Australia Burning

Fire Ecology, Policy and Management Issues

(Main report and 7 theme reports)

Geoffrey Cary, David Lindenmayer and Stephen Dovers

This book is available from CSIRO PUBLISHING through our secure online ordering facility at http://www.publish.csiro.au/ or from:

Customer Service
CSIRO PUBLISHING
PO Box 1139
Collingwood Victoria 3066
Australia

Telephone +61 3 9662 7666
Freecall 1800 645 051 (Australia only)
Fax +61 3 9662 7555
Email publishing.sales@csiro.au

Australia Burning: Fire Ecology, Policy and Management Issues, by Geoffrey Cary, David Lindenmayer and Stephen Dovers, 2003, CSIRO Publishing, 280 pp.

1

Bushfires: a Darwinian perspective

David Bowman

> *In the whole country I scarcely saw a place, without the marks of fire; whether these may be more or less recent, whether the stumps are more or less black, is the greatest change, which breaks the universal monotony that wearies the eyes of a traveller.*
>
> Charles Darwin, 19 January 1836

Despite experiencing a bushfire and seeing evidence of them in the landscape between Sydney and Bathurst, Charles Darwin's diary shows no evidence that he pondered the ecological significance of this quintessentially Australian phenomenon.[1] Indeed, it was not until the second half of the 20th century that the fundamental role of fire in the dynamics of many Australian terrestrial ecosystems was recognised.[2] To this day, the evolutionary path taken by the Australian biota to tolerate bushfires, and eventually exploiting fire for reproductive advantage, remains poorly understood.[3] Most attention has been paid to the possible impacts that followed Aboriginal colonisation in the late Pleistocene.[4]

It is my belief that Australians will continue to be bedevilled by bushfire disasters until they have a coherent evolutionary

Australia Burning: Fire Ecology, Policy and Management Issues, by Geoffrey Cary, David Lindenmayer and Stephen Dovers, 2003, CSIRO Publishing, 280 pp.

perspective on the subject. The quest for this knowledge forms the core of my research.[5] I am also deeply aware of the power of stories in translating academic knowledge into everyday understanding – without a coherent narrative there is just a jumble of facts.[6] The purpose of this chapter is to tell a story concerning the relationship of fire, people and landscape by interpreting the existing knowledge. This is my story of why Australia became the most flammable continent on Earth, and how Australians should adapt to life in the land of fire.

In the beginning Gondwana was green

The Tertiary fossil record of plants and animals, notwithstanding its geographic biases and other deficiencies, leaves little doubt that Australia was once clothed in a diversity of rainforest types.[7] Fossils from the late Pleistocene record a diverse extinct fauna characterised by large animals, a contraction of rainforest associated with an increase in microscopic charcoal in swamp sediments which point to an increase in landscape fire at this time.[8,9] Clearly, powerful forces caused the 'browning' of a once green fragment of Gondwana.[10]

The most popular explanation for these massive changes relates to the alleged impacts of the first Australians who colonised a vulnerable and naïve continent some 40 000 to 60 000 years ago. Wielding spears and fire-sticks, the Aborigines are argued to have despatched the megafauna in a hunting blitzkrieg, and destroyed the rainforests with frequent fires.[11] The subsequent development of 'fire-stick farming' is thought to have maintained the habitat of the smaller marsupials that originally depended upon the openings made by the extinct giant marsupials consuming vegetation. Frequent burning triggered an evolutionary and ecological expansion of flammable plants. In sum, Aboriginal burning created the bushfire 'problem'.

This is a powerful, compelling narrative that speaks to a diversity of concerns including the origins and destiny of modern Australians. Furthermore, this story can be interpreted as holding out hope of breaking the current bushfire-cycle, 'undoing' the ecological damage wrought by the first human colonists. Despite its brilliance and popularity, I believe it is a flawed story because it

Australia Burning: Fire Ecology, Policy and Management Issues, by Geoffrey Cary, David Lindenmayer and Stephen Dovers, 2003, CSIRO Publishing, 280 pp.

seeks to compress enormous ecological and evolutionary changes into a tiny period of geological time. The great antiquity of the archetypal Australian vegetation, dominated by eucalypts and *Acacia*, has been misjudged and consequently the long history of bushfires upon which this vegetation depends has been underestimated.

