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SOME CHARACTERISTICS OF MAJOR FIRES IN CONIFEROUS PLANTATIONS*

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Fires in softwood plantations seem to have acquired—rightly or wrongly—somewhat of an awesome reputation, and it probably is correct to say that, wherever plantations have been established in the Mediterranean environment in the Southern Hemisphere, the number of really successful suppression actions in conditions of bad fire weather has been remarkably small. This is clearly a challenge for the current generation of foresters to take up.

It is aimed here to discuss and summarise briefly some of the characteristics of fire behaviour experienced in plantations in South Australia (largely with Pinus radiata) in the past decade or so and to indicate some of the ways in which this experience is being transmitted into fire suppression tactics, and some of the strategic and economic aspects of fire control.

Fire behaviour is broadly determined by the weather, the topography and the fuels, the first two of these are mentioned only very briefly and the last is discussed in greater detail.

There are, of course, various gradations and characteristics of bad fire weather, but for this discussion the Fire Danger Classification of "Very High" and "Extreme" as computed from McArthur's Forest Fire Danger Index is sufficient description of the weather factor.

Topography can play a vital part in determining fire behaviour variations, but unless specific mention is made, the behaviour patterns discussed here apply to flat or gently rolling topography. Broken topography, of course, accentuates erratic fire behaviour.

The fuels available for burning in softwood plantations vary greatly with the stages of growth, and some form of classification is desirable. The vertical distribution of the fuels is the important thing and the classification given here reflects to some degree the variations in characteristics and quantity of the ground fuels in relation to the nature and vertical continuity of the aerial fuels.

The fuels can be grouped as follows:—

(1) Juvenile plantations — from time of establishment to canopy formation.

(2) Developing plantations — from canopy formation to age of first thinnings.

(3) Middle aged plantations — 1st, 2nd or 3rd thinned stands.

(4) Old stands at or near final crop stage.

(5) Open slash following clear felling.

* Adapted from a lecture delivered to Forests Commission of Victoria Staff Fire Protection Conference, August 1963.

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The first four categories can be further subdivided according to:—

(a) The presence or absence of significant quantities of weed species.

(b) Whether or not the stand is pruned or unpruned.

Also too, patches of categories (a) and (b) in the form of clumps of regeneration may occur in categories (b) and (c).

All these aspects refer to differences within any one species, but there are, of course, significant differences between species, depending on variations in needle size and arrangement; branching habit; the rate of disintegration and "packing down" of the litter; the "flakiness" of the bark; the combustibility of the green foliage, etc.

In addition to these factors, and irrespective of both the phases of growth and the species concerned, the broad overall arrangement of the forest fuel can have a bearing on plantation fire behaviour. Hence the design and layout of the plantations, and the continuity of the various fuel classifications, must also be considered.

FLAME HEIGHTS, SPOTTING POTENTIALS AND RATES OF SPREAD

In Table 1 certain fire behaviour features, viz. flame height, spotting potential and rate of forward spread, for the main fuel classifications listed above are recorded briefly.

SHAPES OF MAJOR FIRES

Plantation fires usually start as ground fires and, if conditions are suitable, rise to the crowns after moving forward a chain or so. The initial run of the head fire is on a narrow front. As the fire becomes larger, the head becomes wider due to the surging movements of the high intensity flame fronts. The flame surges are accentuated by the incessant wave-like oscillations of the strong winds about their mean direction.

As the head fire drives forward, there is an obvious tendency for separate narrower heads to develop within the principal headfire. This occurs even in relatively uniform fuel conditions on flat land. Broken topography and non-uniform fuel accumulation accentuate this tendency for multiple head fires to develop and a distinct bifurcation of the fire can result in these circumstances.

Characteristically, in most areas of Southern Australia during the bad fire weather immediately preceding the passage of a cold front, the mean wind direction swings slowly from North to North-west and West, and hence fires tend to be banana or pear shaped.

FIRE STORM FORMATION

A "fire storm" results from a very rapid increase in fire intensity during which a strong convection column is built up.

For a given rate of spread the fire intensity is directly proportional to the quantity of fuel which is burning (providing the fuels give rise to a reasonably constant yield of heat) and, in favourable atmospheric conditions, even small additional quantities of fuel, or changes in its arrangement, can trigger off fire behaviour intense enough to give rise to the high convection column and its associated high surface winds and strong up-draught velocities.

