viewed over hundreds of years. This is supported by a study of recruitment of *Callitris glaucophylla* at Roxby Downs in South Australia by Read (1996) who demonstrated that, for seedlings to survive to mature adults, several seasons of above average rainfall are required.

### ***The Future Eaters*** (Flannery 1994)

At the beginning of the 'forest land' section, on page 6 of Ryan et al., the authors quote from the book *The Future Eaters* (Flannery 1994) to support their presumptions about vegetation change.

The hypotheses about vegetation change and fire ecology in Flannery (1994) were first published in Flannery (1990) and in summary they are:

- Aboriginal hunting pressure was responsible for causing the extinction of the megafauna over 30 000 years ago and also for subsequent dwarfing of remaining mammals (Flannery does not accept evidence from some sites that some megafauna survived into the Holocene, <10 000 y.b.p. He considers these sites contain redeposited material);
- Without the herbivory of the megafauna there was a build-up of fuel across Australia which led to larger fires than before;
- Aboriginal people adjusted to this changed environment by frequently burning to reduce fuel levels and this led to the development of open grassy ecosystems to which many animals adapted;
- The displacement of Aboriginal people by European settlement led to a suppression of burning, fuel build-up and intense bushfires. This changed fire regime was the primary cause of a type of 'aftershock' where large numbers of mainly medium-sized mammal species became extinct in Australia.

Responses by eight reputable scientists to the hypotheses of Flannery are published in Flannery (1990), as is Flannery's reply to them. The majority of these scientists highlight flaws in Flannery's arguments. Some question his assumptions about the

timing of the megafauna extinctions, his emphasis on changed fire regimes as the primary cause of mammal decline since European settlement, and his views of the degree of vegetation change based on pollen/charcoal evidence.

If some of the megafauna survived into the mid-Holocene (6000 y.b.p.), as dated by Wright (1986a), then Flannery's hypothesis about Aboriginal fire regimes keeping regrowth in check collapses. Steve Morton (in Flannery 1990) points out that Flannery did not take into account the impact of stock and rabbits as factors in the recent decline of central Australian arid zone fauna, much of which tended to live in discrete areas containing higher soil fertility. David Horton (in Flannery 1990) argues that Aboriginal burning was more of a substitute than an addition to fire regimes and that other species of herbivores such as insects and smaller mammals could have filled the grazing niche left by the extinction of the megafauna. Horton also points to a contradiction in Flannery's acknowledgment of the importance of late successional stages of vegetation for some fauna. Constant burning as proposed by Flannery would have eliminated late successional stages. Also, some of this megafauna could have been restricted to open plains, similar to extant African megafauna. If this was so, the Australian megafauna would have had minimal effect on the undergrowth of forests on the eastern escarpment and coast.

The popularity of *The Future Eaters* has led to uncritical public exposure of some of the book's more contentious viewpoints, that are mostly conjecture and not based on empirical evidence. Flannery cites changes in pollen types and increased charcoal deposits from sediment cores off the Queensland coast, the Atherton Tableland (northern Queensland) and Lake George (New South Wales) to support his view (Flannery 1994 p. 224):

> *… we now know that until the last 100 000 years or so, rainforests blanketed vast areas of eastern Australia. They may also have been extensive across the north of the continent … Researchers have thus had to face the possibility that not only did the arrival of the first Aboriginal people dramatically alter Australian's fauna, but that it transformed its flora also.*

Flannery (1994 pp. 218–219) is quoted in Ryan et al. (p. 6) as observing warm temperate rainforest and dense eucalypt forest below a cliff at Bulli south of Sydney. He suggests that in the absence of fire this has replaced grassy woodland seen there by Cook and Banks in 1770. Flannery ignores the fact that both types of vegetation occur in close proximity at Bulli today. The boundaries of the rainforest may have expanded or retreated but the extent of this has not been measured over recent years. Since Flannery could not have known that the area he observed was exactly the same piece of land observed by Cook and Banks in 1770, his inference about vegetation change may not be valid.

