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The effects of mechanical disturbance and burn intensity on the floristic composition of two-year old aggregated retention coupes in Tasmanian wet eucalypt forests

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ABSTRACT

Due to concerns about the ecological impacts of clearfelling in Tasmanian wet eucalypt forests, aggregated retention (ARN) was developed as an alternative harvesting method. It is predicted that, compared to clearfelling, ARN will have ecological benefits such as preservation of old-growth structures and improved regeneration of late successional species in harvested areas. However, early studies have indicated that ARN requires lower intensity regeneration burns and results in greater levels of mechanical soil disturbance than clearfelling. This study therefore aimed to assess the impacts of both soil disturbance and burn intensity on floristic composition, species dominance and species richness following harvesting in ARN coupes. Floristic surveys were conducted on six seedbed classes that reflected the combined effects of both burn intensity and soil disturbance in six two-year-old ARN coupes in southern Tasmania. The results showed that both factors had a significant influence on floristic composition. Higher burn intensities generally favoured colonising species such as eucalypts and *Senecio minimus* and resulted in lower species richness, while lower fire intensities favoured species regenerating from the seedbank and resulted in higher species richness. In contrast, mechanically disturbed seedbed generally had a high cover of the sedge *Gahnia grandis* but a low overall species richness due to reduced regeneration of eucalypts and understorey species. The prevalence of the six seedbed classes, and corresponding plant species composition, varied among four general harvesting-related disturbance categories; firebreaks, snigtracks, windrows of piled logging debris and the general harvested area. Maintaining a variety of burn intensities is likely to maximise plant biodiversity within ARN coupes, and soil disturbance should be minimised, with an emphasis on reducing the total area of firebreaks.

1. Introduction

Many forest communities are dependent on natural disturbances such as wildfire for regeneration. Forest harvesting practices are therefore often guided by these natural disturbances, but there is still a concern that many current logging practices may degrade plant communities (Haeussler et al., 2002). For example, many studies have found that the floristic composition of regeneration following logging differs from natural regeneration (Carleton and MacLellan, 1994; Hickey, 1994; Nguyen-Xuan et al., 2000; McRae et al., 2001; Ough, 2001; Rees and Juday, 2002; Haeussler and Bergeron, 2004; Kembel et al., 2008; Ilisson and Chen, 2009), indicating that logging can affect natural patterns of vegetation recovery. Logging disturbance may exceed the range of natural disturbance variability within plant communities (Baker and Walford, 1995) and may therefore alter long term patterns of regeneration and succession (McRae et al., 2001).

Tasmanian lowland wet eucalypt forests have traditionally been harvested using the clearfell, burn and sow silvicultural method (CBS), which involves the removal of virtually all trees from a site (Forestry Tasmania, 2009a,b), with the remaining understorey species felled or pushed over and the logging debris subjected to a high intensity regeneration burn the following autumn (Hickey and Wilkinson, 1999). These forests regenerate naturally following wildfires, and burning has been shown to be important for eucalypt regeneration (Neyland et al., 2009). However, extremely intense fires can kill propagules such as seeds or vegetative organs that may be important for understorey regeneration (Williams et al.,

Abbreviations: ARN, aggregated retention; CBS, clearfell, burn and sow.

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1994; Burrows et al., 2002). Plant species differ in their response to fire intensity, so fire can have a large influence on the patterns of vegetation recovery following logging (Halpern and Spies, 1995; Ashton and Martin, 1996a; Burrows et al., 2002; Purdon et al., 2004).

Wet eucalypt forests are usually harvested using ground-based logging equipment such as skidders and bulldozers that can place significant pressure on the soil (Greacen and Sands, 1980), potentially leading to soil compaction and disruption of the soil profile through churning, rutting, mixing and/or displacement (Williamson, 1990; Rab, 1994; Williamson and Nielson, 2000). Mechanical disturbance can cause changes to soil properties such as increased bulk density and decreased porosity, aeration and infiltration capacity (Kozlowski, 1999). This can restrict plant root penetration into the soil (Heilman, 1981), reduce water uptake (Sheriff and Nambiar, 1995), reduce nutrient uptake (Arvidsson, 1999), restrict oxygen transfer to roots (Kozlowski, 1999) and interfere with the soil seedbank (Grant et al., 1995). Therefore, soil disturbance is often associated with reduced growth rates (Youngberg, 1959; Rab, 1994; Lockaby and Vidrine, 1984; Williamson and Nielson, 2003b) and can create a barrier to seedling germination and emergence (Thill et al., 1979). These changes to the soil may influence post-harvest vegetation recovery (Peltzer et al., 2000; Pinard et al., 2000; Haeussler et al., 2002; Berger et al., 2004; Newmaster et al., 2007). Soil disturbance may therefore be one of the major factors contributing to the floristic differences between natural (post-wildfire) and post-harvesting regeneration in the wet eucalypt forests of south-eastern Australia (Murphy and Ough, 1997; Ough, 2001).