TABLE 1

Fire Behaviour in Very High and Extreme Weather Conditions

Flame Height	Spotting potential	Rate of forward spread (Average bad conditions FFDI = 50)
(a) Juvenile Plantations		
Almost always tree height and often greater.	Low in very young plantings unless slash from previous crop is present; at or near canopy formation much higher.	Depends on fuel quantity; in very young plantations, with little or no auxiliary vegetation, low; following second spring, usually much auxiliary vegetation, and R.O.S. high, probably 200-500 chains per hour.
(b) From canopy formation to age of first thinning.		
Usually tree height or greater. When pruned, the slash usually has not compacted enough to create a large enough air barrier between ground and crown. Fire runs up unpruned stems because of needles caught in "elbow" between branch and trunk.	Moderately high.	Dense fuel type with little chance for wind entry at ground level; of order of 20-80 chains per hour with higher values where crown fires are throwing spots well ahead.
(c) Middle aged stands.		
Ground fires with flames 10-20′ only are possible in pruned stands where slash is not heavy and is well compacted.	Low	20-40 chains per hour.
Crown fires occur frequently in unpruned stands and where thinning slash is high and widespread.	High	60-80 chains per hour.
(d) Old well-thinned stands at or near final crop stage.		
Ground fires are usually maintained with flame heights 10-20′. However, patchy crown fire development occurs where heavy ground fuels or patches of regrowth are able to lift the flame height close enough to the green level.	Moderate, reduced by the filtering effect of the crowns.	Varies quite widely, say 30-70 chains per hour, with higher rates where intermittent crowning occurs, or where stockings are low enough to allow greater ingress of wind.
(e) Slash after clear-felling.		
Fire intensity and flame height vary with quantity and condition of slash. Old slash with needles fallen from limbs burns less fiercely.	Very high with marked tendency for whirlwind development.	High, may exceed 80-120 chains per hour.

Fire storms may also be caused when adjacent fires draw together. This may occur most commonly when:—

(1) The topography and/or fuels split the fire into two distinct heads;

(2) Attempts at line-firing or back-firing go awry.

In South Australia, the Wandilo tragedy of 1958 was brought about by the sudden development of an intense fire storm which was triggered off by the differential movement of two fires heads moving at different speeds in different fuel types and then their drawing together to form a junction zone of great intensity.

MASS SPOTTING

The high convection column of a fire storm causes spotting downwind on a mass scale. In the case of Wandilo, spots were thrown as far as a mile and between 500 and 600 acres were ignited almost simultaneously.

Mass spotting on a smaller scale can occur in other circumstances. For example, a fire crowning vigorously up a slope will frequently throw thousands of spots well beyond the crest of the rise. If the receiving fuel is "ripe", mass ignition will result. Mass ignition of this type is very conducive to crown fire formation and a severe burn-out.

Spotting distances for upwards of a mile from crown fires in radiata pine have been authenticated on several occasions. The materials thrown are usually portions of cones, flakes of bark, or pieces of twig.

WIND SPEED AND THE PLANTATION FIRE

Inside the average plantation, wind speed near the ground is of the order of one-fifth of the speed in open unforested land. Consequently the rates of fire spread are slower for comparable fuel quantities.

Breaks of the order of an acre or more in the forest canopy which may be due to swamps, areas of soil too shallow to plant, wind blow, etc., etc., are of sufficient size to allow the stronger wind above the tree tops to drop into the gap. Consequently, down wind of these canopy openings, the wind strength is greater and fire intensity is often correspondingly more severe. In plantation fires, when conditions favour intermittent crowning, severe crown fires are almost invariably recorded downwind of these gaps.

These observations are one of the reasons for being suspicious of the value of firebreaks of two or three chains width, and they also point to the value of leaving edge trees unpruned to ground level in order to reduce the wind speed inside the stand where such wide gaps cannot be avoided.

POINTS TO CONSIDER IN PLANTATION LAYOUT AND MANAGEMENT

In order to reduce fire losses and to give suppression crews a better chance of success, the following conclusions have been drawn from consideration of the aspects previously described.

As much access for vehicles as is economically possible should be provided. Generally the access needed for effective logging is enough, and it is best provided from the time of establishment rather than from the time of first thinning because it is prior to this stage that the plantation as an investment is most vulnerable to loss by fire.

Within the stand, pruning provides better access for hand tool workers, and also provides an air barrier between ground and aerial fuels to lessen the chance of crown fire formation.

Reliance on fire breaks as such, should be confined to locations close to the sources of likely ignition, or against grass country. Within large areas of plantation, "fire breaks" can be limited in width to ½ chain or less, their main function being to provide access and to delineate compartments. On breaks as narrow as this, pruning of edge trees has no disadvantage.

Where fire breaks are necessarily considerably wider (because of public roads, etc.), edge trees should not be pruned in order to reduce wind speed inside the plantation and to provide a green barrier against thrown sparks which would otherwise fall on needle litter.

