Background briefings on emerging issues for fire managers from AFAC and Bushfire CRC.

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FIRE NOTE

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FIRE MANAGEMENT OF THE HIGH COUNTRY: A CRITICAL REVIEW OF THE SCIENCE

Recent experience in the use and management of the Australian high country, particularly in the light of the extensive 2003 and 2006 bushfires, suggests a clear need to examine the quality of the relevant science underpinning management policy and practice. To this end, and as opposed to many previous reviews of high-country science, this review of the science underpinning fire management in the high country of south eastern Australia has taken a quantitative approach similar to that used by Bennett and Adams (2004).

RESEARCH BACKGROUND

There has been a long history of research in the high country, as the region contains some of Australia's most important catchments and most valued ecosystems. Early work was initiated as a result of concern about erosion caused by burning and grazing (e.g. Carr and Turner 1959a, Costin 1954) and to improve management of the valuable forests contained within these catchments (e.g. Gilbert 1959, Grose 1957). Historically, research funding levels have varied and earlier research was often done by management agency based researchers who had wide organisational briefs.

Water and silviculture related research continued to be areas of importance through the 1980s, with interest expanding into stream flows (e.g. Brown 1972) and the use of fuel reduction burning (e.g. Kessel et al. 1982, Raison *et al.* 1985b).

During the 1970s and 1980s, fuel-reduction burning became widely accepted as an applicable management practice for reducing the risk of extensive bushfires to montane and alpine forests and woodlands. However, the high country contains a wider range of vegetation types (feldmark, herbfields, bogs, grasslands, heathlands, woodlands, open forests and closed forests) and it is axiomatic that if fuel reduction burning is to be used to reduce fire risks while maintaining other values, we need to understand how each vegetation type responds to fire. It is timely that a critical review of the science be undertaken with a view to identifying priorities for future research.

PEER REVIEW

The research detailed in this Fire Note will soon be submitted to a peer-reviewed journal. It will then be made available to all end users via the Bushfire CRC website.

ABOUT THIS FIRE NOTE

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This critical review of the scientific literature supporting fire management in the high country spans the 50 years before June 2005. It is an output of Bushfire CRC Program B5.1 HighFire: Ecosystem Processes.

SUMMARY

The HighFire project commissioned 'a critical review of the science underpinning fire management in the high country (montane, subalpine and alpine areas) of south-eastern Australia, with particular reference to fuel loads'. The review focuses on the Australian high country ecosystems and consists of two sections: a quantitative, critical evaluation of the science and a literature review of scientific output. This Fire Note presents a summary of the quantitative, critical evaluation. The review includes all research documents published before June 2005 relating to the effect of fire on vegetation in the Australian high country. The earliest work is published in 1954 (Costin, 1954) and the most recent in 2004 (Bennett and Adams, 2004).

Policies and practices of land management in the high country must be underpinned by sound science and quantitative data. Management of the high country is subject to policies that are often formed on the basis of past experience and limited scientific data. We must recognise that the science that underpinned many past decisions about land management was often of a lower standard and was less rigorous than would be internationally acceptable today.

The knowledge base of science must be continuously updated and improved to reflect advances in research techniques, methodologies and approaches. However, while the rigour of some scientific research in the high country has clearly improved, our overall evaluation is that most documents examined failed to reach current standards of scientific rigour.

Fewer than half the documents reviewed were published in peer-reviewed journals and of those that were published, most were in journals of 'lower impact' (see 'Definition of Terms' box). This situation often reflected the historic research commissioning agency's organisational priorities and resourcing levels.

In particular, experimental design needs to improve by including adequate replication of treatments, the use of 'control' or reference sites, and through the establishment of long-term studies to inform future generations.

The results of this review in no way undermine the value of past research but do provide a thorough understanding of the gaps in knowledge and highlight the need to establish on-going research to improve the evidence upon which management is based.

BUSHFIRE CRC RESEARCH

The scope of the review is the high country of south-eastern Australia, including all land above 750 metres in elevation and all major vegetation types from feldmark to cool-temperate rainforests. A thorough literature search was undertaken to include documents published before June 2005, resulting in a total of 477 documents. These were classified according to type of manuscript, region studied and type of research. They were assessed in relation to experimental design, use of control and reference sites, and the validity of conclusions. While the review includes a range of document types (such as journal articles, conference proceedings, book chapters, books and reports), the quantitative analysis focuses primarily on peer-reviewed journal articles that present the results of original research.

RESEARCH OUTCOMES

STATISTICS ON ALL DOCUMENTS EVALUATED (477 IN TOTAL)

- Majority (71%) are based on woodland and forested communities.
- 33% (157) are research documents investigating vegetation types in the high country.
- A disproportionately high number of review articles (70) have been produced from 157 research documents.
- Only 58% (275) are journal articles.
- Only 41% (195) are peer-reviewed journal articles.
- Only 71% (339) of journal articles are peer-reviewed.

