who provided the level of support and information needed to conduct such a study.

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Fire Behaviour in Hardwood Plantations

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Abstract

A large area of hardwood plantation has been established in Australia since the mid 1990s; mainly on short rotations to supply fibre to international paper makers. Common community reaction to these plantations is that they present a greater fire hazard than the formerly cleared agricultural land they replaced. Hardwood plantation fire experience over the last decade has shown that fires in young plantations have not had the intensity or rates of spread expected. Indeed, in the 12 years

since the first reported blue gum plantation fire, the worst area loss was 350 hectares. Most losses have been less than 40 hectares.

The reduced fire behaviour in young hardwood plantations seems related to the way in which the fuel is arranged. Generally there is little ground fuel until the trees are close to harvest age, at which time branches, bark and leaves can accumulate. The most commonly grown hardwood species, Tasmanian blue gum, is self pruning and as they mature there is a separation of ground and aerial fuels, reducing opportunities for crown fires.

Fire behaviour can be more severe where there are grassy or woody understorey fuels, or in second rotation plantations where woody logging debris or coppice thinnings remain.

Introduction

According to the National Plantation Inventory (NPI 2005), at the end of 2004 there were about 716,000 hectares of hardwood plantations in Australia. The dominant hardwood plantation states are WA (259,000 ha), Victoria (168,000 ha) and Tasmania (151,000 ha). Most of these plantations are either Tasmanian blue gum or Shining gum. In the tropics and subtropics, increasing areas of hardwood plantations are being established with a range of eucalypt and acacia species for pulpwood and several other species being grown for sawlog.

As the area of plantations has increased, there has been regional community concern about the level of fire risk these plantations present. Communities have experienced the impacts of fires in native forests and there have been perceptions that hardwood plantations have similar fuel types and therefore similar potential fire behaviour.

This paper is based on actual experiences of fires in hardwood plantations over the last decade and includes observations of fire occurrences in WA, SA, Victoria, Queensland and the Northern Territory. While most of the plantation fire damage has been in first rotation plantations, in the last few years there have been two case study fires in second rotation blue gums. Most of the plantations were blue gums, but the study included fires in tropical acacia and eucalypt plantations.

Factors influencing fire risks

Severe potential fire conditions occur when a number of factors are present coincidentally in time and space. Factors that influence the severity of fire weather conditions include:

- Fuel Moisture – the drier the fuel, the greater the fire hazard.
- Fuel quantity - all other factors being equal, fire intensity will increase in direct proportion to the quantity of available fuel.
- Fuel characteristics and distribution - as the grass cures, its fire hazard increases, but later in the fire season as the grass level is reduced by grazing stock and general breakdown of the organic material, its hazard reduces. Forest fuel includes leaf litter and branches on the forest floor and leafy fuels held aerially in the tree by branches. Crown fires are less likely to develop in plantations where there is separation of the ground fuel and the aerial fuel. This separation is achieved after thinning and also by pruning the lower branches.
- Rainfall deficiencies – forest/plantation fire danger is more severe after long periods of drought. Extended dry periods can result in short, trampled and often discontinuous grass fuels, which may reduce potential grassfire severity.

- Relative humidity – the lower the humidity, the drier the fuel.
- Temperature – hot temperatures dry the fuel and increase the level of fire danger.
- Wind strength – except at low and very high speeds, the rate of spread of a fire varies approximately as the square of the wind speed. In a grassfire, rate of spread increases by four times when the wind increases from 15 to 30 km/hour. Generally wind speeds are lower within plantations because of the protection effect of the trees, resulting in lower forward fire speeds.
- Atmospheric stability – unstable atmospheric conditions favour development of large convective columns above a forest/plantation/scrub fire, which may increase fire intensity, through increased ventilation of the fire, increased wind flow in towards the fire, greater vertical wind currents and therefore more spotting and greater potential for crowning.
- Variation of wind with height – if upper atmosphere winds are strong (winds at 600-1500 metres and above), there is more potential for forward spotting. Strong winds at these levels can be brought down to the surface in short bursts, resulting in more erratic fire behaviour.

