ABSTRACTS

Landscape Fires Conference

Perth, Western Australia
September 27 - 29, 1993

Sponsored by:

Department of Conservation and Land Management
Bushfires Board of W.A.

LANDSCAPE FIRES '93

Australian Bushfire Conference

September 27, 28 & 29th 1993

Department of Conservation and Land Management Training Centre,
50 Hayman Rd, Perth, W.A.

Sponsored by the Department of Conservation and Land Management and the Bush Fires Board of Western Australia

CONFERENCE PROGRAM

Monday September 27

0745 am Registration commences at the Training Centre, Como

0845 Introduction and welcome

0900 Opening address - Mr Roger Underwood, General Manager CALM

Session 1: Fire Danger Rating and Fire Behaviour
(Moderator - Neil Burrows)

0930 Integrating fire spread prediction and fire danger rating
Phil Cheney and Jim Gould

1000 The orchestra grows - two new fire models
David Packham

1030 Morning tea

1100 Time dependence of temperature above wildland fires
Rod Weber, Peter Lyons, Geoff Mercer and Malcolm Gill

1130 The second generation United States Forest Service fire behaviour model
Wendy Catchpole

1200 Fire modelling and fire weather in an Australian desert
Malcolm Gill, Neil Burrows and Ross Bradstock

1230 Fire behavior studies in Western Australian mallee-heath
Lachlan McCaw

1300 -1400 Lunch

Session 2: Fire Measurements for Fire Ecology Studies
(Moderator - Malcolm Gill)

1400 Fire from a plant, animal and soil perspective
Kevin Tolhurst

1430 Predicting acute impacts of fire in jarrah forests for ecological studies
Neil Burrows

1500 Measurement and effects of fire heterogeneity in southwest Australian wheatbelt vegetation
Lyn Atkins and Richard Hobbs

1530 Afternoon tea

1600 Fire measurement and fire effects in tropical savannas of the Kakadu region, Northern Territory
Dick Williams

1630 Bushfire mensuration for ecology
Peter Moore and Malcolm Gill

1700 Close

Tuesday September 28

0845 am Commence

Session 3: Bushfires and the urban/rural interface
(Moderator - Peter Mew)

0900 Using technology to facilitate community preparedness
Michael Whelan

0930 Rural fire management on Canberra's urban interface
Rick McRae

1000 Towards an integrated model for designing for building survival in bushfires
Caird Ramsay, Neville McArthur and Lisle Rudolph

1030 Morning tea

1100 Fire and conservation at the urban interface: resolution of the irreconcilable?
Ross Bradstock and Judy Scott

1130 Fire protection and the urban/rural interface
Geraint Lenegan

1200 The human side of living with the bushfire threat
Andrew Wilson

1230 - 1330 Lunch

Session 4: Bushfire emissions
(Moderator - Kevin Tolhurst)

1330 Atmospheric trace gas emissions from tropical Australian savanna fires
Garry Cook, Dale Hurst and David Griffith

1400 A scheduling approach to smoke management
Martin Crevatin and Chris Trevitt

1430 Mathematical issues in modelling bushfire emissions and their transport
Tony Jakeman

1500 Afternoon tea

1530 Emissions of photochemical smog precursors from bushfires
Peter Rye

1600 Smoke management of forest burns in Western Australia
Rick Sneeuwjagt

1630 Close

Wednesday September 29

0845 am Commence

Session 5: Fire-Plant-Animal interactions
(Moderator - Ross Bradstock)

0900 Responses of plant populations to fire: herbivory and fire season as two under-studied elements of fire regime
Robert Whelan and Ian Tait

0930 Interdependence of woody plants, higher fungi and small marsupials in the context of fire
Byron Lamont

1000 Morning tea

1030 Burning Grevilleas, ants, rats and wallabies
Tony Auld

1100	Post-fire response patterns of invertebrates - are they predictable? Gordon Friend
1130	Responses of birds and reptiles to fire and increasing time after fire in *Banksia* woodland north of Perth, W.A. Mike Bamford
1200 -1300	Lunch

Session 6: Fire-induced landscape mosaics
(Moderator - Gordon Friend)

1300	Fires, vegetation heterogeneity and small vertebrates in hummock grasslands David Pearson
1330	Fire-induced mosaics of natural plant communities on oligotrophic substrates in perhumid environments, Western Tasmania Dr Frank Podger
1400	On the importance of habitat heterogeneity in tropical savanna and its maintenance by anthropogenic means Dick Braithwaite
1430	Fire management in habitat islands - risks and impacts from a fauna perspective Brian Gepp (Presented by John Pratt)
1500	Afternoon tea
1530	Mosaics in Sydney heathlands - the role of fire, competition and soils David Keith
1600	Closing Address - Dr Syd Shea, Executive Director, CALM
1630	Close of Conference

Posters

Monday September 27

A simple test fire exercise for fire behaviour training
Grant Pearce and Martin Alexander

A time dependent model of fire impact on fruits
Geoff Mercer, Malcolm Gill and Rod Weber

Fuel modelling and fire behaviour in buttongrass moorlands
John Marsden-Smedley and Tim Rudman

Nitrogen budgets in regrowth karri following thinning and fuel reduction burning
Tony O'Connell and Lachlan McCaw

A climatology of *very high* and *extreme* fire weather days in southern Western Australian
A.J. Bannister and B.N. Hanstrum

Tuesday September 28

Fire in the human ecosystem - a question map
Dave Ward

Fire history mapping of remnant urban bushland near Perth, W.A.
Patrick Piggott, Bill Loneragan and David Bell

Planning for fire management in a near-urban national park
Jim Williamson, Peter Keppel and Jaqueline Pontre

Wednesday September 29

Patterns of resprouting of eucalypts after fire
Jann Williams and Malcolm Gill

Pre-european fire history of North American tallgrass prairie
Thomas Bragg

Fire frequency and floristic variation in dry schlerophyll communities
Geoff Cary

Modelling for impact of fire on the population dynamics of the splendid fairy wren
Mike Brooker

Influence of herbivores on the vegetation and fire fuels of the Perup Forest region of Western Australia
Kelly Shepherd, Grant Wardell Johnson, Bill Loneragan and David Bell

Influence of fire on the seed germination ecology of species of the jarrah forest
David Bell

INTEGRATING FIRE SPREAD PREDICTION AND FIRE DANGER RATING

N.P. Cheney and J.S. Gould

CSIRO, Division of Forestry
PO Box 4008, Queen Victoria Terrace
Canberra, ACT, 2600

Australian fire danger rating systems have been developed by relating fire danger directly to predictions of fire spread.

New equations to predict fire-spread in grasslands show that fire spreads faster at Moderate to Very High fire danger than were previously predicted by either the McArthur Mk IV or Mk V Grassland Fire Danger rating systems. Preliminary data suggest that revised fire spread equations for dry forests will give similar results when compared with Forest Fire Danger Rating systems. If the prior relationships between fire danger and rate of spread are retained, fire weather warnings and total bans will be introduced under milder weather conditions than they have in the past.

Most fire authorities are satisfied with the existing fire danger rating systems for public warning and setting preparedness levels. This suggests that the original fire danger classes adequately represented difficulty for control for broad planning purposes; that fire authorities had little appreciation of actual spread rates, and; that rate of spread was rarely used for planning suppression tactics.

It is recommended that the original fire danger classes be retained and the fire weather conditions that they represent be computed separately from predictions of rate of spread. In most states the fire danger index as calculated by McArthur Grassland Fire Danger Meter Mk IV will provide a satisfactory system for public warning on a regional basis.

New fire spread equations should be used to predict fire behaviour for specific fuel types within a local area. A broad measure of suppression difficulty is needed. This measure would combine rate of spread with fuel variables such as fuel load, spotting potential etc, to better characterise the suppression task in different fuel types.

THE ORCHESTRA GROWS - TWO NEW FIRE MODELS.

