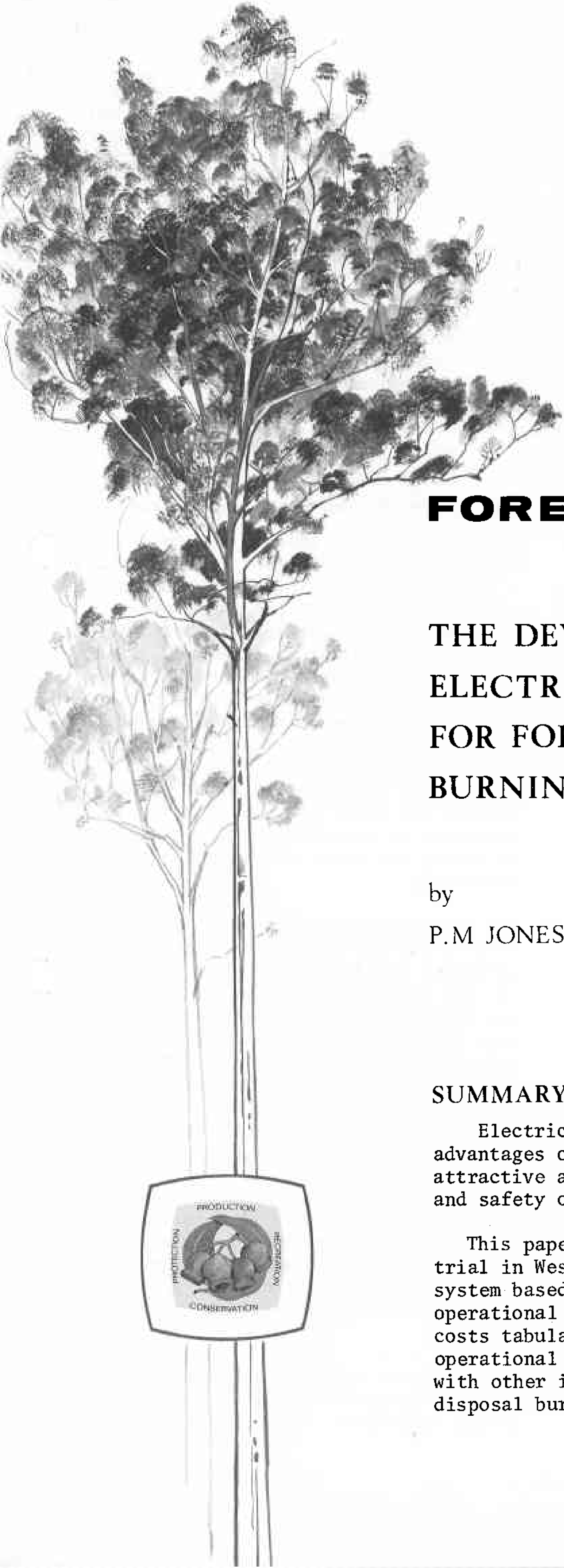

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FORESTS DEPARTMENT
OF WESTERN AUSTRALIA

THE DEVELOPMENT OF AN ELECTRICAL IGNITION SYSTEM FOR FOREST REGENERATION BURNING

by

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SUMMARY

Electrical ignition of logging slash has advantages over manual ignition which make it attractive as a means of improving the efficiency and safety of forest regeneration burning.

This paper describes the development and field trial in Western Australia of an electrical ignition system based on a Tasmanian device. Suitable operational techniques are discussed and associated costs tabulated. The system has proved fully operational and its use is recommended in conjunction with other ignition techniques for future slash disposal burns.

INTRODUCTION

In 1975 the Western Australian Forests Department extended timber cutting in the south-western forest region of the State from pure karri (Eucalyptus diversicolor F. Muell.) to mixed karri-marri (Eucalyptus calophylla R.Br.). This virtually doubled the area requiring regeneration treatment each year to approximately 3000 ha.

Karri regeneration burning requires an intense fire to remove heavy fuel accumulation, produce suitable seedbeds and induce seedfall from seed trees present.

As suitable days for this type of fire are limited, and the increased areas have increased the pressure of work, new methods were needed to extend the capacity of Forests Department fire resources. This requirement initiated research into various ignition devices and techniques. Electrical ignition was one of the techniques tested.

The advantages and disadvantages of electrical ignition as set out hereunder have been described by Schimke et al. (1969) and Chuter and Felton (1972).

Advantages

Safety - it eliminates the need for men to be moving through a hazardous environment of fire.

Night burning - it permits burning at night when conventional lighting techniques could be dangerous or time-consuming.

Reduced lighting time - it provides instantaneous ignition with the additional advantage of a more intense fire.

Manpower distribution - it releases men from lighting duties, thus making them available for suppression work.

Disadvantages

Reduction in flexibility - once circuits are laid the controller is committed to a particular firing pattern unless he resorts to manual ignition.

Possible damage - circuits are susceptible to damage by animals, people or natural fuel movement stretching and breaking the wire. Constant checking is therefore necessary, with the possibility of time-consuming repairs.

Premature detonation - there is a remote chance that circuits may be detonated by lightning or radio transmission.

The development and application of electrical ignition to Western Australian Forests Department requirements are outlined in this paper.