First rotation site preparation techniques

Site preparation techniques vary slightly from company to company and depending on topography and region. In general on the Australian mainland, most first rotation hardwood plantations have been established on former cleared agricultural land. Such sites have little or no woody weeds; mostly only grasses or improved pastures and sometimes bracken. Typical site preparation techniques are to rip and mound the planting lines and to spray any weed regrowth on the mounds to ensure a bare earth environment in the first 18 months of tree growth. Normally any grassy growth will be controlled once the trees are 18 month old, but sometimes bracken and occasionally woody weeds can grow back later. Generally this means that most plantations have very little ground fuel in the early years.

In Tasmania, some hardwood plantations have been established on former native forest sites. In such areas, woody weeds can be more difficult to control, sometimes resulting in a shrubby understorey more typical of native forests. Fuel loadings can therefore be higher than in plantations established on former agricultural sites, leading to potentially higher rates of spread in the event of a fire.

Local government or regional forestry Codes of Practice require that plantations are surrounded by firebreaks and sub-plantation areas (compartments) have trafficable access tracks that act as firebreaks.

Second rotation site establishment techniques

Felling of Western Australian blue gum plantations began about six years ago. While a good deal of harvesting experimentation occurred in the early years, there are now mainly three site types resulting from different logging techniques:

- Sites where trees have been de-limbed and debarked where they are felled, with debarked logs forwarded out to log dumps on compartment firebreaks. Such sites have high levels of logging debris remaining across entire compartments, but little debris on compartment fire breaks. Re-establishment can be by coppice or else the debris is blanket burnt to enable a clean site for seedlings to be planted. Clearly for the coppice option, this site type can have very high levels of woody harvesting waste left on the plantation floor, made worse as the coppice is thinned and dry stems add to the ground fuel, leaving high fuel loads.

- Sites where the trees have been felled and then skidded to mobile processors near the compartment edge where the trees are de-limbed, debarked and cut to required lengths. Such sites are left with long windrows of debris about 15 metres inside two opposite edges of the compartment. This method leaves the compartment generally free of logging debris, but the windrows on compartment edges need to be burnt at the time of site establishment.
- Sites where the trees have been felled and then bunched and skidded to an in-field mobile whole tree chipper. Bunches of trees (with their branches retained) are fed into a flail de-limber at the entrance to the mobile chipper. The chipper normally stays in one location for several days. Each chipper site is left with a large heap of macerated debris; ie. bark, branch and leaf material removed from the trees by the flail de-limber and from the chipper screening system. Normally there are only one or two of such heaps left on the firebreaks in each logging area (depending on how often the mobile chipper needs to be re-positioned). These heaps need to be burnt at the time of site establishment.

The second two options commonly leave a clean planting site and ground fuel types in the second rotation plantation will be low.

Re-establishment can be by coppice (requiring later thinning back to one or two stems per stump) or by seedlings. It seems most managed investment scheme companies intend to re-establish their properties using seedlings, rather than the coppice method. Where seedlings are used for re-establishment, sites generally are left with low levels of woody fuel on the plantation, somewhat similar to first rotation sites. However, where coppice methods are used for re-establishment, fire risk is significantly higher.

Observations from case study hardwood plantation fires

Following investigations of 30 fires in hardwood (mainly blue gum) plantations on mostly former cleared agricultural land that have occurred since 1994, a number of observations have been made. These case study fires were in six plantation regions across four states (WA, NT, SA and Victoria) and include most of the blue gum plantation fires in Australia and all of the serious fires affecting blue gums.

Observations from the 30 case study fires were:

1. In the 12 years since the first reported blue gum plantation fire in Australia (Parker 1994), the worst area loss was on 9th April 2005 in western Victoria. On a day of Extreme Forest Fire Danger, that fire burnt 350 ha of six and seven year old plantations (Crowe and Sheldon 2005). A very hot fire in high fuel load native forest changed to a fire of significantly reduced intensity when it entered the blue gum plantation. Part of the reason for the large plantation loss, was an inability of initial attack as the fire entered the blue gums because of multiple spotting from the adjacent native forest, creating a potential safety risk for fire fighters.
2. The next largest area loss was in Gippsland in February 2003. About 250 hectares of a low quality 10-year-old plantation was burnt. Despite high

grass loads in the plantation, fire behaviour was mild until it exited the blue gums and entered a pine plantation, at which stage fire behaviour became extreme with multiple crown fires, very high flame heights and severe destruction in the pines.

