A long term perspective on fire in the Sydney Basin, set against trends in Australia

Dr Scott Mooney
School of BEES
UNSW
Some background

In 2001 I published...

Clues to the ‘burning question’: Pre-European fire in the Sydney coastal region from sedimentary charcoal and palynology

By Scott D. Mooney, Kate L. Radford and Gary Hancock

which:

• described palaeoenvironmental analysis of sediments in Jibbon Lagoon RNP;
• suggested that fire in the pre-European Jibbon Lagoon catchment was relatively rare (unlike a typical ‘Aboriginal fire regime’);
• that the post-European period was unusual in terms of fire.

Some background II

Since then I have published various case studies of Holocene fire activity in (or near) Sydney region...


Some background III

In the last few years I have been working on syntheses (regional, meso and global)...


• Mooney et al. (2011) Late Quaternary fire regimes in Australia. *Quaternary Science Reviews* 30: 28-46.

• Mooney et al. (*in press*) The Prehistory of Fire in Australasia. A chapter for the CSIRO Press update of *Flammable Australia*.

On a scorching afternoon, arsonists make a city’s nightmare come true

SYDNEY BURNS

- Suburbs fight running battle with flames — Pages 2, 3, 4
- Hundreds flee mountain firestorm — Page 5
- Exclusive: Hunt for the fire suspect — Page 7
Fires burst into suburbs
Canberra firestorm
The Sun-Herald

Friday, February 8, 2009

VICTORIA WEEPS: STATE OF INFERNO

DAY OF DEATH

confirmed dead • Toll could pass 4
The problems...

After every conflagration in Australia...

- **claims** about recent fire are stated as facts
  - *unprecedented* fire size
  - *unprecedented* fire behavior

- ‘popular’ commentators claim that intensive fuel reduction should be undertaken to mimic Aboriginal-style fire management.

This has a number of consequences...

- it tends to imply that we *know* what happened in the past;
- it presents a simplistic and static view of the past;
- assumptions may present false goals for management.
I am **not** making this up...

Green ideas must take blame for deaths

*Miranda Devine*
February 12, 2009
Page 1 of 3 | Single Page View

It wasn't climate change which killed as many as 300 people in Victoria last weekend. It wasn't arsonists. It was the unstoppable intensity of a bushfire, turbo-charged by huge quantities of ground fuel which had been allowed to accumulate over years of drought. It was the power of green ideology over government to oppose attempts to reduce fuel

Effects of large fires on biodiversity in south-eastern Australia: disaster or template for diversity?

Ross A. Bradstock

Table 1. A summary of perceptions concerning the effects of large fires on biodiversity
Supporting examples are drawn from statements made during hearings by the House of Representatives Select Committee into Australian bushfires, during 2003 (see Appendix 1).

<table>
<thead>
<tr>
<th>Perceptions</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large fires are ‘abnormal’ or unnatural</td>
<td>‘I do not know whether you fellows can remember, but years ago there did not seem to be big fires like the ones we have today. I really think we have to get back in a small way to what they used to do years ago...’</td>
</tr>
<tr>
<td>Large fires are intense</td>
<td>‘I call them “feral” because of their impact – the intense feral fires that burn asphalt.’</td>
</tr>
<tr>
<td>Large fires are homogeneous</td>
<td>‘But surely in a high-intensity fire everything gets burned and absolutely destroyed.’</td>
</tr>
<tr>
<td>Large fires kill everything</td>
<td>‘...warned for over a decade that a lightning strike in there would destroy an enormous amount of biodiversity, which has now happened. It has destroyed the biodiversity to the point, as I said earlier, where it has vaporised any known seed stock that may have been below the ground, because it sterilised the earth to 40 feet [12.19 m] below the surface in some areas.’</td>
</tr>
<tr>
<td>Recovery of organisms is dependent on immigration or dispersal</td>
<td>‘...extremely hot fires that have occurred in an environment where they have totally wiped out species and where the only way we can see any vegetation returning is by aerial seeding of some of those areas...’</td>
</tr>
<tr>
<td>Large fires ‘degrade’</td>
<td></td>
</tr>
<tr>
<td>Large fires transform ecosystems</td>
<td></td>
</tr>
</tbody>
</table>
Challenging (fire) myths?