Rainforests – scattered and burnt

In Australia the term 'rainforest' has diverged from the original conception of luxuriant forests that develop in drought-free environments; indeed some Australian ecologists use the perplexing term 'dry rainforest'. This idiosyncratic terminology has arisen because the definition of Australian rainforests hinges not on moisture stress, but sensitivity to fire relative to the surrounding vegetation.[12,13]

The archipelago of fire-sensitive fragments of rainforest in a sea of flammable vegetation has been interpreted as evidence of the tremendous impact of landscape burning by the Pleistocene colonists, based on the assumption that the pre-human landscape was dominated by rainforest. This interpretation overlooks the remarkable diversity of the fire-adapted biota and does not address the question of how this ensemble of species evolved.

The arboretum at Currency Creek in South Australia provides a unique opportunity to see archetypal eucalypts such as *E. obliqua* and bizarre eucalypt species growing side-by-side.[14] The many forms of *Eucalyptus* include species with upright needle-like leaves (*E. angustissima* subsp. *angustissima* from saline sand plains from southern WA), spreading habits with remarkably thick leaves (*E. tetraptera* from the Stirling Range of southern WA), massively robust woody capsules (*E. youngiana* from the Great Victoria Desert) and tiny capsules (*E. dawsonii* from the central western slopes of NSW). This morphological variation is the tip of the evolutionary iceberg. Eucalypt species have dramatically contrasting environmental tolerances and geographic ranges including highly restricted distributions, and display extraordinarily rich variation in associations with plant and animal, particularly invertebrate, species assemblages.[15]

Australia Burning: Fire Ecology, Policy and Management Issues, by Geoffrey Cary, David Lindenmayer and Stephen Dovers, 2003, CSIRO Publishing, 280 pp.

The convergent evolution of distantly related giant eucalypts that require fire to regenerate and that inhabit environments that could support true rainforest, were it not for bushfire, is also consistent with a long evolutionary history. These include mountain ash (*E. regnans* in south-eastern Australia), karri (*E. diversicolor* in southern WA) and flooded gums (*E. grandis* in eastern Australia). While short-lived obligate-seeder plants may have had enough generations to evolve under a regime of Aboriginal fire management, it is inconceivable that the convergence of longer-lived species could have arisen following human colonisation. Even if Aboriginal colonisation occurred 60 000 years ago, there have only been 200 generations of trees with life spans of 300 years. If landscape burning by humans did not trigger the evolution of the flammable Australian biota, what did?

Fire, air, earth and water

The final stage of the break-up of the super-continent Gondwana involved the northwards drift of Australia. Unlike the other southern continents, Australia remained isolated from the rest of the world for most of its northward journey. The northward migration largely offset the cooling involved in the formation of the Antarctic ice-sheet. However, a consequence of the formation of the Antarctic ice-sheet was the intensification and northward displacement of the subtropical high-pressure system, triggering the aridification of the continent from the south to the north since the mid-Tertiary.[16] Sometime after the mid-Tertiary, a monsoonal climate developed in northern Australia, the depauperate fossil and sedimentary deposits precluding more precise determination of its timing.[17] Circumstantial evidence, however, points to the great antiquity of the monsoonal climate, particularly the refined biological adaptations of the biota of the monsoon tropics. Classic examples of the latter from northern Australia are the endemic 'magnetic' termite mounds, and the abundance of primitive eucalypts in the section Eudesmia such as *E. tetrodonta* and *E. miniata* and allied species such as *Allosyncarpia ternata*.

The aridification of Australia combined with the annual penetration of tropical convection storms, and associated lightning, deep into the continental interior stimulated the gradual evolution, diver-

Australia Burning: Fire Ecology, Policy and Management Issues, by Geoffrey Cary, David Lindenmayer and Stephen Dovers, 2003, CSIRO Publishing, 280 pp.

sification and geographic expansion of the flammable biota. The absence of great rivers or mountain chains meant that there were no geographic barriers to check the spread of fires. From the monsoonal 'cradle', fire-promoting species expanded into higher rainfall environments, where lightning was less frequent, gradually displacing the Gondwanan rainforests from all but the most fire-sheltered habitats. The classic example of this is the dynamic balance between the giant mountain ash *Eucalyptus regnans* and the southern beech *Nothofagus cunninghamii*.[18] In high rainfall areas with no topographic shelter from fires, such as southern WA, almost the entire rainforest flora and fauna became extinct, being replaced by a 'modern' fire-adapted biota.[19]