While the use of fire by Aboriginal people may have reduced rainforest distribution, there is no evidence that rainforest blanketed vast areas of eastern Australia at the time of their arrival. Rainforest apparently rapidly declined in Australia in the mid-Miocene 15 million years ago (Martin 1996). By 100 000 years ago it probably occurred in patches more or less where it was present at the time of European settlement – confined to rich soils, of the Illawarra, Dorrigo and Richmond–Tweed Rivers (Big Scrub) in New South Wales with dry rainforest in fire-protected

sites in the inland; protected valleys in Tasmania and Victoria; on the wetter sections of the coastal plain and highlands of tropical Queensland with dry scrubs in fire-protected sites inland; and in patches where soils and hydrological factors were favourable in the Northern Territory. Patches of rainforest must have been present on the southern tablelands of New South Wales 60 000+ y.b.p. because rainforest species pollen are present in the Lake George sediment cores (Singh et al. 1981). Rather than dwell on Aboriginal burning as a sole cause of its demise, it is at least as plausible to explain rainforest extinction in some regions as being due to climate change, which led to a natural increase in fire frequency (Horton 1982). During the last ice age (40 000 –10 000 years ago) rainforest retreated but has re-recolonised suitable habitats over the last 10 000 years.

At least two thirds of the rainforest in eastern Australia was cleared after European settlement (Werren & Kershaw 1984). In the Northern Territory where fire remains a frequent event, it is thought that edaphic factors (soil type, hydrology), rather than fire-history explains the presence of rainforest among the predominant savanna eucalypt woodland (Bowman 1988).

Flannery is quoted in O'Reilly (1996) as stating that:

> *Until the time the white man arrived, Australia was a vast grassland, extending from northern Queensland to Victoria with trees only scattered and well spaced, the soil rich in species of wild grasses and flowers.*

Grasslands with only scattered trees did not cover all of south-eastern Australia 200 years ago (AUSLIG 1990). Flannery's statement could apply to part of the landscape where grassy woodlands predominate in coastal lowland valleys, some tableland areas, western slopes and sections of the inland plains. Given his previous statement above about rainforest, presumably Flannery considers that Aboriginal burning transformed rainforest areas to open woodland over the last 100 000 years. This is not substantiated by the scientific literature as summarised in Groves (1994) or the pollen records quoted elsewhere in this paper. Nor is it supported by many entries in the journals of the early explorers that describe a mosaic of vegetation types during their travels — as has been discussed above.

Horton (in Flannery 1990) warned that:

> *The subjects of extinctions and fire are not simply esoteric topics for academic debate, but have serious ramifications for the environment today .... I don't believe in Flannery's 'trophic cascade' but it certainly has the potential to start an anti-conservation crusade.*

This prophesy was realised with the publication of Ryan et al. Flannery's (1990) unproven hypotheses, popularised in *The Future Eaters* (Flannery 1994), fitted well with Ryan et al's view of vegetation change and land management in the Australian landscape.

## Perceptions about the structure of woodlands in southern Australia

Understanding the perceptions that Ryan et al., Flannery (1994) and Rolls (1981) have of the structure of pre-European vegetation is important in understanding their philosophy about vegetation management in relation to fire and regrowth. Both Ryan et al., and the frequently quoted writings of Flannery and Rolls, state that the pre-European vegetation cover over much of Australia (including the wetter climes) contained trees 'well spaced' with a 'park like' appearance. They do not quantify what 'well spaced' or 'park like' mean in terms of number of mature trees per unit area. However, based on Rolls' estimate of four trees/ha and comments by Flannery and Rolls in the media (O'Reilly 1996), it appears their perception of a pre-European woodland in southern Australia was that it contained trees several crown-widths apart with little undergrowth present other than a ground cover of grasses. It was similar to contemporary scenes of scattered trees in a farm paddock. J. Ryan confirmed this on ABC Radio National (*Earthbeat* 30 March 1996).