STATISTICS ON 'RESEARCH DOCUMENTS' ONLY (FIRE AND RELATED RESEARCH)

- 39% (187) of all documents are research documents (fire and related).
- 67% are focused on nutrients, vegetation dynamics and erosion.
- 69% (129) are published in journals.

DEFINITION: IMPACT FACTOR

Developed almost 50 years ago, the impact factor is an index used to assess the prestige of journals. Used in conjunction with other factors such as peer review, productivity, and the citation rates within specific subject areas it is a widely used tool for estimating the 'quality' of journals and hence the articles published. It is calculated annually as a ratio between citations and recent citable items published and hence accounts for some of the major inherent bias. It has been widely used in market research for publishers and others and more recently used in the process of academic evaluation.

The range and medium value of Impact factors vary considerably among broad subject areas and therefore it is difficult to compare journals from different subject areas. Within subject areas, impact factors range considerably (currently from zero to 69) and journals are loosely classified as having high or low impact factor.

- 58% (108) are published in peer-reviewed journals.
- 36% (67) are published in international, peer-reviewed journals.
- One-third are published in journals without an impact factor (see **Definition: Impact Factor** above).
- 67% are published in journals that have a low impact factor (less than 1.5 (See Figure 1, next page)).
- Of the 178 research documents on Australian high country ecosystems:
  - 37% are based on Tasmania's high country. However, one quarter of these are focused on rainforest at low altitudes (<750m).
  - 27% are on high country ecosystems in NSW.
  - 22% are on high country ecosystems in Victoria.
  - 14% are on high country ecosystems in the ACT.
- The experimental design of the majority of research papers is considered poor by today's standards with:
  - Only half including replicated treatments.
  - One-third lacked any treatment replication.
  - The remaining 20% provided insufficient information on experimental design.
- The proportion of papers with good experimental design, including adequate treatment replication, improved over the decades since the mid 1900s. However, it should be noted that research done in the 1960s by Costin and co-workers stands out as being well designed, and included good treatment replication.
- Only 11% had a clear hypothesis, 63% only presented general aims and 26% had no clear statement of purpose.
- 45% used no statistical analysis.
- Only one-third (32%) of documents presented valid conclusions, whereas, half (49.5%) of all research documents presented conclusions that were not justified by experimental designs and data, 5% provided insufficient information to judge the validity of conclusions, and 13.5% presented no clear conclusions at all (Figure 3, next page).

FIRE-RELATED RESEARCH DOCUMENTS (86 DOCUMENTS)

- Only 5% had a clear hypothesis.
- Half used no statistical analysis.

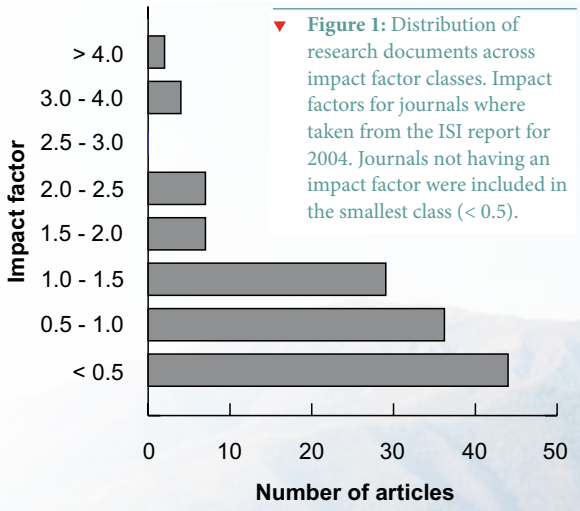

Figure 1: Distribution of research documents across impact factor classes. Impact factors for journals where taken from the ISI report for 2004. Journals not having an impact factor were included in the smallest class (< 0.5).

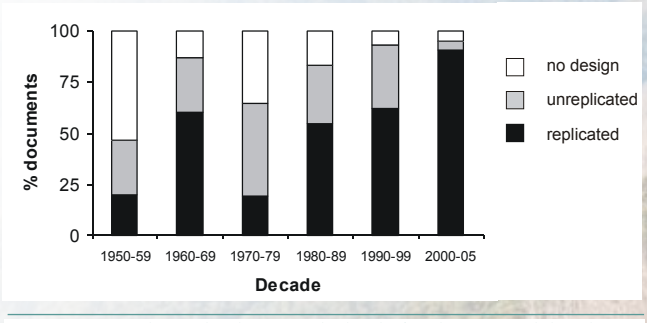

Figure 2: Relationship between the level of replication and decade of publication for documents presenting research on High Country vegetation. See methods for explanation of replication levels.