David Packham

Severe Weather Section, Bureau of Meteorology
GPO Box 1289K, Melbourne, VIC, 3001

Fire models will never be complete predictors of fire spread, fire behaviour or danger. The systems to be modelled are far to complex for resolution. Nevertheless fire models are important and there is a need for a suite, ensemble or orchestra of models which the fire manager and the community will use to meet their particular needs.

This paper will mention two new models still in their development stages that will assist in fire and environmental management. The first is a "synoptic" model due to Krusel to assist in forecasting possible "fire activity" in Mallee and dry sclerophyll forest areas.

The second is totally different in character and is an attempt to model meso-scale meteorological parameters and treats fire on an input to the fundamental numerical equations. The model was developed by Clarke *et al.* at the National Centre for Atmospheric Research, Colorado.

A meso-scale meteorological model is capable of predicting meso-scale meteorology: it also shows promise of predicting fire spread at the high end of the scale.

TIME DEPENDENCE OF TEMPERATURE ABOVE WILDLAND FIRES

R. O. Weber[1], P. R. A. Lyons[1], G. N. Mercer[1] and A. M. Gill[2]

[1] *Department of Mathematics, University College, UNSW, Australian Defence Force Academy, Canberra ACT 2601*

[2] *CSIRO Division of Plant Industry GPO Box 1600, Canberra ACT 2601*

A statistical description is presented for the time dependence of temperatures at various heights above a moving wildland fire. The model was developed using non-linear least-squares curve fitting on experimental data from fires in shrubby fuels as is based on classical theory with empirical modifications (where necessary) to suit the fuel types being studied. Relative to a stationary observation point which is overtaken by a spreading fire, the temperature-time history can be partitioned into two distinct regions:

(i) As the fire approaches the rapid temperature rise above ambient is modelled by a Gaussian curve, having only one free parameter b to describe its steepness. Maximum temperature rise generally occurs within 60 seconds.

(ii) As the fire recedes the temperature falls comparatively slowly, with the fastest rate determined by simple Newtonian cooling (again described by one free parameter, g). In practice the residual burning in larger components of the fuel bed frequently results in a long (tail) so that g becomes an "effective" value.

Fire effects upon vegetation are discussed by comparing lethal exposure experiments in the laboratory with wildland fire temperature-time curves.

THE SECOND GENERATION UNITED STATES FOREST SERVICE FIRE BEHAVIOUR MODEL.

Dr Wendy Catchpole

Department of Mathematics University College, UNSW,
Australian Defence Force Academy, Canberra ACT 2601

A comprehensive series of laboratory fires are being burned in the wind tunnel at the Intermountain Fire Sciences Laboratory in Missoula, MT. Together with field data from experimental and wildfires, information from these fires will be used to formulate and test the U.S. Forest Services second generation fire behaviour model which is currently being developed.

The fuels used in the laboratory fires are excelsior (wood shavings), pine needles, and 6mm diameter sticks. Most fires are homogenous fuel beds, but a series of fires have been burned in mixed excelsior and sticks, to compare fire behaviour in mixed fuel with behaviour in the component fuels.

In conjunction with Dick Rothermel of the U.S. Forest Service, Ted Catchpole and I are developing a firespread model based on radiative and convective heat transfer from the flame to the unburned fuel. Each fire is instrumented with thermocouples, pitot tubes and radiometers to measure the factors influencing fire behaviour. Currently the model appears to predict fire spread well if these factors are known. In order to construct a predictive model it remains to model these factors in terms of fuel and environmental factors that can be measured just prior to a hazard reduction burn or wildfire.

I will talk about progress on the model to date, the experimental results obtained so far, and about preliminary attempts to test current flame structure models which are needed to describe the heat source.

FIRE MODELLING AND FIRE WEATHER IN AN AUSTRALIAN DESERT.

A.M. Gill[1], N.D. Burrows[2] and R.A. Bradstock[3]

[1] CSIRO, Div of Plant Industry
GPO Box 1600, Canberra, ACT, 2601.

[2] WA Dept. of Conservation and Land Management
50 Hayman Rd, Como, W.A, 6152

[3] NSW National Parks and Wildlife Service
PO Box 1967, Hurstville, NSW, 2220

Hummock grasses form a discrete fuel for landscape fires in the vast arid and semi-arid regions of Australia. Fore fires to spread in such discrete fuels, the flames need to be long enough to cross gaps, under sufficient wind to have large tilt angles, and impinge on the next hummock long enough to ignite it. Wind speed, discrete-fuel loadings, fuel moisture contents and gap-size distributions are key characteristics for fire-spread modelling in these fuels. Present models derived in the arid region do not have universal application.

Once a model is formed, formal prediction of fire spread requires a three stage process:

i. a domain analysis for the applicability of the inputs to the fire-spread model;
ii. a likelihood-of-any-spread analysis; and,
iii. application of spread model to predict rate of spread of the headfire.

That directs inputs, such as fuel moisture, are not available for models on a routine basis creates problems of prediction. With each extra step in the estimation of inputs, further errors in spread prediction are likely to arise.

T_f = temp fuel
H_f = Humidity fuel

$$T_f = T_a + \frac{1}{0.015\,U + 0.026}$$

$$H_f = H_a \left[e^{-0.033\,(T_f - T_a)} \right]$$

$$m = f(T_f\ H_f)$$

Byram & Jemison 1943

	T °C	RH %	Wind
Burrows et al	19-50	14-48	4-36

FIRE BEHAVIOUR STUDIES IN WESTERN AUSTRALIAN MALLEE-HEATH :

Lachlan McCaw

Department of Conservation and Land Management
Science and Information Division
Manjimup, W.A. 6258

The ability to reliably predict the likelihood of fire spread, and the subsequent rate of spread and intensity of a fire are important elements in the safe and effective application of prescribed fire in mallee-heath communities. Fires in mallee-heath are prone to sudden and violent changes in behaviour, a phenomenon shared with discontinuous shrublands elsewhere in Australia and overseas. A program of experimental burning in *Eucalyptus tetragona* mallee-heath at the Stirling Range National Park has demonstrated that litter moisture contents below 8 percent appear critical to sustained fire spread. Air temperature, relative humidity and other indices of fuel dryness did not satisfactorily discriminate between failed and successful ignitions. The forward rate of spread of fires which met the fuel dryness threshold was strongly related to wind speed.

Fire spread predictions from models developed for other shrub fuel types consistently underpredicted the rate of spread in mallee-heath and did not discriminate those fires which failed to spread. This suggests that in mallee-heath and similar discontinuous fuels, prediction of the probability of fire spread should be separated from prediction of subsequent spread rate. Simple but reliable methods for estimating the moisture content of the shallow litter layer in mallee-heath are required for prediction of fire behaviour in the field situation.

FIRE FROM A PLANT, ANIMAL AND SOIL PERSPECTIVE

Kevin G. Tolhurst

Forest Research, Department of Conservation and Natural Resources
Creswick, Vic, 3363

The two main areas of interest in landscape fires are the protection of human life and property and the ecological effects of fire regimes. The protection of human life and property involves the provision of adequate fire prevention and suppression strategies and requires an understanding of aspects of fire behaviour such as rate of spread, flame height and fire intensity. However, an understanding of the ecological effects of fire is as complex as the different ecological systems themselves. In this paper I will address the issue of characterising fires in a way that will enable forest managers to predict the likely effects of a fire on a forest community under different environmental conditions.

Two methods of measuring the sensible heat output from different fires, the billy calorimeter and the heat sensitive plate are presented. Sensible heat is defined as the integration of heat in the forms of radiation, convection and conduction resulting from a fire and the environmental conditions at the time of the fire. The fire behaviour and climatic factors affecting the sensible heat flux measured are explored. Measures of sensible heat are used to correlate the effects of fire on tree boles, soil chemistry and soil invertebrates. The usefulness of these measures as measures of the ecological effects of fire are discussed.