Large fires in Australian alpine landscapes: their part in the historical fire regime and their impacts on alpine biodiversity

Richard J. Williams\textsuperscript{A,H}, Carl-Henrik Wahren\textsuperscript{B}, Arn D. Tolsma\textsuperscript{C}, Glenn M. Sanecki\textsuperscript{D,*}, Warwick A. Paps\textsuperscript{B}, Bronwyn A. Myers\textsuperscript{E}, Keith L. McDougall\textsuperscript{F}, Dean A. Heinze\textsuperscript{G} and Ken Green\textsuperscript{D}

Abstract. The fires of summer 2003 in south-eastern Australia burnt tens of thousands of hectares of treeless alpine landscape. Here, we examine the environmental impact of these fires, using data from the Bogong High Plains area of Victoria, and the Snowy Mountains region of New South Wales. Historical and biophysical evidence suggests that in Australian alpine environments, extensive fires occur only in periods of extended regional drought, and when severe local fire weather coincides with multiple ignitions in the surrounding montane forests. Dendrochronological evidence indicates that large fires have occurred approximately every 50--100 years over the past 400 years. Post-fire monitoring of vegetation in grasslands and heathlands indicates that most alpine species regenerate rapidly after fire, with $>$90\% of species present 1 year after fire. Some keystone species in some plant communities, however, had not regenerated after 3 years. The responses of alpine fauna to the 2003 fires were variable. The core habitat (closed heathland) of several vulnerable small mammals was extensively burnt. Some mammals experienced substantial falls in populations, others experienced substantial increases. Unburnt patches of vegetation are critical to faunal recovery from fire. There was, however, no evidence of local extinction. We conclude that infrequent extensive fires are a feature of alpine Australia. For both the flora and fauna, there is no quantitative evidence that the 2003 fires were an ecological disaster, and we conclude that the flora and fauna of alpine Australia are highly resilient to infrequent, large, intense fires.
the modern instrumental record...

MODIS Land Rapid Response Fire Detections

April 2002

Legend
- MODIS Fire Detections from the Terra Satellite
- World Countries
Estimates of area burnt in Australasia...

Annual average total burnt fraction from the GFED v2.1 data set
van der Werf, Randerson, Giglio, Collatz, Kasibhatla and Arellano

See Guido van der Werf’s description of this work at
http://www.falw.vu/~gwerf/GFED/
Assessing variability and long-term trends in burned area by merging multiple satellite fire products

L. Giglio1,2, J. T. Randerson3, G. R. van der Werf4, P. S. Kasibhatla5, G. J. Collatz1, D. C. Morton1, and R. S. DeFries6

Abstract. Long term, high quality estimates of burned area are needed for improving both prognostic and diagnostic fire emissions models and for assessing feedbacks between fire and the climate system. We developed global, monthly burned area estimates aggregated to 0.5° spatial resolution for the time period July 1996 through mid-2009 using four satellite data sets. From 2001–2009, our primary data source was 500-m burned area maps produced using Moderate Resolution Imaging Spectroradiometer (MODIS) surface re-reflectance imagery; more than 90% of the global area burned during this time period was mapped in this fashion. Dur-
The global carbon cycle

• Currently, CO$_2$ emissions from fire are ~50% (2 to 4 Pg C/y) of those from fossil-fuel combustion (7.2 Pg C/y). Year-to-year variation is huge.
• Burning related to deforestation, a net CO$_2$ source, contributes about 0.65 Pg C year$^{-1}$.
• In contrast, the regrowth of vegetation is a sink of atmospheric CO$_2$. Burning also produces black carbon aerosols (which strongly absorb solar radiation, and may have the strongest effect on climate change after CO$_2$).

Palaeoenvironmental information

• from natural **archives** that develop sequentially and in doing so **record** some aspect of the environment;
  – e.g. ice-cores, tree rings, sediments;
  – based on environmental archives or proxies that are sensitive to the environmental condition or process under examination;

• **extend instrumental records**;
  – slow processes, rare/extreme events, environmental responses;
  – baselines, detect longer-term trends or dynamics;
  – the magnitude and rates of change;

• **some questions are inherently historical**;
  – what happened when…?

• provides insights into the environmental responses to a changing environment;
  – what **will** happen when…? (analogues for our potential future;)

• used to test ecological theories or environmental models.
A longer perspective on fire...

Methods...
- Obtaining sediment cores;
- Radiometric dating ($^{14}$C, $^{210}$Pb);
- Quantification of macroscopic charcoal (wet sieving & image analysis);
- Palynology;
- Statistical analyses.