The sketchy fossil record of the late Tertiary has precluded the determination of evolutionary relationships amongst taxa with different fire sensitivities. Perhaps these relationships can be revealed using molecular techniques to measure the 'evolutionary' distance between fire-adapted and taxonomically related rainforest species. For example, I am studying, the phylogeny of the Australian *Livistona* palms, some of which are remarkably fire tolerant (e.g. *L. humilis*) and some of which are not (e.g. *L. benthamii*).[20]

Colonising a land of fire

Although the timing of colonisation remains uncertain, there is no doubt Australian human history stretches back to the limit of conventional radiocarbon dating (40 000 years ago), possibly reaching back to more than 60 000 years ago. The timing of the extinction of the Pleistocene faunas is more precisely known, having occurred sometime after 40 000 years ago. Combining the two sets of geochronological data leaves little doubt that humans and the megafauna coexisted, most probably for an extended period of time.[21] Because the timing and pattern of human colonisation remains uncertain, it is presently impossible to conclusively relate environmental changes detected in the sedimentary record, such as increases in microscopic charcoal particles in pollen cores, to human or natural causes.

Unlike the North American situation, there is no direct evidence of human predation of the Pleistocene fauna. The loss of a wide

Australia Burning: Fire Ecology, Policy and Management Issues, by Geoffrey Cary, David Lindenmayer and Stephen Dovers, 2003, CSIRO Publishing, 280 pp.

cross-section of body sizes suggests that over-hunting was not the primary cause of the extinctions. An alternative theory suggests that anthropogenic changes in fire regimes modified habitats sufficiently to have disadvantaged browsing animals. The primary evidence for this theory rests on the comparison with the extinct giant bird *Genyornys newtoni* which isotopic analyses of eggshells show was a browser. In contrast, the surviving emu is shown to be a generalist feeder.[22] However, it is uncertain if isotopic signatures in fossils can reliably determine differences in habitat caused by landscape burning. For this reason I am undertaking a study to calibrate this methodology by comparing the isotopic signatures of kangaroo teeth from areas in northern Australia where fire management is undertaken by Aborigines and adjacent unmanaged areas.[23]

Despite the absence of hard data demonstrating any impact of landscape burning by Aboriginal colonists, I suspect colonisation was associated with a significant change in vegetation *structure* from dense to open understoreys but did not cause an equivalent change in the floristic composition of fire-adapted vegetation. Initially intensive burning may have also caused the contraction of fire-sensitive rainforest patches, but such burning may have conserved them, particularly during the high of glacial aridity. I reach these conclusions by drawing a parallel between current landscapes managed by Aborigines and similar unmanaged areas and by assuming an ancient and continuous tradition of Indigenous fire management.

Country managed by the fire-stick

My recent studies in Arnhem Land and those of my student, Tom Vigilante, in the north Kimberly have revealed the following three key features of Aboriginal landscape burning. First, the major ecological impact is the opening up of the vegetation by high frequencies of fire that stunt woody species and produces sparse loads of fine-fuels. Second, fire intensities are reduced, allowing the survival of fire-sensitive species such as the cypress-pine *Callitris intratropica* and the conservation of vulnerable fragments of rainforest.[24] Third, whilst there is a wide range of reasons for landscape

Australia Burning: Fire Ecology, Policy and Management Issues, by Geoffrey Cary, David Lindenmayer and Stephen Dovers, 2003, CSIRO Publishing, 280 pp.

burning, our ethnographic studies found that the central reason for Aboriginal fire management was related to kangaroo hunting and habitat management. As one Aboriginal man succinctly stated, 'fire is for kangaroos'.[25]

Regrettably, we cannot undertake similar comprehensive research programs in southern Australia because of the dramatic changes that have occurred over the last 200 years of settlement. Nonetheless, colonial records and allied ecological studies show that at the time of European settlement, many landscapes were more open than today and were ideal for grazing animals. Since settlement there have been marked changes in the distribution and structure of vegetation types with a general trend towards increasing densities of trees. The classic examples of these changes involve the widespread thickening of rangelands, a process that admittedly is confounded by overgrazing by introduced herbivores and the *El Nino–La Nina* climate cycles that brings floods and droughts to eastern Australia.[26] In many forest types, massive fires such as those in Victoria in 1939 have obliterated the evidence of millennia of Aboriginal fire management.[27] It is my impression that the current regrowth forests, once mature, will be far denser than the original stands, and the associated massive accumulations of fuel signal a shift from regular low-intensity fires towards a cycle of infrequent and catastrophic fires.