Concerns about the ecological impacts of CBS, as well as its decreasing social acceptability (Ford et al., 2009), led to the exploration of alternative harvesting methods that would minimise harvesting impacts on biodiversity and increase social acceptability, yet still remain commercially viable (Hickey et al., 2006; Gustafsson et al., 2012). The Warra Silvicultural Systems Trial was established in southern Tasmania between 1998 and 2007 in order to test the potential of five alternative harvesting methods (Hickey et al., 2006). Aggregated retention (ARN), a form of variable retention harvesting, has since proved to be the most suitable for general use in tall old-growth wet eucalypt forests in Tasmania (Forestry Tasmania, 2009a,b). In contrast to clearfelling, ARN retains patches of intact forest as island or edge aggregates within the coupe (cutblock or harvest unit) boundaries (Forestry Tasmania, 2009a,b). ARN maintains animal habitat and old-growth structures such as stags (snags) and coarse woody debris and increases mature forest influence over the regenerating coupe area. Importantly, ARN is also still safe for forest workers and compatible with regeneration of eucalypts (Forestry Tasmania, 2009a,b; Baker and Read, 2011). The first operational ARN coupes were harvested in 2004 and ARN is now the predominant form of harvesting in old-growth wet forests in Tasmania (Forestry Tasmania, 2009a,b) with more than seventy coupes harvested to date.

As ARN has only recently been applied operationally, many of the predicted long-term benefits of retention influencing the ecological trajectory of the harvested areas are yet to be verified. Surveys from operational ARN coupes burnt in 2007 indicated that the regeneration burns in these coupes were less intense than in similar CBS coupes, which resulted in a reduced area of intensely burnt seedbed (Forestry Tasmania, 2009a,b). These lower intensity burns were applied in order to minimise the area of fire escape into the retained aggregates (Forestry Tasmania, 2009a,b). Preliminary investigations have also shown that ARN coupes have a greater proportion of disturbed soil than in CBS coupes, primarily due to large firebreaks that are constructed around coupe edges and aggregates (Baker et al., 2009; Scott et al., 2012). Neyland and Jarman (2012) examined the impact of harvesting disturbance on the floristic composition in wet eucalypt forests and identified a probable relationship between harvesting disturbance, burning and the vegetation response. However, the large plot size used in that study incorporated considerable within-plot variation in soil disturbance and burning impact classes. This meant the relationship could not be fully elucidated by Neyland and Jarman (2012).

This study examines the impact of both soil disturbance and burn intensity on the regeneration of vascular plants following ARN harvesting in six two-year old ARN coupes in southern Tasmania, and the impact these factors have on floristic composition, species dominance and species richness. This will be achieved by examining the floristic associations of six seedbed classes (*sensu* Neyland et al., 2009). These classes represent the substrates for plant regeneration and reflect the intensity of disturbance and burning. The relationship between these seedbed classes and four harvesting disturbance categories (snigtracks, firebreaks, windrows of piled logging debris and the general harvested area) will also be examined.

2. Material and methods

2.1. Study sites

The study sites were six two-year-old aggregated retention (ARN) coupes in southern Tasmania: Arve 23E (E485355 N5222746), Esperance 81B (E487942 N5213255), Picton 7C (E478906 N5226919), Styx 4B (E464001 N5257862), Styx 7A (E465664 N5257570) and Styx 18E (E476410 N5259866) (Fig. 1). All coupes were located in State forest managed by Forestry Tasmania, and were harvested in 2006–2007 and burnt and sown in 2007. The three Styx coupes, as well as Picton 7C, were located on Permian mudstone, while Arve 23E was on Triassic sandstone and Esperance 81B on Jurassic dolerite. All coupes were located in mixed forest (eucalypt canopy above a rainforest understorey), although some had multiple fire ages and contained areas of sclerophyllous understorey. There were differences in the pre-harvesting vascular species composition between the six study sites.

2.2. Field survey methodology

In order to assess the impact of soil disturbance and burn intensity on the floristic composition following logging, vegetation

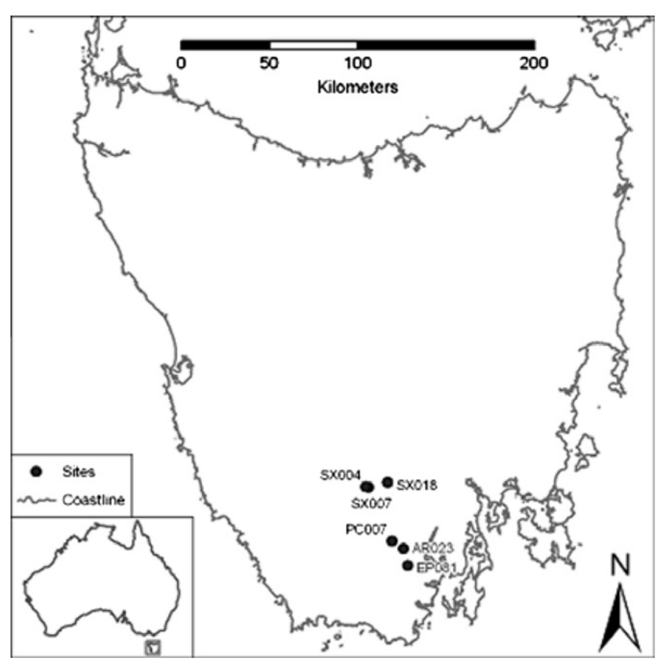

Fig. 1. The location of study sites. All sites are two-year old aggregated retention coupes.