On page 6 of Ryan et al. the authors state:

> ***'Contrary to what is often stated, dense forests did not cover large areas of Australia and the first settlers did not set to and ringbark huge areas. There was no need to. Most of the country was woodland, grassland, savanna or open forest. Grazing was plentiful and there for the taking, many areas could be readily ploughed'.***

This perception has led to controversial statements that clearing has 'restored' the landscape to its original tree density. Trees are widely-spaced in some northern savanna regions bordering semi-arid regions, and on the inland semi-arid plains and floodplains of southern Australia, although thick eucalypt and acacia regrowth may occur after floods. However, forests were and remain more dense on the coast, tablelands and western slopes of south-eastern Australia.

The only evidence provided by Ryan et al. that quantifies the spacing of trees in a woodland in south-eastern Australia comes from page 81 in the journal of Peter Cunningham (1827). Cunningham was visiting various properties in the upper Hunter Valley in New South Wales soon after settlers had arrived there and describes the scene (Ryan et al. p. 8):

> ***'In all these luxuriant plains there is scarcely a superfluous tree to be seen, not often above a dozen to the acre; and patches of acres here and there met with destitute even of one, and only requiring the instrumentality of the plough to produce an abundant crop. It is this freedom from the superfluous timber, which among other things, gives so decided a preference to New South Wales over America, where your capital is often exhausted in making land fit for the plough'.***

A dozen (12) trees to the acre, referred to in the above quote, is equivalent to 30 trees/ha. If we assume these were large woodland trees, as most likely they would have been on the plains of the Hunter Valley, their average crown-widths would have been at least 10 metres. This is based on our estimations of the crown-widths of large trees in the area today.

Fig. 1 provides a visual representation of the spacing of 30 trees plotted on a 10 metre grid covering an area of one hectare. It shows that the trees on average are approximately one crown-width apart and cover about 30% of the area. This would be classified as a 'woodland' bordering on 'open woodland' using the crown cover based classification of Walker and Hopkins (1990). It would be a 'woodland' under the projective foliage cover based classification of Specht (1970).

These grassy woodlands were much denser than a modern rural scene of a farm paddock with a scatter of aging trees, however they were less dense than many remnant regrowth forests that will take decades to self-thin.

In a study of pre-European tree densities of lowland plains in Gippsland, Victoria, using historical maps, Lunt (1997) found that tree densities varied from 2–59 with an average close to 30 trees per ha. The explorer Evans (quoted in Croft et al. 1997) estimated 10 trees per acre (25 trees/ha) on a plain near Bathurst. Both of these estimates support Peter Cunningham's estimate for tree density in a grassy woodland. These woodlands were not similar to a semi-arid savanna in their structure using accepted classifications of Australian vegetation.