Griffith Swamp 2004

Goochs Right 2002

Queens Swamp, Blue Mts, 2004
Charcoal Accumulates in Lake and Swamp Sediments

Charcoal Production

Transport

Deposition

Slopewash

Lake

Mud

Sample Charcoal Particles

C.M. Sutheimer

Photo: M. J. Power

Age Models
From charcoal influx to frequency

Growth curve:

\[ y = 0.000000059188x^4 - 0.4c + 6.317702970180x - 54.0, \]

Walsh et al. 2008
The tools: the GPWG database

Global Charcoal Dataset (version 2, n = 679)

Daniau et al. submitted
Data Processing
The study sites
Data processing allows inter-site comparisons…

Queens Swamp
Wingecarribee Swamp
inter-site comparisons...

Queens Swamp v wingecarribee

Years (Before Present)

Queens Swamp
Wingecarribee Swamp

Transformed Charcoal Influx
“The hallmark of climatic influence on fire history is fire event synchrony at landscape to regional scales”

(Tom Swetnam, IGBP Fire Regimes FTI, Boulder, Nov., 2004)
All Sydney inter-site comparisons...

Black, Mooney, Martin (2006) *QSR* 25: 3003-3016
Late Quaternary fire regimes of Australasia

S.D. Mooney a, S.P. Harrison b, P.J. Bartlein c, A.-L. Daniau d, J. Stevenson e, K.C. Brownlie f, S. Buckman f, M. Cupper g, J. Luly h, M. Black i, E. Colhoun i, D. D'Costa j, J. Dodson k, S. Haberle e, G.S. Hope e, P. Kershaw l, C. Kenyon m, M. McKenzie l, N. Williams n

Quaternary Science Reviews 30 (2011) 28–46

ABSTRACT

We have compiled 223 sedimentary charcoal records from Australasia in order to examine the temporal and spatial variability of fire regimes during the Late Quaternary. While some of these records cover more than a full glacial cycle, here we focus on the last 70,000 years when the number of individual records in the compilation allows more robust conclusions. On orbital time scales, fire in Australasia predominantly reflects climate, with colder periods characterized by less and warmer intervals by more biomass burning. The composite record for the region also shows considerable millennial-scale variability during the last glacial interval (73.5–14.7 ka). Within the limits of the dating uncertainties of individual records, the variability shown by the composite charcoal record is more similar to the form, number and timing of Dansgaard–Oeschger cycles as observed in Greenland ice cores than to the variability expressed in the Antarctic ice-core record. The composite charcoal record suggests increased biomass burning in the Australasian region during Greenland Interstadials and reduced burning during Greenland Stadials. Millennial-scale variability is characteristic of the composite record of the subtropical high pressure belt during the past 21 ka, but the tropics show a somewhat simpler pattern of variability with major peaks in biomass burning around 15 ka and 8 ka. There is no distinct change in fire regime corresponding to the arrival of humans in Australia at 50 ± 10 ka and no correlation between archaeological evidence of increased human activity during the past 40 ka and the history of biomass burning. However, changes in biomass burning in the last 200 years may have been exacerbated or influenced by humans.
Late Quaternary fire regimes of Australasia

S.D. Mooney\textsuperscript{a,*}, S.P. Harrison\textsuperscript{b}, P.J. Bartlein\textsuperscript{c}, A.-L. Daniau\textsuperscript{d}, J. Stevenson\textsuperscript{e}, K.C. Brownlie\textsuperscript{f}, S. Buckman\textsuperscript{f}, M. Cupper\textsuperscript{g}, J. Luly\textsuperscript{b}, M. Black\textsuperscript{d}, E. Colhoun\textsuperscript{d}, D. D’Costa\textsuperscript{j}, J. Dodson\textsuperscript{k}, S. Haberle\textsuperscript{e}, G.S. Hope\textsuperscript{e}, P. Kershaw\textsuperscript{l}, C. Kenyon\textsuperscript{m}, M. McKenzie\textsuperscript{l}, N. Williams\textsuperscript{n}

Quaternary Science Reviews 30 (2011) 28–46
Hovmöller diagrams are two-dimensional plots showing how the value of some attribute varies in space–time; one axis refers to time and the other to spatial location. They are particularly useful for displaying large amounts of data.