It is concluded that sensible heat output from a fire is a key criterion for determining the effect of individual fires on plants, animals and soils.

PREDICTING ACUTE IMPACTS OF FIRE IN JARRAH FORESTS FOR ECOLOGICAL STUDIES

N. D. Burrows

Department of Conservation and Land Management
Science and Information Division
50 Hayman Road, Como 6152 W.A.

Bushfires are commonly described in terms such as rate of spread, flame dimensions or Byram's intensity, which reflect suppression difficulty or general damage potential. Meaningful descriptions of bushfires for interpreting ecological effects are those which reflect the amount and rate of heat energy released and its distribution These factors determine the immediate physical or acute impacts of fire which give rise to ecological effects.

The acute impacts of fire in jarrah forest can be studied and predictive models developed by;

(i) stratifying the area within and around the flames (impact zones);
(ii) identifying the physical impacts within these zones;
(iii) identifying readily measurable descriptions of the amount and rate of heat energy release;
(iv) identifying factors affecting the transfer of heat to plant tissue and the soil;
(v) experimenting to determining functional relationships between physical impacts, readily measurable fire descriptions and factors affecting heat transfer.

MEASUREMENT AND EFFECTS OF FIRE HETEROGENEITY IN SOUTHWEST AUSTRALIAN WHEATBELT VEGETATION

Lyn Atkins and Richard J. Hobbs

CSIRO, Division of Wildlife & Ecology
LMB 4, PO Midland, WA 6056

Shrub vegetation in the Western Australian wheatbelt is vary spatially heterogeneous, with variation in structure, floristics and litter cover. Using thermocolor pyrometers and thermocouples, we show that this vegetation heterogeneity translates into heterogeneity in fire fuel configurations which result in marked variability of fire treatment within individual fires. Vegetation heterogeneity combines with variations in wind speed to produce variation in fire severity at broad and fine scales. Temperatures can vary greatly in the canopy and at and under the soil surface over very short distances and between different species. Variation in litter cover also affects temperatures reached, and we show that this results in variation in the post-fire establishment of seedlings. Fire heterogeneity may be an important factor contributing to the coexistence of shrub species in species rich heath communities. We argue that some measures of fire heterogeneity needs to be incorporated into fire studies.

FIRE MEASUREMENT AND FIRE EFFECTS IN TROPICAL SAVANNAS OF THE KAKADU REGION, NORTHERN TERRITORY.

R.J. Williams

CSIRO, Division of Wildlife and Ecology
PMB 44, Winnellie, NT, 0821.

Frequent fire is a feature of the tropical savanna forests and woodlands of the Kakadu region of the Northern Territory. In a landscape-scale fire experiment at Kapalga Research Station in Kakadu, fires have been lit experimentally in catchments 15-20 km^2 in area, both early in the dry season (June) and late in the dry season (September) between 1990 and 1993. In *Eucalyptus miniata* - *E. tetrodonta* forest the mean intensity of early dry season fires (3700 kW m^{-1}) was less than that of the late dry season fires (7700 kW m^{-1}), although there was considerable spatial and yearly variation. In 1991/2 both tree canopy cover and tree mortality were least in plots burnt late in the dry season and greatest in the unburnt plots. Season of burn (unburnt, early or late dry season burn) was not a statistically significant predictor of tree mortality; fire intensity (fitted as a covariate) explained the majority of the variation in tree mortality. Season of burn is not a precise estimator of fire intensity in tropical savannas. Measurement of fire intensity, which can be used as a co-variate in experimental fire-effects studies, is therefore a vital component of fire experiments where season of burn is a factor within the design.

BUSHFIRE MENSURATION FOR ECOLOGY

P. H. R. Moore & A. M. Gill

CSIRO Division of Plant Industry
GPO Box 1600, Canberra ACT 2601

The main fire input to models concerned with the ecological impact of fires on biota or soils is temperature, either as a critical instantaneous value or as a time sequence. An instrumented system for measuring temperature-time curves in fires is described. Based on shielded mineral insulated thermocouples and a datalogger, it has been proven to be effective, rugged, reliable and portable in a wide range of vegetation types. This system is relatively expensive. To obtain more extensive coverage of fires, less expensively, and also measure rates of spread of fires, a "temperature-residence-time meter" (TRTM) has been developed. This meter records the time that temperatures persist over a chosen value. By analysing 106 temperature-time curves from near ground level during fires in woodlands and forests at Kakadu National Park, we have found that the duration of chosen high temperatures were statistically intercorrelated ($r > 0.82$) but that the times to peak temperatures from 60°C (a measure of flame residence time) were poorly correlated with these duration's ($r > 0.40$). Selected biological attributes may be measured *post hoc* as a guide to variations in fire properties within and between fires.

USING TECHNOLOGY TO FACILITATE COMMUNITY PREPAREDNESS

Michael Whelan

Country Fire Authority, PO Box 71
Mt Waverly, Victoria, 3149

Fire authorities constantly strive to improve their capacity to control bushfires, using the results of inquiries and research. Significant gains have been achieved in strike power and organisation have been achieved following major bushfires. Despite this however significant life and property loss are still likely in major bushfires in the urban interface.

This paper considers the public warning and importance of providing knowledge of the bushfire phenomena and real time information on the immediate fire threat. It reviews a new CFA project, Community Fireguard, which targets people in high fire hazard areas with a view to getting them to accept responsibility for their own bushfire safety. The CFA's technological thrust using sophisticated computer technology is also considered in the context of being better able to provide real time fire spread information to the threatened public.

RURAL FIRE MANAGEMENT ON CANBERRA'S URBAN INTERFACE

R.H.D. McRae

Fire Management Officer, Rural Fire Service
PO Box 3587, Manuka, ACT, 2603

An approach to using data on man-made ignition patterns, as part of an overall system for rural fire hazard management, is presented. The area being managed is divided into blocks with a relatively uniform land-use pattern. A predictive model relates expected number of ignitions per square kilometre per annum to distance from suburbs and principal land use.

The behaviour of ignition rates between land use types is of interest. Canberra Nature Park, industrial lands, commercial sites and pine plantations all have high values close to suburbs. C.N.P. and commercial sites have high decay rates. Rural lands have consistent, low values.

The implications of this are discussed. A rural/urban interface transition zone can be defined using the model. The model allows improved liaison with planning authorities and land managers. It also allows better meeting of standards of fire response.

TOWARDS AN INTEGRATED MODEL FOR DESIGNING FOR BUILDING SURVIVAL IN BUSHFIRES

G. Caird Ramsay[1], N. A. McArthur[1] and L. Rudolph[2]

[1] *CSIRO Division of Building, Construction and Engineering*
PO Box 56, Highett, Victoria 3190

[2] *The University of Melbourne*
Parkville, Victoria 3052

To date there has been generally two approaches to mitigating building destruction. One approach has been to manage the vegetation (the 'landscape approach') whereas the other has been to select building materials and designs to minimise the effect of the bushfire attack (the 'building approach'). There is a need to integrate these two approaches and this paper suggests that it can be done on the basis of agents by which bushfires ignite, damage and destroy buildings, vis. burning debris, radiant heat, flame and wind.

A model to integrate these approaches might have three components. The first component is the potential bushfire attack, based upon the properties of the vegetation producing that attack. The second component is the modification of the attack by the environmental conditions and the landscape; this provides the opportunity to use the 'landscape approach'. The third component is the reaction of the building materials and design to the (modified) bushfire attack; this provides for the 'building approach'.

This paper describes the benefits of such an integrated model, briefly discusses the current state of knowledge with regard to the components and the research that is needed to realise a quantitative model.

FIRE AND CONSERVATION AT THE URBAN INTERFACE: RESOLUTION OF THE IRRECONCILABLE?

