

FUELS OF THE FUTURE: THE CHALLENGE OF NEW FUEL TYPES

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Abstract

Landscape disturbances associated with human activities result in many changes in vegetation structure and floristics. These changes include invasion of native vegetation by both introduced and native species, which leads to the development of "new" vegetation types. These new vegetation types are often associated with greatly increased fuel loads, and increased levels of fire hazard. Two of these "new" fuel types are dense thickets of woody weeds, such as Coyote Bush (*Baccharis pilularis*) and swards of exotic grasses with very high fuel loads, such as Buffel Grass (*Cenchrus ciliaris*) and Para Grass (*Urochloa mutica*). The "new" fuel types which can now be recognized have significant implications for the accuracy of fire behaviour prediction and modelling. For example, modelling fire behaviour in areas invaded by exotic grasses in Australia is problematic, as current grassland fire behaviour models do not allow for the input of the high fuel loads associated with these invasive grasses. In forest, McArthur Forest Fire Danger Meters may not be appropriate for forests with significant levels of elevated fuels. Two case studies from southeastern Australia are discussed: the invasion of native vegetation in the urban interface by the woody shrub Burgan (*Kunzea ericoides*) and invasion of native grasslands by Phalaris (*Phalaris aquatica*).

Introduction

Landscape disturbances associated with human activities result in many changes in vegetation structure and floristics. Weed invasion has the potential to disrupt ecosystem processes and functions, often with unexpected implications. Invasion of native vegetation by both introduced and native species can lead to the development of "new" vegetation types which are often associated with greatly increased fuel loads, leading to unexpected fire behaviour, altered fire regimes, and increased levels of fire hazard and changing risks (Russell and McBride 2003). Good fire management relies on our ability to model fire behaviour, and our understanding of fuel characteristics is crucial. In particular increased risk to fire fighters and landowners needs to be recognized so that human behaviour is appropriate to actual risk.

Two of the "new" vegetation types are dense thickets of woody weeds, such as Coyote Bush (*Baccharis pilularis*) (Russell and McBride 2003) and Burgan (*Kunzea ericoides*) (Kirschbaum and Williams 1991), and swards of exotic grasses such as Para Grass (*Urochloa mutica*) (Douglas and O'Connor 2004) and Buffel Grass (*Cenchrus ciliaris*) (Butler and Fairfax 2003). Both these "new" fuel types have very high fuel loads not encountered before in the vegetation in which they are now established (eg Hughes *et al.* 1991; D'Antonio and Vitousek 1992, Brooks 1999; Platt and Gottschalk 2001).

The impact of changes in fuel characteristics following invasion of Phalaris (*Phalaris aquatica*), a grass, and Burgan (*Kunzea ericoides*), a woody weed, on fire behaviour and risk is described here. Phalaris is a widespread pasture species which can attain high biomass where it is unmanaged, and it retains much of its biomass in the form of standing dead matter (Johnson 1999; Stoner *et al.* 2004; 2005). Burgan rapidly colonizes disturbed areas and abandoned pastures and is also actively invading native vegetation in south eastern Australia (Judd 1990; Kirschbaum & Williams 1991; Singer and Bergman 1999). Invasion of abandoned agricultural land usually results from mass seedling recruitment to produce relatively even-aged monospecific stands (Judd 1990; Kirschbaum and Williams 1991), and it is suggested that development of Burgan thickets in native bushland and abandoned farmland dramatically increases fuel loads, thereby escalating the probability of high intensity fire (Judd 1990).

Materials and Methods

Phalaris

Paired sites were selected on roadside reserves in southern Victoria. Each paired site consisted of a dense Kangaroo Grass (*Themeda triandra*) grassland which had not been subject to fuel modification for many years, and an adjacent exotic grassland dominated by unmanaged Phalaris. Fine fuel loads were measured using randomly placed 0.5 X 0.5m quadrats, and within each quadrat all above-ground fine fuel was clipped to ground level and oven dried (Stoner *et al* 2004)

Burgan

Three typical dense stands of Burgan were selected north-east of Melbourne. At each stand 10 random 1m X 1m quadrats were sampled along three 50m transect lines. Within each quadrat all above-ground fine fuel was clipped to ground level and oven dried (Riedell 2003).

Results and Discussion

Phalaris

Fuel loads of Phalaris are significantly greater than those of native Kangaroo Grass dominated grassland. Fine fuel biomass for Kangaroo Grass grassland was consistent with results from other studies (eg Lunt and Morgan 2002), and ranged from 6.9 t/ha to 8.7 t/ha (mean 7.9 t/ha), while fine fuel biomass of Phalaris dominated sites ranged from 22.8 t/ha to 31.1 t/ha (mean 27.0 t/ha). Fine fuel biomass levels >20 t/ha fall well outside expected fuel loads in most grasslands (Stoner *et al.* 2004). Existing grassland fire behaviour models have not been derived from grasslands with this fuel load. The impacts of fuel characteristics on grassland fire behaviour is complex, with no simple correlation between fuel load and fire behaviour (Cheney *et al.* 1993). However, the fuel loads reported here for Phalaris (~27.0 t/ha) are nearly seven times greater than the fuel loads in the experimental fires (maximum site mean 4.33 t/ha) used to derive fire behaviour models (Cheney *et al.* 1993). Similarly, the height of Phalaris recorded (1.2 m) is much greater than recorded in experimental grassland fires (maximum site mean 0.43 m). While fuel load did not influence fire spread in experimental fires, it may impact on variables such as flame height and fire intensity. Given the marked difference in fuel height and fuel load between Phalaris dominated grassland and grasslands used in experimental fires, current models are problematic and are unlikely to adequately predict fire behaviour in Phalaris. Large tussock size and a high proportion of available dead material may extend the length of the fire season, and high fuel loads may make fire suppression more difficult and decrease the probability of successful direct attack (Stoner *et al.* 2005). The "safe distance" for fire fighters may also increase (Butler 1997). In invaded plant communities higher intensities during fires may also have a negative impact on the native overstorey, alter target species regeneration (Butler and Fairfax 2003), and decrease native species cover (D'Antonio *et al.* 2000).