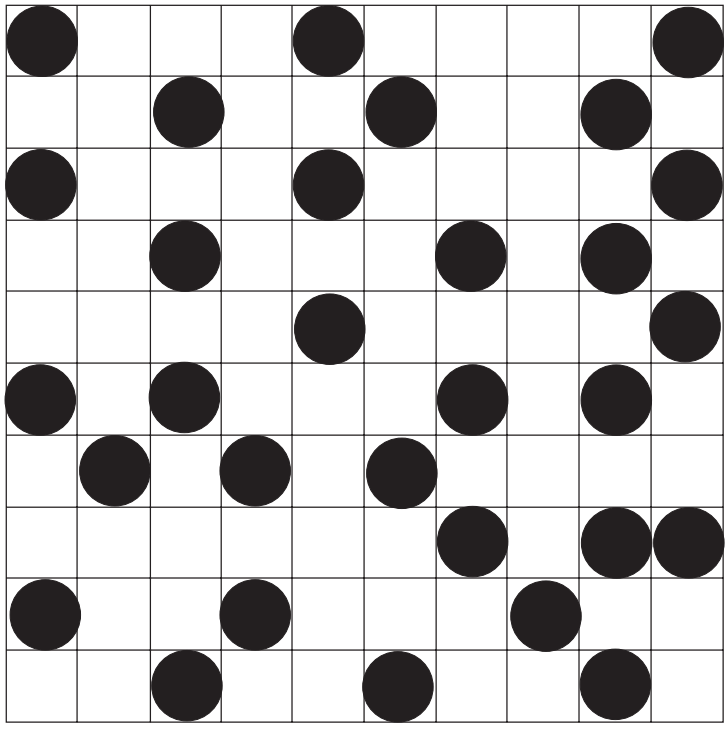

**Fig. 1**. Interpretation of the spacing of trees in a typical grassy woodland of south-eastern Australia prior to European settlement. The plotted spacing of tree crowns is based on estimates of 10–12 trees/acre (approximately 30 trees/ha) by Evans 1815 (quoted in Croft et al. 1997) for woodland near Bathurst, Peter Cunningham (1827) for woodland in the Hunter Valley and Lunt (1997) for woodland on the Gippsland lowland plain. It is assumed that trees were mature and the width of their crowns would have been approximately 10 m in diameter. Eucalypt forests with touching crowns and rainforest with overlapping crowns would have been present in wetter regions, as they are today.

Oxley (1820) described the forests of the Northern Tablelands of New South Wales as being 'park like' in appearance. In his study of the original forests of the Northern Tablelands, Curtis (1989) considers the gaps between trees would have been one half to one and one half tree-crowns. This fits with both Walker and Hopkins (1990) and Specht (1970) classifications of 'woodland'. Curtis (1989) discusses the history of ringbarking and fire regimes in the region. Clearing began in the 1840s and by 1890 over 400 000 ha of the region had been ringbarked. Subsequent grazing by stock, combined with frequent burning by the early settlers, led to a reduction in diversity of understorey shrubs and seedling trees (Curtis 1989). Norton (1971) considers that European burning differed from the previous Aboriginal burning and it may have eliminated some native legumes. While there has been substantial regrowth of some types of forest on the Northern Tablelands, particularly stringybark (J. Benson & Ashby 1996), many isolated paddock trees (notably Yellow Box, Blakely's Red Gum and New England Peppermint) have suffered from dieback caused by insect attack and other factors (Nadolny 1995, Landsberg and Wylie 1988).

The degree of recent dieback events along the tablelands of New South Wales may have been exacerbated by land clearing and pasture improvement. The aging, widely-spaced trees that are now a common scene in the rural countryside are particularly susceptible to insect infestations and other contributing factors associated with dieback. If there was a similar structure of woodland prior to European settlement in southern Australia, as portrayed by Flannery (1995), Rolls (1981) and in Ryan et al. (p. 2., p. 15 quoting Blainey), then one would expect that dieback may have been a major disease in the pre-European forests and woodlands. Norton (1886) recorded grubs and beetles infesting New England peppermint and manna gum on the Northern Tablelands of New South Wales, albeit after 40 years of stock grazing. However, if trees were as isolated before European settlement as perceived by Ryan et al., its impacts should have been more widespread and conspicuous, yet it is rarely mentioned by the early explorers.

Based on Cunningham (1827), Curtis (1989), Lunt (1997) and the estimates of Evans in 1815, it can be concluded that the spacing of the pre-European grassy woodland trees in the valleys and tablelands of south-eastern Australia was between half a crown-width and two crown-widths apart (Fig. 1). In addition, there were, and remain, tracts of denser forest — open forest and rainforest spanning the coastal plain, eastern escarpment and parts of the tablelands of eastern Australia from Queensland in the north to Tasmania in the south. During pre-European times (as today) these open forests and rainforests would have consisted of dense stands of trees, often with overlapping crowns (NSW National Parks and Wildlife Service 1995).

## Conclusions

The following conclusions relate to the main sections in Ryan et al. (1995).

**Fire regime**: The substantial volume of research on fire ecology (reviewed in Keith 1996 and Williams & Gill 1995) does not support the central thesis of Ryan et al. that most of the landscape was burnt every year or so before European settlement.

Gaining an understanding of the fire ecology of a landscape and its constituent species is extremely complex and requires detailed studies of the life histories of a range of plants and animals and studies of palynological evidence. Many Australian plant species have adapted to increased aridity, low nutrient soils and increased fire over the last 15 million years. No species is adapted to fire per se (Gill 1981). Each species may be adapted to a range of fire regimes. For many species, these regimes do not include repeated high frequency fires. While we acknowledge that fire frequency may have decreased in some places since European settlement, to the detriment of some species (eg. species in grasslands and grassy woodlands), elsewhere the early settlers and modern farmers may have increased fire frequency to the detriment of other species.

