Fuel modelling and fire behaviour in buttongrass moorlands

J. MARSDEN-SMEDLEY[1] AND T. RUDMAN[1]

[1] Tasmanian Parks and Wildlife Service, GPO Box 44A, Hobart 7001, Tasmania.

Abstract

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 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 headfire 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.

CALMScience Supplement 4: 207-216 (1995)

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 per cent, temperatures between 8° and 25°C, and surface wind speeds below 15 kmph (i.e. low to moderate intensity fires). When wind speeds are between 15 and 35 kmph the models should provide adequate predictions.

purposes 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] WA Herbarium, Science and Information Division, Department of Conservation and Land Management, PO Box 104, Como 6152, Western Australia.

[2] Botany Department, University of Western Australia, Crawley 6009, Western Australia.

Abstract

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 valuable aid for the management of urban reserves requiring special fire protection.

Planning for fire management in a near-urban national park

J. WILLIAMSON[1], P. KEPPEL[2] AND JACQUELINE PONTRÉ[1]

[1] Planning Branch, Department of Conservation and Land Management, PO Box 104, Como 6152, Western Australia.

[2] Department of Conservation and Land Management, District Office, Mundaring 6073, Western Australia.

Abstract

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

The fire management plan aims to provide the greatest diversity possible within the constraints of protection of life and property. Fuel Reduction 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. M. GILL[2]

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

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

Abstract

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 per cent of which resprouted. Trees started sprouting 54 days after the fire although sprouting of *E. macrorhyncha* was delayed for up to two months on exposed aspects. Sprouting continued throughout winter, however, rates

appeared to 'slow down' on sheltered compared with exposed aspects over the cooler months. Most trees had sprouted within a year of the fire; three individuals were recorded sprouting after October 1992 (20 months post fire). Larger individuals sprouted more rapidly - approximately 90 per cent of individuals ≥20.1 cm d.b.h had sprouted by the end of August 1991 compared with less than 50 per cent 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 the 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

T. B. BRAGG[1]

[1] University of Nebraska at Omaha, Nebraska, USA

Abstract

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 heterogeneous fire-temperatures across a grazed landscape.

Fire frequency and floristic variation in dry sclerophyll communities

G. J. CARY[1]

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

Abstract

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 per cent 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 the impact of fire on the population dynamics of the Splendid Fairy Wren

M. G. BROOKER[1]

[1] CSIRO Division of Wildlife and Ecology, LMB 4, PO Midland 6056, Western Australia.

Abstract

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 per cent of female-years experienced fire in the 12 months prior to nesting and 33 per cent of

female-years in the two 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, population growth 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 6009, Western Australia.

[2] Science and Information Division, Department of Conservation and Land Management, Manjimup Research Centre, Brain Street, Manjimup 6258, Western Australia.

Abstract

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 years compared with 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 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 Brushtail Possum (*Trichosurus vulpecula*) consumed not only leaves of the dominant trees, but sampled species from the understorey, including *Leptomeria cunninghamii* and *Hakea lissocarpha*. Faecal samples of the Western Ringtail 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 this 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[1]

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

Abstract

Plant species of the jarrah forest can be categorized 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.

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Survival of trapdoor spiders during and after fire

BARBARA YORK MAIN[1]

[1] Zoology Department, University of Western Australia, Nedlands 6009, Western Australia.

Abstract

The response to fire by two myglamorph 'trapdoor' spiders with very different life histories was studied. The study site was in sandplain heath/shrubland in Durokoppin Nature Reserve in the central Wheatbelt of Western Australia. The fire, in March 1989, was part of several experimental fires undertaken by CSIRO and CALM to study the effects of fire on the biota as part of a program to assess the role of fire in management of small reserves.

The two trapdoor species studied were *Anidiops villosus* (Rainbow) and an unnamed *Cethegus* species.

Cethegus spiders are web weavers which catch prey in a flocculent, curtain-like web over a shallow retreat burrow (Main 1960, 1964; Raven 1984). Webs are sited against the base of small shrubs, logs or fallen branches. The species studied here matures rapidly (in about a year) but females continue to live for at least several years. Spiders may move nest sites a short distance if webs are damaged by heavy rain. Juveniles disperse aerially (Main 1991, and personal observation).

In contrast, *Anidiops villosus* digs a deep (70 cm), permanent burrow closed by a trapdoor and with a radiating fan of twiglines attached to the burrow rim (Main 1978). These twiglines are used for foraging. Nests are sited in litter under the the shade of shrubs and low trees. Spiders have a long developmental period (at least eight years for males and longer for females). Females reproduce iteroparously and may live for upwards of 25 years (Main 1987, and unpublished data). Spiders are dependent on both shade and permanent litter. Juvenile dispersion is ambulatory and restricted to a short distance, often to the litter mat of the maternal shade tree.

Webs and burrows were marked individually with numbered steel tags on wire pegs along two transects (625 m and 100 m long) in the site to be burnt and along a parallel transect (625 m) in an adjacent control (non-burn) site. Nests along all transects were marked progressively when found on census dates between 5 September 1987 and 17 December 1988. Nests viable at the last day of census marking were censused again on 18 March 1989 one week after the fire.

Response of *Cethegus*

All active nests at the last pre-burn census (17 and 1) along the burnt transects (625 m and 100 m respectively) were destroyed and the spiders presumed killed by the fire. Of the the 11 active nests at last pre-fire census in the unburnt control 10 were still active on the post-burn census date. By June and July 1989 and 2 February 1990 (eleven months post-fire), none of the burn site nests had recovered nor were there any webs rebuilt nearby. In the control non-burnt site, of the 11 nests active on the pre-burn census date, 10 were still active at the post-fire census date. During the autumn following the fire (1990), aerially dispersed spiderlings from adjacent unburnt bush recolonized the regenerating bush on the burnt site.

Response of *Anidiops villosus*

Most adult nests (11 of 14 on the long transect, 5 (all nests) on the short transect) survived the fire; 17 of 24 along the unburnt transect persisted (of these one had been preyed upon). On the burnt site four (of 11) and one (of 5) became defunct within three months following the fire. Several of these nests were vigorously attacked by birds, i.e. by pecking off rebuilt doors and twiglines thereby disrupting the spiders' foraging capabilities. There was no recruitment of juveniles in the burnt site during the autumn-winter following the burn.

Conclusions

From survival and recruitment data of *Cethegus* and *Anidiops* following an induced burn it seems that *Cethegus* although destroyed outright by fire is able to recolonize a regenerating post-burn site provided there is adjacent unburnt habitat with a reservoir population.

Conversely, although adult spiders of *Anidiops* survive fire, spiders are disadvantaged in a post-burn habitat due to inadequate shade, litter and possibly reduced prey and exposure to predation - all factors which lead to a progressive mortality following fire. Main (1978) suggested that the behaviour and deep burrows of the spiders (adaptations to aridity and drought) 'fits them to survive through a bushfire' and also that fire would probably not be deleterious to a population. However, although the observations reported here show that adult spiders can survive a fire, the post-fire mortality combined with lack of juvenile recruitment means that in a population sense *Anidiops* is indeed vulnerable to fire.

These contrasting responses by two mygalomorph spiders demonstate that a knowledge of invertebrate species' life history particularities is desirable in order to adequately manage small reserves for maintenance of their species diversity.

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