Ross Bradstock & Judy Scott

New South Wales National Parks & Wildlife Service
Box 1967, Hurstville 2220

Conflicts between human protection and conservation cannot be resolved without thorough understanding of each objective. Prescribed fire for fuel reduction remains the chief method for protecting humans from wildfire along the extensive interface between suburbia and conservation reserves in the Sydney region. Despite major development in fire-planning, community debate and potential conflicts with conservation objectives still hinge on the frequency and extent of hazard reducing burning.

Analyses are presented, which quantify the degree of protection provided by hazard reduction at the interface. The approach provides insight into the minimum frequency and extent of prescribed fires, necessary to provide protection and maximise conservation options for bushland in the Sydney Region.

FIRE PROTECTION AND THE URBAN/RURAL INTERFACE
"CONSTRAINTS OR OPPORTUNITIES"

Geraint Lenegan

Manager Fire Safety, Bush Fires Board of W.A.
201 Kent Street, South Perth WA 6051

Fire protection and safety of the urban/rural interface throughout Australia has resulted in a wealth of research and findings that focus on the technical aspects of standards, specifications, planning processes, environmental considerations and fire suppression.

Internationally the same aspects have been analysed, researched and documented however there is little reference made to the other relevant and just as profound elements that are an integral aspect of ensuring fire protection of the urban/rural interface.

This discussion paper sets out to highlight these other elements of Social, Funding and Education and attempts to analyse them in relation to the normally accepted processes utilised in bringing into place urban/rural interface fire safety.

It is the author's intention that greater awareness of these frequently overlooked elements will result in a more determined effort by developers, planners, State and Local Authorities, fire agencies, land managers and other stakeholders to address and incorporate these in the urban/rural interface planning, development and maintenance cycles.

THE HUMAN SIDE OF LIVING WITH THE BUSHFIRE THREAT

Andrew A.G. Wilson

Department of Conservation and Natural Resources Victoria, PO Box 41, East Melbourne, Victoria, 3002.

The expectations of fire managers about the preparations and emergency responses of people to bushfires are discussed in the context of the numerous pressures and options of living in the 1990's. People may be expected to make decisions and take actions according to their individual circumstances, and may take much more into account than just the threat of fire. Fire managers need to develop strategies that are based on greater social insight. the literature on disaster sociology should be investigated and any relevant lessons should be applied.

ATMOSPHERIC TRACE GAS EMISSIONS FROM TROPICAL AUSTRALIAN SAVANNA FIRES.

Garry Cook[1], Dale Hurst[2] and David Griffith[2]

[1] *CSIRO Tropical Ecosystems Research Centre*
PMB 44 Winnellie, NT 0821

[2]*Dept. of Chemistry*
University of Wollongong, NSW 2522

Burning of savannas in northern Australia accounts for 60-80% of all biomass burning in Australia, but the role of these fires in atmospheric chemistry remains poorly quantified. The fuel of these fires is normally grass and leaf litter, with a high fuel consumption. Annual fires of relatively low intensity are common and crown fires are rare. In this paper the results are presented of measurements of the prompt release of trace gases from savanna fires at Kapalga, NT. The emission ratio of carbon species from the Kapalga fires were similar to those measured elsewhere in the world. The effects of possible fire management options on the trace gas emissions were investigated by simple modelling of the dynamics of fuel loads and fire intensities. Reducing the fire frequency from annual to once every three years would increase the likelihood of fire intensities being sufficiently high to reduce the tree cover. The consequent reduction in the size of the C and N pools in the woody fraction would result in a net release of carbon and nitrogen into the atmosphere. The release of trace gases in the absence of fires needs to be quantified to enable more complete modelling of the effects of management of trace gas emission from these savannas.

A SCHEDULING APPROACH TO SMOKE MANAGEMENT

M.A. Crevatin[1] and A.C.F. Trevitt[2]

[1] *Department of Primary Industry, Forest Service*
GPO Box 944, Brisbane, Qld, 4001

[2] *School of Resource and Environmental Management*
Australian National University, Canberra, ACT 0200

Smoke, produced by prescribed burning activities, and the management of it has become an increasingly important issue in metropolitan regions of Australia. Two broad strategies can be employed in smoke management, either in isolation or in combination to varying degrees. These strategies are: first, scheduling of burning operations to coincide with days during which atmospheric ventilation is adequate for effective dispersal and transportation of smoke; and second, emission source strength management where ignition and burning techniques are combined with fuel and meteorological conditions to increase fuel combustion efficiency and hence reduce smoke production (emission) rates. Due to high research inputs required for the second strategy it is probable that any immediate smoke management activity in Australia will employ the scheduling strategy.

Some meteorological conditions required for prescribed burning and effective smoke dispersion and transportation can be seen to be incompatible, for example wind speed. A method is described which indicates the technical feasibility of scheduling for meteorological conditions which are conducive to both safe and effective prescribed burning as well as effective smoke dispersion and transportation. A prerequisite of this method is the existence of a database of surface meteorological parameters suitable for climatological analysis.

The method involves the parameterisation of "windows of opportunity" for both prescribed burning and smoke dispersion and transportation. Data requirements are restricted to readily available and measurable surface meteorological parameters. Construction of chrono-isopleth diagrams provide graphical representations of the diurnal and seasonal occurrence of both windows. The timing and duration, both diurnally and seasonally, of any overlap between these two windows is indicative of the technical feasibility of adopting a scheduling approach to smoke management in a particular region.

This method is used to indicate if the scheduling approach to smoke management in the Brisbane area was technically feasible. It was found to be so.

EMISSIONS OF PHOTOCHEMICAL SMOG PRECURSORS FROM BUSHFIRES.

P.J. Rye

Senior Environmental Officer, Environmental Protection Agency
141 St Georges Terrace, Perth, W. A. 6000

Visibility reductions in the Perth region, due to smoke from bushfires and controlled burns, have at times been measured by the EPA of Western Australia to be in excess of accepted standards. The smoke has been observed to include high concentrations of hydrocarbons, with the potential to contribute to the formation of photochemical smog.

During the spring and summer of 1992-1993, two photochemical smog events occurred which were clearly associated with the passage of smoke from controlled burns. The background to these events, and some implications, are discussed.

SMOKE MANAGEMENT OF FOREST BURNS IN W.A.

R.J. Sneeuwjagt

Department of Conservation and Land Management
Science and Information Division
PO Box 51, Como WA 6152

The Department of Conservation and Land Management (CALM) conducts an extensive program of prescribed burning in the south-west forests, south of Perth. The smoke generated from these managed burns can often be carried on southerly winds into Perth and regional centres such as Bunbury and Mandurah.

The weather conditions that are normally suitable for a safe forest burn are most often the same that lead to poor smoke dispersal and high smoke accumulation. The Department has successfully managed smoke emanating from burns in the northern jarrah forest near Perth for about 20 years by limiting burning to days when winds blow away from Perth. However, smoke from southern forest burns up to 350 km from Perth can often reach the metropolitan area and cause a smoke haze nuisance.

Over the past two years, CALM has applied a number of strategies to reduce the incidence of haze events. These strategies include identifying suitable meteorological conditions for rapid smoke dispersal; reducing total area burnt on any one day; dispersing burn jobs; and modifying burn prescriptions to reduce smouldering and re-ignition.

A set of burn constraints were developed on the basis of analysis of burn programs and weather conditions encountered over the previous three years.

A decision support model has been developed to assist managers to program burns within these sets of constraints.

Joint studies between CALM and the Bureau of Meteorology are being undertaken to develop more accurate smoke dispersal and trajectory prediction models.

RESPONSES OF PLANT POPULATIONS TO FIRE: HERBIVORY AND FIRE SEASON AS TWO UNDER-STUDIED ELEMENTS OF FIRE REGIME.

