# EFFECTS OF FIRE FREQUENCY ON VEGETATION IN WESTERN SYDNEY'S GRASSY CUMBERLAND PLAIN WOODLAND AND IMPLICATIONS FOR MANAGEMENT

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## Abstract
Recent studies have sought to develop an understanding of the relationship between fire regimes and plant diversity in the woodlands of Western Sydney's Cumberland Plain. Results suggest that fire has a powerful influence on community composition and structure. A survey in a series of remnants with differing fire histories found a markedly higher abundance of *Bursaria spinosa* in sites where fire frequency was low, to the point where this species dominated the landscape. Other native shrubs, particularly obligate seeders, were most abundant at moderate fire frequencies. Kangaroo grass (*Themeda australis*) dominated the ground layer in high and moderate fire frequency sites, but not where fire frequency was low. Open patches, patches around trees and patches under Bursaria varied in species composition: fire frequency is therefore likely to affect ground layer floristics indirectly, though its influence on the shrub layer. Exotic species were most abundant in low fire frequency remnants. Findings can be synthesized into a state and transition model which allows exploration of management actions. Maintenance of *Themeda* woodlands which contain a balance between Bursaria thickets and open areas, and a good complement of obligate seeder shrubs, will require some fire. Variable intervals between 4 and 12 years are suggested.

### Introduction
Although the importance of fire management for biodiversity conservation is increasingly being recognised, little is known about the relationship between fire regimes and plant diversity in Australia's temperate grassy woodlands. Over the past four years we have attempted to address that gap for the woodlands of Western Sydney's Cumberland Plain. This paper summarises broad findings from a series of studies from a PhD project undertaken at the University of Western Sydney (Watson 2005), along with their implications for conservation management.

Cumberland Plain Woodland (CPW), like most of the ecosystems endemic to the Western Sydney basin, is listed as endangered – only 10% remains, in scattered remnants. CPW is very different to the shrubby woodland on sandstone that visitors to Sydney generally encounter. It grows on shale-based clay soils, receives approximately 800mm of rainfall annually, is subject to hot summers and frosty winters, and hosts a species complement which has more in common with the grassy woodlands of the Western Slopes than with the shrubby sandstone woodlands nearby. Three eucalypts are abundant: *E. moluccana* (Grey Box), *E. tereticornis* (Forest Red Gum), and *E. crebra* (Narrow-leaved Ironbark). Shrubs include *Bursaria spinosa* (Bursaria, or Australian Blackthorn), and a number of leguminous species. The ground layer consists of grasses interspersed with forbs.

### Summary and discussion of findings
Our research indicated that fire frequency profoundly affects both vegetation composition and structure in CPW.

*Shrubs*
The influence of fire cycles was most readily apparent in the shrub layer. A survey in CPW remnants with differing fire histories found a high abundance of *Bursaria spinosa* in sites where fire frequency was low (these sites had been unburnt for at least 20 years prior to a recent fire), to the point where this species dominated much of the landscape (Figure 1). Sites in the other two fire frequency categories (high, most intervals between 1 and 3 years; and moderate, most intervals between 4 and 10 years) all had some Bursaria thickets, but much of the landscape was open and grassy (Figure 2). Increases in the density of woody plants in the absence of fire have been noted in productive grassy ecosystems around the world (eg Allen *et al.* 2002, Bond *et al.* 2005). Other native shrubs, particularly obligate seeders (species whose adults are killed in a fire and rely on regeneration from seed), were significantly more abundant in sites burnt once or twice a decade than in either low, or high, fire frequency sites.

The relatively low abundance of obligate seeders in very frequently burnt sites is easily explained: if a second fire occurs before these species have grown sufficiently to set seed, then only ungerminated seed from before the first fire will be available to keep them in the community. In low fire frequency sites, competition from resprouting Bursaria may have played a role in the reduced abundance of other native shrubs. Unlike most other CPW shrubs, Bursaria

plants can establish between fires, a characteristic which gives them a decided advantage in long unburnt areas. Obligate seeders on the Cumberland Plain mature rapidly, flowering by three or four years post-fire. Some appear to be short-lived. Once a generation of fire-cued obligate seeders dies, the population exists only as soil-stored seed. Seeds will germinate after the next fire, but may decay if the interval between fires becomes too long.