Fire frequency may also have increased in some forests due to modern control-burning practices, and this may now be threatening a wide range of species in temperate forests of southern Australia. Compared to southern Australia fires are more frequent in the sorghum-dominated grassy woodlands of the 'top end' of the Northern Territory. Season of burning is an unresolved issue for the 'top end'. There is some evidence that Aboriginal people previously burnt these grassy woodlands patchily in the early or very late periods of the dry season, rather than in driest periods (August–October) as is happening today, and which is leading to annual high intensity grass fires (R. Williams pers. comm.).

In light of a paucity of data on pre-European burning and the fragmented nature of the natural southern Australian landscape today, modern fire management should be based on scientific understanding of species and their habitats (Williams & Gill 1995), rather than on selective interpretations of some of the early explorers' observations. The omission of other sources of evidence, renders Ryan et al.'s discussion of the 'fire regime' topic highly deficient.

Notably, the interpretations espoused by Rolls, Flannery or Ryan et al. have not gained currency in the peer-reviewed scientific literature.

**Forest land and regrowth**: While we agree with Ryan et al. that the vegetation in large parts Australia has been altered since European settlement, we disagree with their interpretation of this change — that there has been a dense regrowth of vegetation as a result of a decreased fire frequency due to a lack of Aboriginal burning. Vegetation varies from site to site in response to a range of factors, as Croft et al. (1997) demonstrate for the central western region of New South Wales. Ryan et al. appear not to appreciate this.

South-eastern Australia was not completely covered with 'well spaced' trees or treeless grasslands 200 years ago. Ryan et al. ignore the plethora of references by the early explorers and settlers to dense scrub and forest. The perceptions of Ryan et al. that large areas of pre-European woodlands were composed of trees many crown-widths apart (akin to a semi-arid savanna) are supported by neither the historical record nor modern measurements of little-disturbed forest on the coast and tablelands of south-eastern Australia.

Native plants have evolved in adaptation to particular soils, climates and disturbance patterns over millions of years. Our understanding of vegetation change from studies of pollen cores, combined with the results of research on the population dynamics of plant species in the Sydney sandstone region, suggest that the current shrub-dominated vegetation is not an artefact of post-European fire history. Since 1788 the structure and floristic composition of the vegetation has changed little in less disturbed sites, but in places affected by European land use including clearing, thinning, logging, changed fire regimes and weed invasion, change has occurred. Dense regrowth is occurring in some areas as a consequence of logging, clearing or flooding. Changed fire regime may contribute to this but it is only one factor. Left undisturbed this regrowth will self-thin over time.

The main causes of change to Australia's vegetation since European settlement have been large-scale clearing and cultivation of land (J. Benson 1991). Other factors include overgrazing of remnant vegetation by stock and feral animals; loss of native herbivores and vertebrate and invertebrate pollinators or seed dispersers; invasion of weed species in both agricultural and naturally vegetated areas; and changed fire regimes in some areas of forests, woodlands and grasslands. These factors have resulted in a reduction in native species diversity and biomass in the agricultural zones of the continent (with the exception of places with woody regrowth). Loss of top-soil over the last 200 years, combined with rising saline water tables, threaten the long term sustainability of agriculture over large tracts of land.

Finally, the impact of the early years of European settlement on the landscape of southern Australia is poignantly captured in the following recollection from E.M. Curr (1841–51 p. 82), about the changes to the forests near Moira on the Murray River:

> *Since that day, some five-and-thirty years only have passed, and the Blacks, reeds, and bell-birds are gone. Of the first scarce one remains; his cooey is heard no more in those parts, whilst the old forest itself is fast being converted by steam sawmills into railway sleepers. In our go-ahead days people of course are jubilant about such things, and I suppose I ought to be so too; but as a fact, the saws and the steam engines do not fill me with any particular delight, and I may as well out with the truth, that when the subject occurs to me it is to remember with regret the primitive scene, the Black with his fishing canoe, the silence, and the gum-trees.*

The above passage was not selected by Ryan et al.

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