Robert Whelan and Ian Tait

Department of Biological Sciences
University of Wollongong
Wollongong, NSW, 2522

It is well known now that the effects of fire on plant populations depend on *fire regime*. Different fire intensities and different fire frequencies can alter both plant population dynamics, but other aspects of fire regime have received less attention. We review the likely effects of fire can have on plant populations by affecting the level of herbivory: plants in small burned patches generally suffer greater mortality because of greater herbivory levels. We also review the ways in which season of burning might affect plant populations by altering recruitment. We manipulated fire season in replicated fires in Hawkesbury Sandstone vegetation and measured germination rates of sown seeds of *Banksia* and *Hakea*. Recruitment varied markedly between fires in the same season but different years. Unlike other studies in Mediterranean-climate regions, the timing of germination after fire was not predictable. We conclude that the vagaries of post-fire climate introduce a stochastic element into the plant population response to fire that must be incorporated into population models and fire management strategies.

INTERDEPENDENCE OF WOODY PLANTS, HIGHER FUNGI AND SMALL MARSUPIALS IN THE CONTEXT OF FIRE.

Byron B. Lamont

School of Environmental Biology, Curtin University of Technology
GPO Box U1987, Perth, WA, 6001

As a "fire weed", the gastrolobiums and other mycorrhizal peas form dense thickets after intense fires: these serve as essential shelters from carnivores and nesting sites for small mammals, such as *Bettongia penicillata*. This marsupial is the major consumer of the underground sporocarps of at least 18 species of higher fungi in eucalypt forest in Western Australia. When fresh faecal pellets from captured animals were applied to seedlings of *Gastrolobium bilobum* (Fabaceae) and *Eucalyptus calophylla* (Myrtaceae) in autoclaved soil they formed far more ectomycorrhizal rootlets than the controls in non-autoclaved soil. Application of fresh spores of two *Mesophyllia* species to the seedlings produced neither mycorrhizas nor growth responses. The most likely explanation is that digestion by the marsupial facilitates germination of the spores. More recent work on the *Gastrolobium* has shown the pellets are likely to increase the numbers of mycorrhizal types in a range of soils and fire histories from an average of three to five. Restoration of these fungi after fire appears vital for re-establishment of species such as the *Gastrolobium* as it is killed by fire. Not only does consumption of sporocarps escalate after fire but the Bettong may travel up to 3 km overnight and moves from one burnt patch to another. This gives the capacity to be an effective dispersal and restoration agent, but the extent to which the soil is sterilised by fire remains uncertain: it probably depends on its intensity and patchiness.

BURNING *GREVILLEAS*, ANTS, RATS AND WALLABIES

Tony Auld

N.S.W. National Parks & Wildlife Service
P.O.Box 1967, Hurstville NSW 2220

The interactions between fire, plants and animals is poorly understood. In this work I use examples from a widespread plant genus (*Grevillea*) in the context of fire-prone Sydney heaths and woodlands on Hawkesbury sandstone. I examine the impact of fire, in particular fire frequency, on the long-term maintenance of population of some *Grevillea* spp. and how this is influenced by both seed dispersers (ants) and seed predators (rats and wallabies).

The *Grevillea* spp. studied are all killed by fire and rely on germination from a soil seed bank to re-establish populations post fire. Two ecologically functional seed dispersal groups exists within these *Grevillea* spp., depending on the structure of the seed. In one group ants may potentially be functioning as agents that reduce the impact of seed predators. In the second group ants play no role and the nature of the interaction between seed predators and fire is critical in controlling the size and long-term survival of *Grevillea* populations.

POST-FIRE RESPONSE PATTERNS OF INVERTEBRATES - ARE THEY PREDICTABLE?

Gordon Friend

Science and Information Division
Department of Conservation and Land Management
PO Box 51, Wanneroo, WA 6065

It is becoming increasingly recognised that invertebrates constitute much of the biodiversity in ecosystems and that they are critical to the maintenance of these systems. Indeed, certain guilds of invertebrates have potential as bio-indicators of environmental condition, including pyric status. A review of the available literature on the impact of fires on invertebrates, however, indicates that a wide variety of response pattern occur, and that these are often not consistent within taxonomic group or habitat type between different studies. In many instances invertebrate groups show marked locality, season and year-to-year effects which outweigh any changes attributable to fire. Furthermore, many inconsistencies seem to have arisen because of variations or shortcomings in experimental design, taxonomic treatment and length of study.

Given the inherent variability of invertebrate populations it is crucial that studies obtain pre and post-fire data over several years, and that they are standardised with respect to experimental design and taxonomic treatment. It is only by minimising/eliminating such experimental variability that we can determine whether the inconsistencies in outcomes are a true feature of invertebrate responses to fire, or are largely human-induced. This has important ramifications for the use of invertebrates in studies examining community stability and resilience.

RESPONSES OF BIRDS AND REPTILES TO FIRE AND INCREASING TIME AFTER FIRE IN *BANKSIA* WOODLAND NORTH OF PERTH, W.A.

M. J. Bamford

In the study of the impact of fire on terrestrial vertebrates in Australian ecosystems, most work has focussed on small mammal species while often more diverse bird and reptile assemblages have received little attention. Studies on mammals have found that dramatic changes in abundance after fire can be related to changes in vegetation structure; but is not clear to what extent generalisations based on mammals can be extended to birds and reptiles.

In a three year study, birds and reptiles were sampled in six areas of *Banksia* woodland unburnt for different lengths of time; from 0 to 23 years. The bird assemblage varied most in the first 3 years following fire and little thereafter, although some insectivorous and nectarivorous species were less abundant in long unburnt sites than from 3 to 6 years after fire. The reptile assemblage varied mainly in the first two years after fire, mainly due to differential survival of adult and immature specimens immediately after fire.

Birds and reptiles were tolerant of fire-induced changes to their environment. The mobility of birds and the ectothermy of reptiles may be of significance. Furthermore, the bird and reptile assemblages studied had survived over a century of a variable fire regime and thus may contain species most able to tolerate the impact of fire.

FIRES, VEGETATION HETEROGENEITY AND SMALL VERTEBRATES IN HUMMOCK GRASSLANDS.

David Pearson

Department of Conservation and Land Management
PO Box 51, Wanneroo, WA, 6065.

Fire is a profound and regular disturbance in the hummock grasslands of arid Australia. It may act to create, enhance or diminish "patchiness" in vegetation. The impact of the associated vegetation structural and spatial changes on vertebrates are little understood. Since the decline of Aboriginal burning by the mid-1900's, fire regimes appear to be increasingly dominated by summer wildfires, which may have led to more homogenous vegetation communities. A return to Aboriginal-style patch-burning has been widely advocated as desirable for nature conservation, although there is sparse supporting evidence. Some earlier studies are reviewed.

At a study site in the great Victoria Desert, the relative impacts of spring and summer fires on plant species richness and vertebrate assemblages were studied over six years. In the Gibson Desert, survivorship of reptiles in different-sized refugia within a fire-scar has been examined for four years.

The season of fire (usually correlated to its intensity) proved to be important in determining the extent and distribution of post-fire cover. Major changes in species composition of small mammals and reptiles followed both types of fires. Whilst spring fires usually resulted in increases in species richness in reptiles, some species rapidly colonised and increased their population sizes after summer fires.

The size of refugia was crucial for the survival of many species following fire. Fires which leave few, very small or widely spaced refugia are likely to delay recolonisation by many species for long periods, and may lead to local extinctions if fires are frequent.

FIRE-INDUCED MOSAICS OF NATURAL PLANT COMMUNITIES ON OLIGOTROPHIC SUBSTRATES IN PERHUMID ENVIRONMENTS, WESTERN TASMANIA

Dr Frank Podger *et al**

Consultant, c/- Department of Conservation and Land Management
Hackett Drive, Crawley, W.A.

1. A series of slides will be presented which provide graphic evidence of the importance of fire in determining sequences in the patterns of vegetation mosaics (from temperate rainforest to sedgeland heath).

2. The vital attributes, vegetative morphology and anatomy of many plants, combine to make the oligotrophic, perhumid environments of the 'Gondwanan' cool temperate flora a model environment for studies in plant/fire interactions.