3. Plantation area losses of greater than 100 hectares occurred in only three of the 30 fires. In those cases, losses in other vegetation types exceeded thousands of hectares.
4. Area losses in more than 85% of the fires observed were less than 40 hectares. In 10% of cases, this was due to small-scale plantations caught in the path of large wildfires. In 45% of cases, the mild fire behaviour in the hardwood plantations was a contributing factor to the fires being brought under control. In several of the case fires, the fire went out in blue gum plantations without any human intervention, due to lack of fuel!
5. About 75% of the fires occurred on days when the Forest Fire Danger was Very High or Extreme. Under such conditions, plantation losses would normally be expected to be severe (Vercoe 2003).
6. Two of the case study fires were in second rotation blue gum plantations where coppice techniques had been used for re-establishment. In both cases, fire behaviour was much more intense than in similar age first rotation plantation fires. Both coppiced plantations had high ground fuel loads from the logging debris remaining after harvesting and from recently thinned coppice stems. Severe damage to the trees occurred in both cases.

Drawing on actual fire behaviour in the 30 hardwood plantation fire case studies, and from discussions with fire fighters who observed actual fire behaviour in the plantations in several of the more serious fire losses, there are a number of generalisations that can be made.

Where blue gums have been established on formerly cleared agricultural land, fire behaviour is different to that in grassland, pine plantation and native vegetation fuel types. Normally rates of spread are lower and spotting is not common. Fire behaviour is likely to be more severe in a hardwood plantation where there is a large amount of grassy fuel understory.

There is a difference in the fire spread into a young blue gum plantation, depending on row direction relative to the fire travel. It is likely rows perpendicular to the fire direction provide a better barrier to fire spread than rows parallel to fire direction. Where rows are in the same direction as the fire, grassy fuel between the rows may enable a fire to carry for short distances.

In older blue gum plantations, fuel loads increase due to leaf fall accumulation and branch shedding. Higher growth-rate plantations accumulate such fuel at an earlier age. Such fuel loads can allow the fire to easily spread through the plantation and on upward sloping terrain, crown fires can occasionally occur (Boness and van Etten 1996). Short distance spotting may occur. An example was a fire in January 2006 near Dwellingup in Western Australia. A wild fire was able to carry through about 135 ha of a nine-year old plantation, largely because of the leaf litter on the forest floor. There were several minor areas of spotting, mainly on uphill slopes.

The evidence from the case study fires suggests that large-scale young blue gum plantations have the ability to slow a wildfire on Extreme Forest Fire Danger (FFD) days.

However there will be some plantation losses, depending on the intensity of the fire entering the plantation. For large wildfires, it is reasonable to assume that the compartments on the leading edge of the fire strike could be burnt. For example, in the Valley View fire in December 2000 (Braun 2002) about 25% of the plantation area was burnt, but this three-year-old plantation arguably saved the township of Mount Barker from serious destruction, despite no fire fighting activity taking place in the plantation. Similarly, a blue gum plantation in the Grampians in western Victoria largely survived a major wildfire in January 2006, with damage to the leading fire edges. The blue gums were virtually the only vegetation type to survive in the 25,000 ha fire.

It could be expected that the parts of blue gum plantations burnt on a severe FFD day would be killed. However, depending on the intensity of the fire, many trees may have scorched leaves without being killed. In milder fire conditions, there is a good chance of tree survival from a wildfire. Experience has shown that blue gum trees will either die or the wood will be too badly damaged for eventual sale if the cambium has been damaged. Some post fire indicators of cambium damage are:

- Complete leaf scorch – usually indicating the fire has been hotter. When some green leaves still remain on the tops of trees, there is a chance the tree will survive the fire.
- When lower branches are burnt off the tree, heat is normally enough to damage the cambium. Also, when branches are burnt off the tree, it is likely there will be charcoal left inside the stem that is difficult to remove at time of harvesting. Woodchip customers have very low tolerances for char. In cooler fires, lower branches can survive without being burnt off the tree.

Fire behaviour in open areas within plantations (such as creek lines, swamps or dead patches of trees) may be similar to grass fire rates of spread due to increased grassy fuel and increased wind.

If a fire enters a second rotation plantation where there is logging debris remaining and coppice thinnings, fires are likely to be too intense to allow any fire fighting activity within the plantation. It is likely that crews will only be able to contain the fire at compartment tracks.