Wild, tame and feral bushfires

I consider there are three great ages of bushfires in Australia: the pre-human, when lightning started massive wildfires and enabled fire-adapted species to eventually subordinate the Gondwanan rainforests throughout the continent; the Aboriginal, when bushfires were tamed; and the post-Aboriginal and the current period, when fire has become feral. Different plant and animal species populations were advantaged and disadvantaged, in some cases to the point of extinction, under the dominant fire regimes characteristic of these great ages.

Under the pre-human fire regime that developed in the late-Tertiary, fires were caused by infrequent lightning strikes to create a 'coarse-scale' mosaic of large areas of vegetation in different stages of recovery. This pattern of landscape would have provided habitat

Australia Burning: Fire Ecology, Policy and Management Issues, by Geoffrey Cary, David Lindenmayer and Stephen Dovers, 2003, CSIRO Publishing, 280 pp.

for a wide diversity of herbivores including browsers and grazers, and the extensive fire edges would have supported animals requiring a mix of resources. The Aboriginal colonists gradually 'tamed' wildfire as a tool to hunt game, including the extinct megafauna. This system of fire usage created mosaics that supported high densities of game species adapted to burnt landscapes. Although more research is required to test the hypothesis, I suspect that the extinct fauna that required long-unburnt habitats, such as the leaf-eating kangaroos *Sthenurus*, *Simosthenurus* and *Procoptodon* would have been disadvantaged, and the addition of human hunting pressure may have eventually driven such species to extinction.[28] Significantly, the cessation of Aboriginal fire management and the associated periodic landscape-wide loss of unburnt habitats seems to be an important cause of the extinction of smaller mammals and some bird species in the continental interior and monsoon tropics.[29,30] I suspect these species were originally adapted to the long ecotones that formed the boundaries between areas burnt by infrequent fires caused by lightning. Following the imposition of Aboriginal fire management these 'edge species' become dependent upon the fine-grained mosaic created by Aboriginal fire-stick 'ranching'. In sum, I suggest that one of the great triumphs of the Pleistocene Australians was the taming of wildfires through the development of 'igniculture'.

While it is true that in some cases the 19th century squatters and 20th century cattlemen adopted Aboriginal burning practices, this technological transfer ceased with the more intensive husbandry of stock that requires investment in infrastructure such as fencing.[31] The disruption of the refined and consistently implemented system of fire management established by Aboriginal people is, I believe, the root of the current fire management problem – tamed fire has become feral.

Learning to living with bushfire

Although there remains much uncertainty about how Australia became 'the land of fire', there is sufficient information to inform fire management. I interpret the existing knowledge as showing that attempts to totally suppress fire are futile. Rather than fighting against the inevitable 'tide' of bushfires, Australians need to adapt

Australia Burning: Fire Ecology, Policy and Management Issues, by Geoffrey Cary, David Lindenmayer and Stephen Dovers, 2003, CSIRO Publishing, 280 pp.

more effectively to their fire-prone land. However, this now represents a tremendous challenge because of the construction of infrastructure and habitations established in bushland.

The very serious threat fire poses to life and property, and the widespread phobia of landscape fires provides a strong incentive to impose a policy of fire prohibition backed by fire suppression technologies. In the short term these approaches may work, but in the longer term they will fail because it is impossible to snuff out the inherent flammability of the Australian environment. Just as flood mitigation encourages people to build on flood plains so too fire suppression encourages the establishment of flammable buildings and settlements embedded in bushland. The typical media portrayal of bushfires as 'disasters' reinforces the desire to wage war against fire, and failure seems only to spur on heroic attempts to achieve a total victory.