3. Locations where the evidence for the competing hypotheses of 'ecological drift' (sensu W.D. Jackson) v Stability (see A.B. Mount) might be evaluated are listed and their plant communities illustrated.

4. Commentary on the importance of pre and post European human influence on the frequency of fire and its significance will be presented.

5. The presentation includes an evaluation of the relative utility for land of the hypotheses of Jackson and Mount,

6. Finally an appeal is made for a program of dynamics management which will ensure conservation of world class examples of the key stages in vegetation patterns which reflect adaptive processes in fire mediated landscapes.

* Tasmanian colleagues, especially Michael J. Peterson, Mick Brown, Trevor Bird and Peter Bennett.

ON THE IMPORTANCE OF HABITAT HETEROGENEITY IN TROPICAL SAVANNA AND ITS MAINTENANCE BY ANTHROPOGENIC FIRES.

R. W. Braithwaite

CSIRO Division of Wildlife and Ecology,
PMB 44, Winnellie, NT 0821

Savanna vegetation is associated with a highly seasonal tropical climate which results in high-frequency grass fires. There are strong relationships between habitat heterogeneity or patchiness and mammal richness and abundance in the savannas of Kakadu National Park. Fires vary greatly in intensity and impact on vegetation. Both pronounced patchiness and differentiation of ground and canopy strata are fundamental characteristics of savannas. A model to account for what appears to be a dynamic stasis is presented. Lower intensity fires create great patchiness in the ground layer. In contrast, both high-intensity fire and absence of fire create patchiness in the tree layer, due to differential tree mortality and recruitment from the ground layer respectively.

Experimental fires in Kakadu showed different effects on the tree and ground layers. There is some support for the above model with apparent fire-induced changes in vegetation patchiness, dominant plant species richness and mammal abundance and richness. It is concluded that an anthropogenic fire regime approximately the pattern created by traditional Aboriginal burning is the best management for savanna biodiversity.

FIRE MANAGEMENT IN HABITAT ISLANDS: RISKS AND IMPACTS - A FAUNA PERSPECTIVE

B.C. Gepp

Department of Primary Industries (SA) Forestry

In the high production agriculture regions of South Australia native vegetation is extremely fragmented and frequently highly modified. Fire is regarded both as the major threat and habitat management tool in these isolated remnants. Two case histories will be discussed firstly to illustrate the risks to "isolate" from wildfires and secondly to demonstrate the impacts of prescribed burning frequency on regeneration of the overstorey and its habitat value for hollow dependant fauna. These case studies are used to discuss fire management issues in habitat islands. Such as: in areas subdivided by access tracks each block has the potential to be managed as a mosaic within a mosaic and in the absence of internal access, how can fire be used for habitat management?

MOSAICS IN SYDNEY HEATHLANDS
The role of fire, competition and soils.

David Keith

NSW National Parks & Wildlife Service
Box 1967, Hurstville, NSW 2220

Open heath/sedgeland and tall dense scrub thicket are two structural formations that form a mosaic in the heathlands of Sydney's coastal sandstone plateaux. The former includes a diverse complement of small shrubs, forbs and graminoids that are infrequent in well developed stands of thickets. Conversely thicket dominants are infrequent or absent in open heath. Examination of a sequence aerial photographs spanning 50 years show that mosaic is dynamic over time and that changes in the distribution and abundance of the two structural forms are related to fires. Comparative studies on one species of small shrub have shown that its fruit production is reduced when in the present of mature thicket dominants. This species, and numerous others with simular life-cycles attributes, is less abundant in thicket than in open-heath, suggesting that competition from thicket dominants may be an important factor influencing community composition. Manipulative experiments to test this hypothesis are in progress. Analyses of soil chemistry have shown some variability between sites within the mosaic. Further work is necessary to determine the long-term significance of this spatial variation in soils.

A SIMPLE TEST FIRE EXERCISE FOR FIRE BEHAVIOUR TRAINING

H.G. Pearce[1] and M.E Alexander[2]

[1] *New Zealand Forest Research Institute*
Forest Technology Division, Plantation Management Group
Private Bag 3020, Rotorua, New Zealand.

[2] *Forestry Canada, Northwest Region*
Northern Forestry Centre, 5320-122 Street
Alberta, T6H 3S5, Canada

Three advanced fire behaviour courses were held in New Zealand during 1992-93. We experimented with the idea of using small outdoor test fires (≈ 1.2 x 2.4m) to help reinforce some of the principles and concepts being described in the classroom (e.g., fire development from point versus line ignition, influence of slope steepness, documentation of fuels, weather and topography in relation to quantified fire behaviour, meaning certain fire behaviour characteristics). The fuel beds used consisted of forest floor material collected more or less *in situ* from beneath nearby radiata pine plantations and stored under cover for at least a month. Three test fires were undertaken simultaneously: point-source ignition at 0° slope, line-source ignition at 0° slope, and line source ignition at 10° slope. Course participants found the test fire exercises an invaluable element of the courses. For fire behaviour training purposes, the present methodology is an acceptable alternative to conducting field-scale test fires which are often difficult, if not impossible, to carry out in most course situations.

A TIME DEPENDENT MODEL OF FIRE IMPACT ON FRUITS

G.N. Mercer[1], A.M. Gill[2] and R.O. Weber[2]

[1] *Mathematics Department, University College, UNSW*
Australian Defence Force Acadamy
Canberra, ACT, 2601, Australia

[2] *CSIRO Division of Plant Industry*
GPO Box 1600, Canberra, ACT, 2601, Australia

Many plants rely on the seed in woody fruits for their post-fire regeneration. Therefore, seed survival during fire is critical. A model for the survival of seeds in woody fruits is constructed using heat-flow equations with time-dependent temperature inputs. The model is used to predict the survival of seed in fruits exposed to both laboratory heating and field fires as reported in the literature. The inclusion of thermal arrest in the inputs to the model gives the upper bounds for estimated times of seed survival. The model gives reasonable predictions of seed fate. It is shown that seed location in the fruit is not a critical factor provided the seed is within the central core of the fruit. The applicability of the model is also demonstrated using time-temperature curves at two heights from experimental fires burning in different fuel types.

FUEL MODELLING AND FIRE BEHAVIOUR IN BUTTONGRASS MOORLANDS

J. Marsden-Smedley & T. Rudman

Tasmanian Parks & Wildlife Service
GPO Box 44A, Hobart Tas 7001

Buttongrass moorlands are a low open sedge community that covers vast tracts of western and south-western Tasmania. These moorlands have the interesting fire management characteristics of being highly flammable, overlaying peat soils, occurring in extensive unbroken plains and abutting fire sensitive vegetation. Management of both wildfires and fuel reduction burns has been fraught with problems and arguments. The Fuel Characteristics and Fire Behaviour in Tasmanian Buttongrass Moorlands research project has attempted to quantify the basic fire parameters to enable an objective approach to fire management in this fuel type.

Fuel characteristics in the Tasmanian buttongrass moorlands have been sampled for a wide range of sites in south-western and western Tasmania. The fuel characteristics sampled were: various Rothermel fuel characteristics, fuel moisture, fuel high heat contents, fuel loads and percentages of dead to live fuel. Most of the variation observed of fuel loads can be accounted for in the variables geology, vegetation age and vegetation cover. Due to problems with measuring vegetation cover, age and geology are used to predict fuel loads. The percentage of dead fuel at a given age did not vary between different geologies, and is modelled using age alone. Two fuel load and one dead-fuel percentage prediction models have been produced. Only a preliminary fuel moisture model is available at present.

Forty-nine fires including both research burns and wildfires were measured for fire behaviour model development and a further seven fires used for model verification.

Empirical models have been produced to predict buttongrass moorland head fire rate of spread and flame heights, using the variables moorland age, dead fuel moisture and surface wind speed. Alternatively, fire behaviour predictions can be made from the moorland age, relative humidity, temperature and surface wind speed.