Why is fire behaviour less severe?

In the case studies, fire behaviour had been less intense in young hardwood plantations than many firefighters had expected. In order to cause severe damage, fires require a combination of high fuel loads and wind to drive the fire. Wind within plantations is reduced by 33-50% of the wind external to the plantation. Fuel loads in well managed young blue gum plantations with good weed control and an absence of woody debris on the forest floor, are lower than open pastures and significantly lower than native forests. Further, ground fuel in plantations aged less than seven years is often discontinuous, providing in effect a series of mini firebreaks within the plantation. In older plantations there is a gap between ground fuel and the crowns, reducing the chances of crown fires and leading to similar low intensity fire behaviour such as in well-thinned pine plantations.

It is known that a number of fires have been stopped by firebreaks and have not entered the plantations. Managers in several regions have also mentioned that lightning strike fires have started within blue gum plantations, but have not developed due to lack of ground fuel. These incidents are not included in the 30 case study fires.

Despite the low area losses to date, fire authorities should not become complacent when dealing with blue gum fires. When drawing conclusions from case studies there is a need to recognise fire experience in blue gum plantations is still at a relative early stage and there is still not a good balance of data from spring, summer and autumn fires. There is still potential for much higher losses than have been experienced, particularly in older hardwood plantations where leaf litter and dry branches accumulate on the ground. Further, all except two of the 30 case study fires were established on formerly cleared agricultural land.

Where plantations have been established on former native forest sites, understory fuel levels can be more like in a native forest (Gould, McCaw and Cheney 2001). Depending on harvesting techniques, woody ground fuel loads may be high in second rotation plantations, giving rise to more severe fire behaviour (Wettenhall 2003).

Conclusions

Plantation fire risk factors include fuel loading, separation of ground and aerial fuels and suppression difficulties at different plantation stages:

- In very young first rotation blue gum plantations there is very little grassy understorey due to normal plantation weed control silvicultural practices. Fire behaviour is much less severe than a grass fire due to low fuel loads.
- In young plantations (age two to six years) there is little understorey fuel and low wind speeds. Fire rate of spread is very low, but it is possible for a fire to travel slowly under the plantations unless there is some direct action. There will be places where there is very little grassy understorey or leaves on the ground where the fire may extinguish itself, particularly if combined with a downhill fire run.
- In older blue gum plantations (age 7-12 years) there is a build-up of bark and branches on the forest floor, increasing fuel loads. Fire rate of spread is moderate, but crown fire potential is unlikely except on uphill slopes.

Where hardwoods have been established on formerly cleared agricultural land, plantation fires will be less intense than in pine and native vegetation types and slower spreading than in fully cured grasslands. However, caution must be taken in comparing past fires. Most large blue gum fires have been in plantations where the grassy or shrubby understorey has been almost non existent. If dry grass or woody shrubs are present under plantations, it is quite likely fire behaviour will be more severe.

Depending on prior harvesting techniques, second rotation plantations also have a higher potential rate of fire spread because of the higher quantity of wood debris.

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Fire Protection of Victoria's Broadacre Agricultural and Plantation Assets

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Abstract

Recent pictures of farmers disposing of burnt stock, grain crops turned to ash and blackened timber plantations are harsh reminders that fire remains a significant threat to agricultural enterprises.

To reduce the incidence of these fires in Victoria, Country Fire Association (CFA) is developing fire management guidelines focused on fire protection in cropping, grazing and plantation timber industries and those living on small rural farm blocks.

These draft guidelines titled 'On the Land' (CFA 2006) provide a practical framework for fire management on private land; identifying key fire management objectives for consideration by all property owners and managers and providing advice on industry good practice and regulatory requirements where relevant.

A draft of 'On the Land' is available for public consultation until the end of November 2006 and the finalised document should be available for public distribution early 2007.

Introduction

CFA has a legislative responsibility to prevent and suppress fire in Victoria. CFA has 56,000 volunteers, 1100 staff and about 2,500 purpose designed rural firefighting appliances.

To further reduce the incidence of wildfire, as part of a state-wide response to the recent Victorian Bushfire Inquiry following the 2002/03 Victorian bushfires, there are two projects that are being currently undertaken that will impact on fire management on rural land in Victoria.