**Figure 1. Bursaria-dominated landscape at Orchard Hills 2.5 years after a fire; no fire had occurred here for at least 30 years prior to this burn. Photo by Venesa Brusic.**

**Figure 2. Kangaroo Grass flowering in frequently burnt Cumberland Plain Woodland at Holsworthy twelve months after a fire. Photo by Penny Watson.**

*Ground layer*
The main effect of fire frequency on the ground layer concerned *Themeda australis* (Kangaroo Grass). This species dominated high and moderate fire frequency sites, but not where fire frequency was low. These findings echo those from Victorian grasslands, where *Themeda* has been found to decline in the absence of fire (Lunt and Morgan 1999, Morgan and Lunt 1999). A study focused on woodland microhabitats found no evidence of a direct effect of fire frequency on ground layer species richness or composition in CPW – although low replication and stratified sampling may have obscured effects. However open patches, patches around trees and patches under Bursaria varied significantly in species composition. Thus fire frequency is likely to affect ground layer composition in CPW indirectly, through its influence on the shrub layer: ground layer species with a preference for open areas will decline as Bursaria density increases.

*Trees*
Fire frequency did not significantly affect either adult tree density, adult tree basal area, or the density of suppressed seedlings or saplings. Trends suggest frequent fire may be associated with an increased density of juveniles, but also with a decrease in the number of saplings 'getting away' into the canopy.

*Exotics*
Woody exotics were considerably more abundant in low fire frequency sites than in areas which had burnt at least once a decade. Very frequently burnt sites had virtually no woody exotics. Similarly, significantly fewer herbaceous weed species were found in very frequently burnt areas than where fire frequency had been low. There was a significant negative association, at a small scale, between the abundance of *Themeda australis* and the species richness and abundance of exotic herbs: more *Themeda*, less weeds. Again these results echo those from grasslands and grassy woodlands elsewhere (Lunt and Morgan 1999, Prober *et al.* 2005).

*Fuel*
We also assessed fuel loads in CPW at different times after fire. Fuel accumulation in CPW starts from a low base as even low intensity fires consume most available fuel. Modeling based on field data indicated equilibrium fuel loads would be reached within ten years, however peak loads of around 9 tonnes per hectare are very low relative to those in nearby sandstone woodlands, which can reach over 30 tonnes per hectare. Eucalypt litter – leaves, sticks and bark – was the major contributor to fuel loads. The contribution of shrubs, mostly Bursaria bushes, was many times higher in infrequently burnt sites than where fire had occurred at least once a decade. These findings have major implications for balancing conservation and property protection; the two aims conflict to a considerably lesser extent in CPW than they do in Sydney's sandstone environments.

**Management implications**
Findings can be synthesized into a state and transition model which allows exploration of management actions for maintenance of each state, and for transition between states.

Interfire intervals between 4 and 12 years are predicted to maintain *Themeda* woodland with Bursaria thickets, open areas, and obligate seeder shrubs. Variable intervals across time and space within these thresholds should maintain much of the landscape at fuel levels compatible with property protection. A simple monitoring program, focused on flowering of obligate seeder shrubs, *Themeda* health, and Bursaria expansion, could help managers tailor these thresholds to particular site and climatic conditions.

Low fire frequency remnants dominated by Bursaria retain many conservation values, but are likely to support lower abundances of obligate seeder shrubs and open patch herbs, and to be more weed-prone, than remnants burnt once or twice a decade. Experimentation with one or two short interfire intervals may be appropriate in long unburnt CPW.

Despite perceptions of overburning, very frequently burnt CPW remnants are not common, and those that do exist are not adequately conserved. Although shrub abundance is low, these areas are less weedy than others, have a diverse ground flora, provide habitat for macropods, and contribute to structural diversity across the Plain.

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