The rate of spread model takes the form of:
ROS = constant x wind function x moisture damping x fuel function.

The flame height model takes the form of:
FH = constant x (heat content x fuel consumption x rate of fire spread)$^{\text{power}}$.

The models should provide good predictions for relative humidities between 30 and 100%, temperatures between 8° and 25°C, and surface wind speeds below 15 kph (ie low to moderate intensity fires). When wind speeds are between 15 and 35 kph the models should provide adequate predictions.

NITROGEN BUDGETS IN REGROWTH KARRI FOLLOWING THINNING AND FUEL REDUCTION BURNING

A. M. O'Connell[1] and W. L. McCaw[2]

[1] *CSIRO, Division of Forestry*
Floreat Park, W. A. 6014

[2] *Department of Conservation and Land Management*
Science and Information Division
Manjimup, W. A. 6258

The Department of Conservation and Land Management is undertaking an experimental program to investigate the feasibility and impacts of burning slash fuels created by thinning operations in young regrowth stands of karri (*Eucalyptus diversicolor*). Potential constraints on prescribed burning of thinning slash include damage to retained crop trees and losses of nutrients, particularly nitrogen, from the ecosystem. The amounts of nitrogen volatilised during fuel reduction burning of thinned karri forest are significant and for the most intense of eight experimental fires corresponded approximately to the amounts of nitrogen in growing vegetation (about 180 kg/ha). Compared to the total nitrogen in the ecosystem (vegetation + litter + soil) these amounts are small so that a single fire event is not likely to have a large impact on total nitrogen stores. However, inputs and outputs of nitrogen as a result of regular burning will affect the balance of nitrogen in the long term. Minimising volatile losses of nitrogen will help to maintain this balance. This is best achieved by burning under conditions when the lower part of the fuel profile is moist (litter profile moisture content > 80%), resulting in reduced combustion of the litter layer - the main compartment of nitrogen storage in fuel. Such conditions are also likely to minimise damage to retained crop trees.

A CLIMATOLOGY OF *VERY HIGH* AND *EXTREME* FIRE WEATHER DAYS IN SOUTHERN WESTERN AUSTRALIA.

A.J. Bannister and B.N. Hanstrum

WA Severe Weather Section
Bureau of Meteorology, Perth, W.A.

Days of extreme and very high fire danger for the 22 seasons 1970/71 to 1991/92 (November to April inclusive) were identified using 3 hourly data from the Bureau of Meteorology stations in southern parts of the State. Calculations of the fire danger index (FDI) were made using the McArthur Mark IV grassland fire danger meter assuming 'average' fuel amounts and 100% fuel curing.

The average number of extreme (FDI > 49) days per season graded from about 1 in the southwest corner to more than 15 in the Eucla and 9 around Geraldton, with appreciable year-to-year variability. In southeast parts of the State most *extreme* days occurred during the first half of the season whereas in the Geraldton area the majority of these occurred during January and February. Active fire seasons in the Geraldton region tended to correspond to less active seasons at Esperance and vice-versa. An analysis of *very high* and *extreme* fire danger days (FDI > 26) during the period revealed a similar distribution but values ranged from an average number of 10 days per season in the southwest corner to about 50 days at both Forrest and Geraldton. The monthly distribution of these events is also similar.

A study of weather patterns that led to the *extreme* fire weather conditions revealed that the prefrontal trough was the major influence in south coastal areas whereas the combination of a strong high to the south of the state and a trough over the Gascoyne was dominant for west coastal areas. Strong afternoon sea breezes due to a deepening trough inland and a high to the west of the state also generated *extreme* conditions along the Geraldton coastline.

FIRE IN THE HUMAN ECOSYSTEM -A QUESTION MAP-

David Ward

Department of Conservation and Land Management
Science and Information Division
50 Hayman Road, Como 6152 W.A.

The human ecosystem consists human beings and their interactions with their environment. The human environment is a seamless garment, but for conceptual purpose can be split into two parts. "Society" is the part of our environment, created by us, which would vanish with us were we to disappear in a puff of smoke. "Nature" is the part of our environment which would remain. Human artefacts lie somewhere in between, since they would outlast us for a while, but eventually succumb to entropy due to a lack of maintenance. Our survival and wellbeing depend upon our activities within both parts of our environment, so that CALM policy must take both into consideration, seeking harmony between human systems and natural systems. As a human activity, prescribed burning, is linked to many phenomena, both natural and social. Question-maps are a way of starting to think in a structural way about our activities, our wellbeing, society and nature, and a question-map about fire in our forest systems leads us into conceptual model building, or Systems Ecology, using ideas from General Systems Theory, Graph Theory, Matrix Theory, and Human Ecology. The resulting models are useful for policy formulation, management training, public education and research project management.

FIRE HISTORY MAPPING OF REMNANT URBAN BUSHLAND NEAR PERTH WA

J. P. Pigott[1], W. A. Loneragan[2] and D. T. Bell[2]

[1] *Department of Conservation and Land Management*
WA Herbarium, Science and Information Division
PO Box 104 Como WA 6152

[2] *Botany Department*
University of Western Australia
Crawley WA 6009

The fire history since 1948 at Star Swamp Bushland Reserve is interpreted from aerial photographs. Fire scars were traced separately from the 18 sets of aerial photographs available for the period. Fire frequency and the number of months since fire, were calculated for 185 survey points used for vegetation mapping as well as 32 permanent plots used for monitoring vegetation dynamics. The effect of fire frequency on the canopy of the dominant tree species *Eucalyptus gomphocephala,* composition and distribution of plant communities, and weed invasion was analysed using the geographic information system ARC/INFO, correlative and multivariate techniques. It is shown that mapping fire history can be a variable aid for the management of urban reserves requiring special fire protection.

PLANNING FOR FIRE MANAGEMENT IN A NEAR-URBAN NATIONAL PARK

Jim Williamson[1], Peter Keppel[2] and Jacqueline Pontré[1]

Department of Conservation and Land Management
[1] Planning Branch, Pinnacle House, Mt Pleasant, 6153
[2] District Office, Mundaring, 6073

John Forrest National Park is located on the edge of the Darling Scarp 25 km from Perth. It is almost totally surrounded by residential areas. The major objective in planning for fire management is to protect life and property without compromising environmental and ecological values.

The fire plan proposed in the draft management plant for John Forrest National Park (Plan A on poster) was amended after considering submissions that indicated the draft proposal did not provide sufficient protection for the community from wildfire.

Plans B, C and D on this poster are alternative suggestions submitted during the public review process. A revised fire plan (Plan E) was developed (taking into consideration these options) in consultation with people who contributed a submission to the draft plan for John Forrest National Park.

The fire management plan will achieve the greatest diversity possible within the constraints of protection of life and property.

The Fuel Reduction Regime areas will be reviewed annually in the light of additional scientific knowledge, and the effect of unplanned fires to determine whether or not they should be burned for ecological or protection purposes.

PATTERNS OF RESPROUTING OF EUCALYPTS AFTER FIRE

Jann E. Williams[1] and A. Malcolm Gill[2]

[1] *Research School of Biological Sciences*
The Australian National University, Canberra ACT 0200

[2] *CSIRO Division of Plant Industry*
GPO Box 1600 Canberra, ACT 2601

Patterns of resprouting of *Eucalyptus rossii* and *E. macrorhyncha* were monitored on two sheltered and two exposed aspects following a wildfire in February 1991 in the Black Mountain Nature Reserve, ACT. Overall 673 individuals were monitored, 87% of which resprouted. Trees started sprouting 54 days after the fire although sprouting of *E. macrorhyncha* was delayed for up to 2 months on exposed aspects. Sprouting continued throughout winter, however rates appeared to 'slow down' on sheltered compared to exposed aspects over the cooler months. Most trees had sprouted within a year of the fire; 3 individuals were recorded sprouting after October 1992 (20 months post fire). Larger individuals sprouted more rapidly - approximately 90% of individuals $\geq$20.1 cm d.b.h had sprouted by the end of August 1991 compared to less than 50% of individuals <20.1 cm d.b.h. The percentage of individuals sprouting only from the base of the tree increased over time. Most of later sprouters were smaller trees with complete cambial death on the stem. Patterns of resprouting were related to, at least, soil moisture availability, air temperature and tree species, size and vigour.