While it is unrealistic to attempt to 'return' to Aboriginal fire management, the fact that Aborigines were able to 'tame' wildfire should be a great source of inspiration in the quest for ecologically sustainable fire regimes. To achieve this goal, a landscape perspective is required with analyses of why some styles of fire management work and others fail: current landscapes should be seen as great 'natural experiments' that await investigation. The findings of these studies are vital to sustain the process of 'adaptive management' that involves learning about and articulating the efficacy of various management interventions. In this regard, I suspect that the common mode of conducting short-term and narrowly focused ecological studies has generated a blizzard of details that engender a sense that coherent solutions will remain forever elusive. There is a fundamental mismatch between the temporal and spatial scales at which fire managers and ecologists operate. Ecologists typically work at the local scale and consider the longer-term fate of populations, while fire managers work at the landscape scale with the immediate goal of fire suppression. Fire managers often see only 'fuel' and forget about the conservation of biodiversity so valued by ecologists. It remains a great challenge to balance these sharply contrasting but legitimate perspectives. We must identify relative costs and benefits of recurrent fuel reduction fires compared to infrequent massive 'back-burns' used in bushfire suppression, and indeed wildfire.

Rather than attempting to manage landscapes for all possible biological and social outcomes, I suggest we should accept that fire management can achieve only a limited number of objectives. Further, fire management is context specific, for example small fragments on the urban fringe present fewer options than large tracts in remote areas. Nonetheless, I see no reason why focused fire management should not be ecologically sustainable. In this regard, I see a parallel with the fire management system developed by Aborigines, which was focused on the management of a few core species but nonetheless conserved the biodiversity we value today. There can be no doubt that some styles of management are more sympathetic to biodiversity and ecosystem services than others. I believe the currently ascendant 'bushfire disaster' mode of management is ultimately more destructive of biodiversity than a program of recurrent fires to reduce fuel loads.

Sustainable fire management requires complicated trade-offs to realise specific objectives. A concrete example concerns the management of bushfire smoke. High concentrations of microscopic particulates from severe wildfires surrounding Darwin are correlated significantly with hospital presentations for asthma, whilst no such pattern was evident with the low levels of particulates associated with control burning and less severe wildfires.[32] We must accept that some management goals, such as reduced fire hazards, may have costs including the loss of some elements of biodiversity and the nuisance of low levels of smoke pollution.

Just as gardens reflect the character of their owners, I suggest that landscapes reflect the character of their communities. As I drive through the settled landscapes of southern Australia I sense we are 'still settling Australia'.[33] I sense a Darwinian struggle of an industrial civilisation adapting to a fiery land. While I am confident that we will achieve sustainable fire management, the question remains whether this will be achieved rapidly by design or painfully by being gradually worn down by implacable evolutionary forces.[34]

1 Nicholas, F.W. & Nicholas, J.M. (2002). *Charles Darwin in Australia*. (Cambridge University Press: Cambridge.)

2 Bradstock, R.A., Williams, J.E., & Gill, A.M. (2002). *Flammable Australia: the fire regimes and biodiversity of a continent.* (Cambridge University Press: Cambridge.)

3 Bond, W. (2002). Burning issues down under. *Trends in Ecology and Evolution* **17**, 393.

4 Bowman, D.M.J.S. (1998). Tansley Review No. 101: The impact of Aboriginal landscape burning on the Australian biota. *New Phytologist* 140, 385–410.

5 I wish to record my debt to the late Professor W.D. Jackson who taught me to think about bushfire as an evolutionary force.

6 Cronon, W. (1992). A place for stories: nature, history and narrative. *The Journal of American History* **78**, 1347–76.

7 Hill, R.S. (1994). *History of the Australian vegetation: Cretaceous to Recent.* (Cambridge University Press: Cambridge.)

8 Flannery, T.F. (1994). *The future eaters: an ecological history of the Australasian lands and people.* (Read Books: Sydney.)

9 Kershaw, A.P., Clark, J.S., Gill, A.M. & D'Costa, D.M. (2002). A history of fire in Australia. In *Flammable Australia: the fire regimes and biodiversity of a continent* (Eds R.A. Bradstock, J.E. Williams & A.M. Gill.) pp. 3–25. (Cambridge University Press: Cambridge.)

10 White, M.E. (1994). *After the greening: the browning of Australia*. (Kangaroo Press: Sydney.)

11 Hill, op. cit.

12 Bowman, D.M.J.S. (2000). *Australian rainforests: islands of green in the land of fire.* (Cambridge University Press: Cambridge.)

13 Bowman, D.M.J.S. (2001). On the elusive definition of 'Australian rainforest': response to Lynch and Neldner (2000). *Australian Journal of Botany* **49**, 785–7.