Hovmöller (1949 in *Tellus* 1, 2153–3490)
Hovmöller diagram by latitudinal order last 50ky
Late Quaternary fire regimes of Australasia

1. People and fire in Australia...
Impacts associated with
fire?

Sensitivity of the Australian Monsoon to insolation and vegetation:
Implications for human impact on continental moisture balance

Gifford Miller* Jennifer Mangan*
David Pollard* Stanley Thompson*
Benjamin Felzer* John Magee
Institute of Arctic and Alpine Research and Department of Geological Sciences, University of Colorado, Boulder, Colorado 80309, USA
National Center for Atmospheric Research, Boulder, Colorado 80305, USA
Department of Earth and Marine Sciences, Australian National University, Canberra, ACT 0200, Australia

ABSTRACT
General circulation model experiments test the geologically based correlation of high monsoon rainfall over interior Australia with Northern Hemisphere insolation and evaluate the sensitivity of the Australian Monsoon to ecosystem change. Our results suggest that Northern Hemisphere insolation control on the intensity of the Siberian High, rather than summer insolation over the Australian continent, determines the strength of the Australian Monsoon on millennial time scales, unlike a classic monsoon regime. Additional simulations show that the penetration of monsoon moisture into the interior is sensitive to biosphere-atmosphere feedbacks linked to vegetation type and soil properties. This sensitivity offers a resolution to the observed failure of the Australian Monsoon to penetrate the interior in the Holocene. Postulated regular burning practiced by early humans may have converted a tree-shrub-grassland mosaic across the semiarid zone to the modern desert scrub, thereby weakening biospheric feedbacks and resulting in long-term desertification of the continent.

Keywords: Australia, monsoon, human, paleoclimate, climate models, biomass burning.

Ideas about fire and people in Australia...

“We see this country in the pure State of Nature; the Industry of Man has had nothing to do with any part of it”

Captain Cook
Ideas about fire and people in Australia...

FIRE-STICK FARMING

By RHYS JONES
Research Fellow, Department of Prehistory, Australian National University, Canberra, A.C.T.

In recent years there has been increasing interest in the effect of man on the Australian environment. Forests have been bulldozed, swamps drained, heaths sown with trace elements, beaches chewed up, and the litter of the mid-twentieth century spread everywhere. That this is deeply affecting the countryside is obvious to all and causes concern to some. G. P. Marsh saw the same thing happening to the face of America during the last century, and doubtless the Roman intelligentsia of the rich provinces of North Africa gave the matter some thought as the wheatfields around their villas turned slowly into desert.

In most discussions a contrast is made between a “natural” environment as opposed to an “artificial” one. We imply that the former represents the climax without the effects of man, and as examples of it we think of bushland around our cities, the national parks, and remote areas. We imagine that the country seen by the first colonists before they ringbarked their first tree was “natural”. But was it?

Mannalargenna, an Aborigine from the east coast of Tasmania, holding a burning fire-stick. [Watercolour painting by T. Bock, in the National Library, Canberra.]
Portrays Aboriginal people as living in *socialised* landscapes (*cf.* *Terra nullius*).
Portrays fire as ubiquitous, frequent, low intensity, small, within a well-defined season. (And fuel loads are low.) (And vegetation is more open.)
Warra warra wai*

*the first words spoken to white explorers on the east coast of Australia by a Gwyegal/Gwygal man

*loosely translated as “bugger off”
2. Climate and fire in Australia...

Charcoal data are summarized using a lowess curve with a 400-year half-window width (black).
2. Climate and fire in Australia...
People and fire in Australia...
Burn-off theory up in smoke

The popular notion that Aborigines carried out widespread burning of the Australian landscape is a myth, research shows. Scientists have analysed charcoal results from more than 220 sites dating back 70,000 years.

Cold water is poured on Aboriginal burnoff culture

Deborah Smith
SCIENCE EDITOR

The popular notion that Aborigines carried out widespread burning of the Australian landscape is a myth, research shows.

A study of charcoal records has found that the arrival of the first Australians about 50,000 years ago did not result in significantly greater fire activity across the continent.

An international team of scientists led by Scott Mooney, of the University of NSW, analysed results from more than 220 sites in Australia dating back 70,000 years, the most comprehensive survey so far.

Dr Mooney said their findings challenged a widely held view that frequent use of fire by Aborigines had had a big impact on vegetation and the environment in prehistoric times. Instead, it was the arrival of European colonists more than 200 years ago that led to a substantial increase in fires, the study showed.