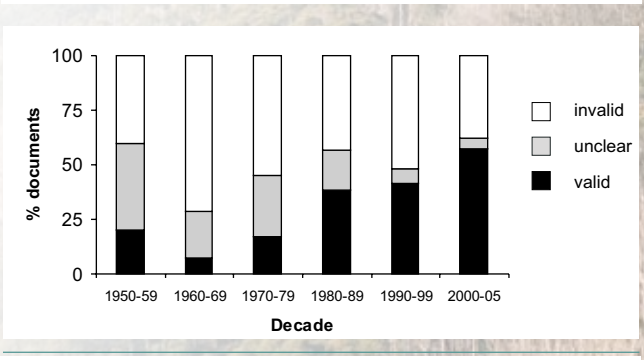

Figure 3: Relationship between validity of conclusions and decade of publication for documents presenting research on high country vegetation. Conclusions were considered valid when treatments were replicated and did not extend beyond the limitations of the data.

- Of the 86 documents that specifically focus on fire, the majority (63%) focus on management fires, 22% on wildfire and 20% do not specify the origin of fire.
- One-third included pre-fire data and only 6 have used BACI (Before / After Control Impact) experimental designs to compare pre-fire data to that of the recovering ecosystem and control sites. While there are limitations to establishing BACI experimental designs (particularly given the ad hoc nature of bushfires), they are nonetheless important as they enable significantly stronger conclusions to be made.
- About half (42) were completed within a six-month period, and about three quarters (60) within one to five years. Three studies have continued for between 26 and 50 years. However, the longest running among them, the vegetation/grazing study established by Maisie Carr (nee Fawcett) on the Bogong High Plains in 1947, lacks a robust experimental design as neither the vegetation type nor grazing treatment is replicated and the ungrazed areas were enclosed either five or seven years after the 1939 fires.

MODELLING HIGH COUNTRY ECOSYSTEMS

- 15 documents present models, only two of which were based on replicated data. Instead, models used data from a single site, did not replicate site ages, or did not supply any details of the data used.

CHRONOSEQUENCE STUDIES

Chronosequence studies (space for time) can provide a guide to long-term changes after fire. However, they make unrealistic assumptions that limit their value. Less than 20 fire-related research documents are based on chronosequence studies but the results form the basis of many of the models developed to explain the response of high country vegetation to fire.

APPLYING THIS RESEARCH

The existence of the Bushfire CRC signifies the industry-wide recognition for the need to increase the industry's research capacity to provide evidence required to support management decisions. This has become increasingly important given the threat of litigation in the aftermath of incidents that can and do result in loss of life and property. The recent devastating Victorian fire season is testament to the risks we face.

Paramount in developing policies and practical guidelines is the appropriate use of scientific evidence that considers the quality of the science and hence of the evidence provided. The use of scientific evidence must be tempered by a thorough understanding of the limitations of the evidence available. In particular, critical review of science provides the means to:

- identify limitations of scientific evidence and therefore use it appropriately
- identify major gaps in our knowledge and inform priorities for future research
- establish useful guidelines for strong experimental design for future research
- avoid making decisions based on weak, inconclusive science.

This critical review, currently in preparation for submission to a peer-reviewed journal, will be made available to all end users via the Bushfire CRC website.

FUTURE DIRECTIONS

Based on this review, we suggest the following design standards should be followed in future work.

1. REPLICATION OF TREATMENTS

Future experiments should be properly replicated. Two replicates (at the treatment level) is the statistical minimum but three would be more generally considered as the acceptable minimum.

2. PRE- AND POST-FIRE DATA

BACI designs are clearly preferable to the opportunistic studies that are the more common approach when researching unplanned fires. Nevertheless, the latter can bring substantial benefits provided that available pre-fire data are included in the analysis. Descriptive studies of the changes in a site after wildfire are of strictly limited predictive or mechanistic value, owing to the variation in intensity, rate of spread, extent and season among fires, as well as variation in post-fire conditions.

3. ADEQUATE CONTROLS

Any study of fire should include sites of comparable vegetation that remain unburnt. This is essential in order to directly compare the effects of burning with fire exclusion.

4. LONG-TERM STUDIES

Although chronosequence (space-for-time) studies are informative, their limitations are well known. Particular difficulties in Australia are the relatively small areas of high country vegetation and the pronounced spatial heterogeneity in geology, soils and microclimates, and thus vegetation. Long-term *in situ* studies are thus essential. Research sites should be monitored at least until the ecosystem has returned to its pre-fire condition.

A greater knowledge of the impacts of successive fire regimes (planned and unplanned fires) on selected ecosystems would clearly be desirable.

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AFAC is the peak representative body for fire, emergency services and land management agencies in the Australasia region. It was established in 1993 and has 26 full and 10 affiliate members.