There is merit in keeping young plantations, which are so vulnerable and in which fires are so difficult to control, well spread among the "safer" older stands. This will tend to spread the losses of timber over a wide range of diameter classes should a fire eventuate and so reduce the management problem after the fire, in that uneven distribution of future log sizes is eased if not circumvented.

Good fire protection requires that the older "safer" stands should be capitalised upon and chosen blocks or areas should be made as "crown-fire-free" as is economically possible. Such areas, where big enough, represent the best chance and probably the only one of stopping the headlong rush of a crown fire within the forest area. First, the fire must be brought to the ground, and then ground fires inside plantations can be successfully fought with modern equipment.

SOME POINTS ON SUPPRESSION TACTICS

Once a fire is too large for a quick knock-down by the first attack unit—it is necessary to plan immediately for a big fire and direct attention to keeping the area lost to a minimum. The biggest devourers of area are the fire flanks—not the head. Hence immediate concentration on tackling the flank fires from the origin towards the head (giving priority to the eastern flank) is recommended. Suppression action on the flanks should do everything possible to limit the development of secondary head fires from the flanks as the wind gradually shifts its mean direction.

The history of back burning in the heat of the day in plantation fires in South Australia is a sad one although successful efforts have been made in the early evening and night. However, even in most of these cases, less area would have been lost if trained men, even with only hand tools, had been available to work directly on the fire edge.

Analysis of a number of fires indicates that there is very little evidence to show that back burning in the heat of the day has enabled fires to be controlled earlier, and that less total area had been lost, as compared with less dramatic tactics. The evidence, on the contrary, points to the reverse.

Fighting the flanks of crown fires in plantations is too hot for direct attack unless water under pressure is available along the length of the fire edge.

South Australian experience to date indicates that 20 g.p.m. at the nozzle is adequate in average plantation fuels. This implies, of course, long hose lays and a well organised system of maintaining adequate water up to the nozzle.

All action with water must be followed up by a physical separation of burnt from unburnt material, achieved either by mechanical means or by the use of hand tools. The rake is still perhaps the most valuable of all tools for plantation fire suppression.

Action to attack the heads of crown fires can only be justified where it is possible to take advantage of a reduction in quantity or changes in the type of fuel. Otherwise it is better to do nothing more than watch it from a safe distance and use all available equipment on the fire flanks.

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REFORESTATION OF FORMER FARM SITES ON THE NORTH COAST OF NEW SOUTH WALES

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SUMMARY

The re-establishment of Eucalyptus grandis (Flooded Gum), saligna (Bluegum) and pilularis (Blackbutt) on former farm sites can be carried out successfully and economically at Coffs Harbour by the planting of suitably raised nursery stock. Removal of grass in strips and associated cultivation is necessary site preparation.

Spot sowing succeeds if the seed is dieldrin-dusted but is less reliable than planting. Growth of planted seedlings on such sites may exceed 10 feet in height by the end of the first year, but this is achieved only if nitrogenous fertiliser is applied in the year of planting.

Provenance trials have shown that there is no major genetic improvement in the Eucalyptus grandis growing stock which gives fast growth in plantations in South Africa as compared with the low growth rate in native forests in Australia.

In the first year of growth on grassy sites at Coffs Harbour insect attack is usually at a low level and generally plays little part in reducing the growth rate at that stage.

It is likely therefore that the poor growth in Australia in the first year under such conditions is due mainly to nutrient limitations and not losses due to leaf-eating insects.

INTRODUCTION

During the last twenty years a considerable amount of research has been carried out by the New South Wales Forestry Commission in growing the North Coast timber trees Flooded Gum and Blackbutt. In general this work has been on forest sites from which many of the mature trees have been removed but which at the same time have not been degraded by gross changes in the vegetation cover. Early trials with Eucalypts in the late thirties were mainly by planting, but subsequently a technique of spot sowing was developed on areas which had first been logged, then clear-felled and burned. This has proved very successful with Flooded Gum and has been much cheaper than by planting with tubed nursery stock.

In 1958 A.P.M. Forests Pty. Ltd. commenced experimental work on the establishment of commercial plantations of Eucalyptus in the Coffs Harbour region. The aim was to determine the techniques necessary for the successful establishment of Flooded Gum, Blue Gum and Blackbutt to be managed on a short rotation for pulpwood production. The areas chosen for these trials were degraded, unproductive farmlands which, prior to conversion to farming, had been forested with typical North Coast hardwood species.

During the past five years the writers have been associated with this work in co-operation with the company and progress results are presented in this paper.

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