“We’ve put the firestick in the wrong hands,” Dr Mooney said. “The firestick shouldn’t be in Aboriginal people’s hands. It’s really a European thing.”

He said there were often calls after big, destructive bushfires for authorities to carry out Aboriginal-like burnoffs—frequent, low intensity fires—to manage the landscape and prevent further configurations. But this was not based on evidence. The new research showed that climate, not prehistoric people, had had the biggest impact on fire in Australia.

The message was that “we’re really going to have problems in the future”, he said, referring to rising global temperatures.

Australia has some of the most fire-prone landscapes on earth. To help determine the continent’s fire history, researchers have drilled core holes into old swamp sediments.

They then worked out the charcoal content in different layers, radiocarbon dating them to determine their age.

Dr Mooney and his team of 18 scientists analysed results from 223 sites in Australia, New Zealand, Papua New Guinea and some islands in the western Pacific. Their study, published in the journal Quaternary Science Reviews, shows that bushfire activity was high from about 70,000 to 28,000 years ago.

It decreased until about 18,000 years ago, around the time of the last glacial maximum, and then increased again, a pattern consistent with shifts between warm and cool climatic conditions.

“We found no evidence of a change in fire regimes at a continental scale at the time of Aboriginal colonisation,” Dr Mooney said. During the past 200 years, burning activity was “remarkably flat, except for the pronounced increase in fire in the past 200 years.”
Back to Sydney....

Kings Waterhole
Goochs Swamp
Lake Baraba
Comparison of Lake Baraba charcoal with regional archaeological data*

*Archaeological data from the NSW South Coast and hinterland (Attenbrow, 2004)
Comparison of Kings Waterhole Swamp charcoal with Upper Mangrove Creek archaeological sequences

A Comparison of Charcoal and Archaeological Information to Address the Influences on Holocene Fire Activity in the Sydney Basin

S. D. MOONEY, M. WEBB & Y. ATTENBROW, University of New South Wales, Australia; University of New South Wales, Australia; Australian Museum, Sydney, Australia


*Archaeological data from the Upper Mangrove Creek catchment, ~30 km away
What is the primary driver of past fire at a regional scale? Climate?
What is the primary driver of past fire at a regional scale? People?
What is the primary driver of past fire in eastern Australia? Climate and People!
Conclusions

- this work provides a long perspective on fire activity in the Sydney Basin (against a broader region);
- fire was variable through time and is driven by climate at continent-wide scales;
- Aboriginal fire is visible at a few sites… probably related to resources?
- Holocene fire activity in the Sydney Basin appears to result from an interplay of natural and anthropogenic forcing (=complicated!);
- the work demonstrates very large changes in fire in the post-European period (peaking in the C19th);
- the links between fire, humans and climate change suggest future increases in fire in our landscapes.
Acknowledgements

• The Global Palaeofire Working Group is *many* people…
  • [http://www.bridge.bris.ac.uk/projects/QUEST_IGBP_Global_Palaeofire_WG](http://www.bridge.bris.ac.uk/projects/QUEST_IGBP_Global_Palaeofire_WG)

• The Australian component of the GPWG is QUAVIDA was a working group of the ARC-NZ Network for Vegetation Function and in the UK, QUEST.
  • [http://www.bridge.bris.ac.uk/projects/quavida](http://www.bridge.bris.ac.uk/projects/quavida)

• The Australian Charcoal Database was an OZPACS project funded by the ARC Environmental Futures Network.

• Special thanks to **Sandy Harrison**, Janelle Stevenson, Patrick Bartlein, Val Attenbrow and Allan Williams for *diagrams, methods, discussion*…

• UNSW Faculty of Science for funding.
• NSW NPWS for permission to work in their reserves.
The tools: 3. sedimentary charcoal records
At the May 2007 NCC conference (*Bushfire in a heating world*) I presented...

Case studies of Holocene fire activity in the Sydney Basin: natural, anthropogenic or something much more complicated?

which described:

• fire activity was variable across space and time;

and concluded:

• broad generalisations about Aboriginal use of fire were premature;
  • depended on the prevailing climate, thresholds in population size and resources available at individual locations.
  • ‘fire stick farming’ may only be as old as current patterns of seasonality;

• fire was frequent in some places since the mid-to-late Holocene (last ~5,000 years).