14 Nicolle, D. (2000). *Currency Creek Arboretum (CCA) eucalypt research, Volume 1*. (D. Nicolle: Adelaide.)

15 Williams, J.E. and Woinarski, J.C.Z. (1997). *Eucalypt ecology: individuals to ecosystems.* (Cambridge University Press: Cambridge.)

16 Bowler, J.M. (1982). Aridity in the late Tertiary and Quaternary of Australia. In *Evolution of the flora and fauna of arid Australia*. (Eds W.R. Barker & P.J.M. Greenslade.) pp. 35–45. (Peacock Publications: Adelaide.)

17 Bowman, D.M.J.S. (2002). The Australian summer monsoon: a biogeographic perspective. *Australian Geographic Studies* **40**, 261–77.

18 Jackson, W.D. (1968). Fire, air, water and earth – an elemental ecology of Tasmania. *Proceedings of the Ecological Society of Australia* **3**, 9–16.

19 Bowman, D.M.J.S. (2000). Rainforest and flame forests: the great Australian forest dichotomy. *Australian Geographical Studies* **38**, 327–31.

20 The research is in collaboration with Professor Yuji Isagi, of Hiroshima University and supported by a major Japanese Government research grant.

21 Brook, B.W. & Bowman, D.M.J.S. (2002). Explaining the Pleistocene megafaunal extinctions: models, chronologies, and assumptions. *Proceedings of the National Academy of Sciences, USA* **99**, 14624–27.

22 Miller, G.H.F., Magee, J.W., Johnson, B.J., Fogel, M.L., Spooner, N.A., McCulloch, M.T. & Ayliffe, L.K. (1999). Pleistocene extinction of *Genyornis newtoni:* human impact on Australian megafauna. Science **283**, 205–8.

23 The research is in collaboration with a number of other researchers (Professor Rainer Gruen, Associate Professor Rod Wells and Dr Michael Gagan), my student PhD Brett Murphy and is supported by the Australian Research Council.

24 Bowman, D.M.J.S., Garde, M. & Saulwick A. (2001). *Kunj-ken makka man-wurrk*: fire is for kangaroos: interpreting Aboriginal accounts of landscape burning in Central Arnhem Land. In *Histories of old ages: essays in honour of Rhys Jones.* (Eds A. Anderson, I. Lilley & S. O'Connor .) pp. 61–78. (Pandanus Books: Canberra.)

25 Bowman, D.M.J.S., Price, O., Whitehead, P.J. & Walsh, A. (2001). The 'wilderness effect' and the decline of Callitris intratropica on the Arnhem land Plateau, northern Australia. *Australian Journal of Botany* **49**, 1–8.

26 see papers in Bowman, D.M.J.S. & Farrer, S.L. (2002). Measuring and imagining: exploring centuries of Australian landscape change. The Special 50th Anniversary Issue. *Australian Journal of Botany* **50**.

27 Griffiths, T. (2001). *Forests of ash: an environmental history.* (Cambridge University Press: Cambridge.)

28 Prideaux, G.J. (in press). Systematics and evolution of the sthenurine kangaroos. *University of California Publications in Geological Sciences.*

29 Franklin, D.C. (1999). Evidence of disarray amongst granivorous bird assemblages in the savannas of northern Australia, a region of sparse human settlement. *Biological Conservation* **90**, 53–68.

30 Woinarski, J.C.Z., Milne, D.J. & Wanganeen, G. (2001). Changes in mammal populations in the relatively intact landscapes of Kakadu National Park, Northern Territory, Australia. *Austral Ecology* **26**, 360–70.

31 Barr, N. & Carey, J. (1991). *Greening a brown land: the search for sustainable land use.* (Macmillan: Melbourne.)

32 Johnston, F.H., Kavanagh, A., Bowman, D.M.J.S., & Scott, R. (2002). Exposure to bushfire smoke and asthma: an ecological study. *Australian Medical Journal* **176**, 535–8.

33 Dovers, S. (2000). Still settling Australia: environment, history, and policy. In *Environmental history and policy: still settling Australia.* (Ed. S. Dovers.) pp. 2–23. (Oxford University Press: Melbourne.)

34 I thank Don Franklin, Fay Johnston, Aaron Petty and Peter Whitehead for allowing me to rehearse these ideas with them.