Burgan

Fine fuel biomass of Burgan thickets ranged from 23.2 t/ha to 34.7 t/ha (mean 30.8 t/ha), which is markedly higher than biomass in non-invaded sites in the same area (mean fine fuel load for 11 long unburned sites ranged from 13.7 t/ha to 21.1 t/ha mean 16.9 t/ha) (Simmons and Adams 1986).

Burgan has increased its abundance and distribution into a wide range of plant communities in many areas, where it out competes other native species (Singer and Burgman 1999). It is an early colonizer of bare ground, it is not seral, recruitment continues even in dense stands, and this results in stands dominated by Burgan with very few other species present (Kirschbaum and Williams 1991). The dense stands of Burgan prevent establishment of other potentially overtopping species and dominance by Burgan is likely to last for many decades (Kirschbaum and Williams 1991).

In many urban fringe areas where there has been vegetation disturbance, or areas where agricultural land has been abandoned, Burgan is increasing its distribution, and in areas previously covered by pasture there is a shift from grassland to dense, elevated shrubby fuel accompanied by a significant increase in fire hazard. In many areas of relatively open eucalypt forest, Burgan invasion results in vegetation with an elevated fuel layer which was previously absent. As fuel type and quantity change, landholders may underestimate their exposure to high fire hazard. For those who do recognize the potential risk, there are often local government constraints on landholder vegetation modification. In some urban fringe areas Burgan is a protected species and requires a permit for removal. Setback distances required using Victoria's Wildfire Management Overlay standards may need to be adjusted for the change in vegetation type in the vicinity of houses. For example, prescribed set back distance in Medium forest would be 50m, but in Shrub vegetation it would be 70m for the north-western zone on flat ground (CFA 2002).

Invasion by some species such as Pittosporum (*Pittosporum undulatum*) may decrease fire hazard due to lower flammability of vegetation, however new vegetation types are usually associated with greatly increased fuel loads, and increased levels of fire hazard. For example the invasion of fynbos by Blue-leafed wattle (*Acacia saligna*) can lead to increased nitrogen cycling in low nutrient soils, which is followed by weedy grass invasion, even after the wattle is removed (Yelenik *et al.* 2004). Invasion by Gorse (*Ulex europaeus*) and Montpellier Broom (*Genista monspessulana*) increased fuel loads, and where English Broom (*Cytisus scoparius*) has invaded subalpine eucalypt

woodland with a grassy understorey, it has resulted in a dense shrub layer, higher fuel loads and higher intensity shrub fires instead of grass fires (Downey 2000).

When invasion occurs, it will be difficult to reverse the impacts of invasive species, and the "new" vegetation types being established will require new approaches to management, including fire management. Burning of *Phalaris* may result in undesirable impacts on existing native species due to more intense fires (Butler and Fairfax 2003; Stoner *et al.* 2004). Burning woody weeds such as *Burgan* is unlikely to kill mature plants and *Burgan* is the most likely species to reestablish, so that *Burgan* dominated vegetation is likely to continue indefinitely (Singer and Burgman 1999).

Elevated fuels result in extreme fire behaviour with high rates of spread and high intensities, and current fire behaviour models are not appropriate for vegetation with significant elevated fuels (Catchpole *et al.* 1999). The McArthur forest meters are based on experimental fires in dry forests with open understoreys, and fine fuel loads of approximately 12.5 t/ha (Burrows and Sneeuwjagt 1991), and at the lower end of the intensity range the McArthur forest meters are generally successful at predicting fire behaviour. The McArthur fire meters have been used in a wide range of other vegetation types and situations quite different to the forests for which they were designed (eg Weise and Biging 1997) and the McArthur Forest Fire Danger Meter Mark 5 provides a reasonable estimate of fire behaviour if shrub and litter fuel loads are combined (Buckley 1994), although in these fuels the model usually underestimates fire behaviour. However, the fuel loads in *Burgan*, and in other vegetation types with high fuel loads such as heath, are outside the range of fuel loads which could be modeled using the original meters, and new meters which incorporate elevated fuels, and higher fuel loads are needed. In areas invaded by woody shrubs with high elevated fuel loads, fire behaviour is likely to be more extreme than predicted (Table 1).

Table 1. Indicative impact of increased fuel load on the Fire Danger Index response “triggers” and fire behaviour (flame height and forward rate of spread) using the McArthur Mark 5 Forest Fire Danger Meter for dry forest and dry forest invaded by *Burgan*.

FDI	20		35		50	
Fire Behaviour	FH (m)	FROS (km/hr)	FH (m)	FROS (km/hr)	FH (m)	FROS (km/hr)
Dry Forest (17 t/ha)	7.4	0.4	11.3	0.7	15.5 crown	1.0
<i>Burgan</i> (30 t/ha)	14.7 crown	0.7	21.5 crown	1.3	28.9 crown	1.8

Conclusion

Invasion of native vegetation by both introduced and native species is leading to the development of "new" vegetation types with “new” fuel characteristics. The fuel loads in these vegetation types can be well outside the range of fuel loads used to derive existing fire behaviour models. The impacts of changed fire behaviour and associated increased fire hazard needs to be recognized by both firefighters on the fireground, and landholders as they prepare to survive wildfire. The immediate challenge for fire managers is to recognize the altered fire risks presented by the new fuel types and attempt to incorporate the fuel characteristics into updated models which will satisfactorily predict fire behaviour.

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