PRE-EUROPEAN FIRE HISTORY OF NORTH AMERICAN TALLGRASS PRAIRIE

Thomas B. Bragg

University of Nebraska at Omaha
Nebraska, U.S.A.

Fire was an important component of the historical maintenance of the North American Tallgrass Prairie. Three aspects of the natural (pre-European) fire conditions have recently been studied. First, fires were estimated to have occurred an average of every 4.8 + 0.56 years based on fire-scarred trees growing along the margin of extant native prairies. Second, while not optimal for present objectives such as domestic livestock, fires occurring during the growing season may have been important in maintaining the natural diversity of the ecosystem. The herbs, false sunflower (*Heliopsis helianthoides*) and white aster (*Aster ericoides*), for example increase with summer and fall burning; big bluestem (*Andropogon gerardii*), the dominant grass of the tallgrass prairie, responds best to spring burning. Fires routinely applied during the same season ultimately may reduce ecosystem diversity. Thirdly, simulated grazing designed to approximate the effect of large grazers such as bison (*Bison bison)* on fuel distribution, resulted in a significantly greater fire temperature heterogeneity ($P < 0.001$) than occurred without grazers. Fire in the pre-European tallgrass prairie, thus appears to have been a complex factor involving frequent and seasonally-variable occurrences and heterogenous fire-temperatures across a grazed landscape.

FIRE FREQUENCY AND FLORISTIC VARIATION IN DRY SCLEROPHYLL COMMUNITIES

Geoffery J. Cary

Department of Applied Biology, University of Technology
PO Box 123 Broadway, NSW 2007
(Current address: Ecosystem Dynamics Group, Research School of Biological Sciences, The Australian National University, Canberra ACT 0200)

Fire frequency, a function of the number of fires experienced by a community within a given time period, may be resolved into the components of time since the most recent fire and the lengths of intervals between fires. The dynamics of dry sclerophyll woodlands in the Sydney region were examined in relation to fire frequency in the recent (< 30 years) fire history. Direct gradient analysis of floristic data indicates that:

(i) Fire frequency accounts for around 60% of the floristic variation among the samples.

(ii) The effect of time since fire and the length of intervals between fires on floristic composition was equal in magnitude but unrelated in the nature of the variation associated with them.

Increasing time since fire is associated with a decline in the evenness of fire-tolerant species while inter-fire intervals of decreasing length are associated with the decrease in evenness of fire-sensitive species. Increasing variability of the length of the inter-fire intervals is associated with an increase in the richness of fire-tolerant and fire-sensitive species, implying that it may be variation of inter-fire intervals that is responsible for maintaining the presence of a wide range of plant species in a particular community.

MODELLING FOR IMPACT OF FIRE ON THE POPULATION DYNAMICS OF THE SPLENDID FAIRY WREN

Michael G. Brooker

CSIRO, Division of Wildlife and Ecology,
LMB 4, PO Midland, W.A. 6056

During a 20-year study of a population of Splendid Fairy-wrens near Perth, nine wildfires have impinged on the area. Although the fires did not directly affect the survival of wrens, they had a major effect on reproductive success in the following years. On average, 19% of female-years experienced fire in the 12 months prior to nesting and 33% of female-years in the 2 years prior to nesting. The fires had a dual impact. Most importantly, the rate of nest predation almost exactly doubled in the years following fire and secondly the onset of breeding was delayed by up to a month, presumably because the wrens had trouble finding suitable vegetation in which to hide nests.

In addition to fire frequency and nest predation, the demography of the population is influenced by brood parasitism, seasonal fluctuations and patch-size, presently a complex picture of demographic-environmental interactions. These data have been incorporated into a computer simulation model which can be used to make predictions of likely outcomes from a variety of landscape and management scenarios.

INFLUENCE OF HERBIVORES ON THE VEGETATION AND FIRE FUELS OF THE PERUP FOREST REGION OF WESTERN AUSTRALIA.

K.A. Shepherd[1], G.W. Wardell-Johnson[2], W.A. Loneragan[1] and D.T. Bell[1]

[1] *Department of Botany*
The University of Western Australia, Nedlands, W.A., 6009.

[2] *, Department of Conservation and Land Management,*
Manjimup Research Centre , Brain Street, Manjimup, W.A. 6258.

Studies in the southern jarrah (*Eucalyptus marginata*) forest situated in the Perup Nature Reserve indicated significantly higher cover values for plant species inside wire-mesh exclosures after 10 year compared to outside the exclosures. Particular species that were favoured by herbivore exclusion included *Bossiaea ornata, Billardiera variifolia, Opercularia hispidula, Logania serpyllifolia* and *Tetrarrhena laevis*, among others. Plant species showing the greatest decrease in cover outside wire enclosures were found in the faecal pellets of the herbivores of the region. Faecal analyses documented by a preference for 42 forest species by the Western Grey Kangaroo (*Macropus fuliginosus*), the Western Brush or Black-gloved Wallaby (*Macropus irma*) and the Tammar Wallaby (*Macropus eugenii*). The Common Brush-Tailed Possum (*Trichosurus vulpecula*) consumed not only leaves of the dominant trees, but sampled species from the understory, including *Leptomeria cunninghamii* and *Hakea lissocarpha.* Faecal samples of the Western Ring-Tailed Possum (*Pseudocheirus peregrinus occidentalis*) included only forest canopy species. Overlaps in the diets of herbivores indicated the possibility of competition for plant resources, but the polyphageous nature of all Perup Forest herbivores and an ability to shift resource preference would indicate the food resources are probably not limiting in the region of the forest despite some habitat fragmentation. The polyphageous nature of the native herbivores also indicates that rare plants are probably not endangered due to feeding effects by the animals. Herbivory has strong implications for fire management in the animals ability to reduce fuel loads and preferential feeding choices on fire-regrowth could affect particular species populations.

INFLUENCE OF FIRE ON THE SEED GERMINATION ECOLOGY OF SPECIES OF THE JARRAH FOREST.

D.T. Bell

Department of Botany
The University of Western Australia, Nedlands, W.A., 6009

Species of the jarrah forest can be categorised by their life history syndromes related to the survival of fires and their mode of seed dispersal. Obligate seeding species require re-establishment following fire from seed because the parent plant is killed by the fire. Resprouting species differ in that the parent survives and reproductive output by seed is usually limited. Also, species may differ in the timing of seed dispersal; i.e. seed dispersed annually to the soil or retained in serotinous fruits for the plants for a period of years. Obligate seeding, soil seed store species, especially jarrah forest legume species, often have seed dormancy mechanisms which prevent them from germinating until after a fire. The heat shock provided by the fire can serve to break an impervious seed coat or possibly denature some seed coat inhibitor. To differentiate potential differences in these two influences of fire, differential germination results following scarification and boiling revealed that the jarrah forest could have both types of species. Examples of species which germinate following the mechanical breaking of the seed coat include *Acacia nervosa, Bossiaea eriocarpa, Daviesia physodes*, and *Gompholobium knightianum*. Species predicted, but not proven to have seed coat inhibitors are *Acacia drummondii, A. pulchella, Gastrolobium spinosum* and *Oxylobium cuneatum*. In addition to a requirement for a heat shock pre-treatment many jarrah forest species also must have the proper temperature and light cues to break dormancy. For example, *Acacia pulchella* var. *glaberrima* germinates in highest percentages corresponding to winter incubation temperatures in the dark, while *Banksia grandis* and *Hakea amplexicaulis* seeds germinated best at cool temperatures, but when light intensity is high. The implications for maintenance of the species under forest management are described.