PROCEDURE

Incendiary development and testing

Manufacture - The initial impetus for the Western Australian trials was provided by a Tasmanian device (Hodgson, personal communication). It consisted of a polythene bag containing 25 g of blasting powder and an electric fusehead. This was then rolled into a cigar shape and attached to another polythene bag containing a commercial fire lighter. On detonation of the fusehead the blasting powder ignited, burning long enough to set fire to the fire lighter which in turn ignited the fuel. Many of these incendiaries were manufactured and tested, revealing two major problems requiring resolution.

(1) The blasting powder burnt so rapidly that it did not consistently melt the polythene and ignite the fire lighter. To rectify this it was necessary to decrease the burning rate of the blasting powder or more closely associate the fire lighter with the blasting powder. Mixing 1 g of fine-grained aluminium dust with the blasting powder provided the solution. The dust coated the blasting powder granules, partially insulating them from one another. This reduced the ignition time from an instantaneous explosion to a fuse lasting approximately three to five seconds (Fig. 1). The addition of the aluminium dust meant that the quantity of blasting powder could be reduced to 12 g and still ignite the fire lighter in virtually 100% of cases.

(2) The fire lighters used consisted of kerosene encapsulated in the microcells of a foam structure. This is a common type of

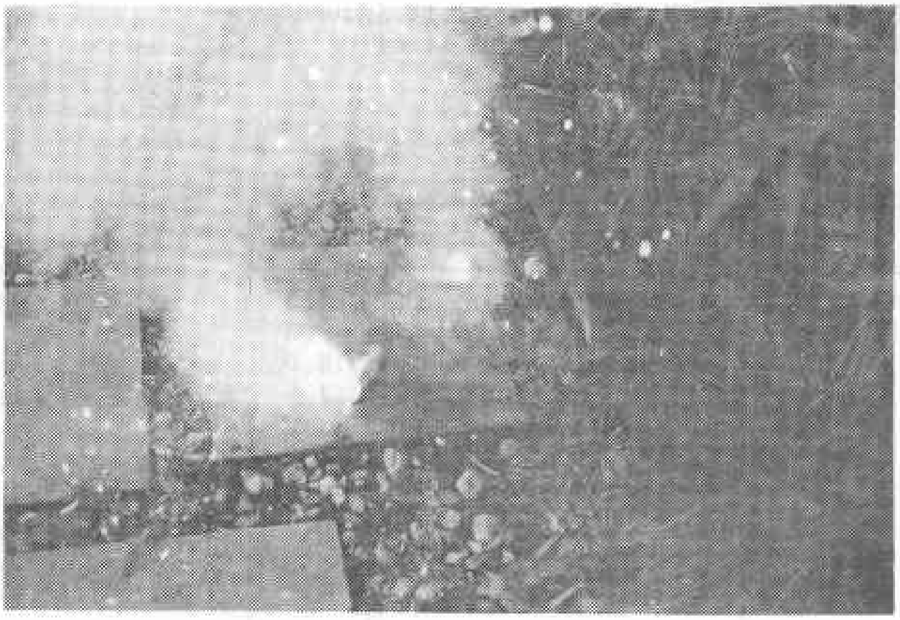

FIGURE 1: Two incendiaries showing blasting powder burning immediately after detonation.

fire lighter and is available in at least three proprietary brands. After several weeks storage the kerosene had vaporised from the foam and penetrated both polythene bags. This led to the breakdown of the match-head compound on the electric fusehead, dampening of the blasting powder and the destruction of the weatherproof sealing of the incendiary. Any one or a combination of these factors was sufficient to cause a misfire. The problem was solved by replacing the polythene of the fire lighter wrapping with cellophane. Cellophane is impermeable to kerosene, thus preventing its vaporization and consequent loss. Without it however, fuel loss would amount to 35% after 60 days in a storage environment of 35% relative humidity and 21°C (Muraro, 1970).

Although other incendiary devices reported on (Chuter and Felton, 1972; Schimke et al., 1969) used diesel-gel blivets, the use of commercial fire lighters was selected as superior for these tests because:

(1) they are more readily available;
(2) they are cheaper;
(3) they are less dangerous;
(4) they are quite adequate for igniting fine fuel.

Diesel-gel burns for longer periods and creates a more intense fire than commercial fire lighters, so would be advantageous for the ignition of coarse fuel particles such as heavy sticks. However, the need to ignite this type of fuel in isolation rarely occurs in the stands under consideration where there is much fine fuel which, when lit, emits sufficient heat to ignite heavier material. A special device was therefore unnecessary.

The improved incendiary comprised 12 g of blasting powder, mixed with 1 g of aluminium dust, and an electric fusehead, all placed in a 100 x 150 mm polythene bag which was then rolled into a cigar shape. This was attached to a cellophane bag, containing 12 g of crushed fire lighter and also rolled into a cigar shape. The two components were then placed in a 100 x 150 mm polythene bag which was then sealed with cellotape to make it weatherproof.

Storage properties - shelf storage of the incendiaries presented no problems as one year after manufacture they showed no sign of deterioration. For safety reasons, however, it is advisable to restock the annual requirement in spring rather than store from year to year.

In the field incendiary durability depended chiefly on climatic conditions. Incendiaries in the field have remained active after two months of exposure to summer weather and 25 mm of rain which fell in short heavy showers. Exposure during winter when the incendiaries were continuously wet, however, led to their breakdown after two weeks.

Cost - the cost of one complete incendiary is 41.5 cents. Details are itemized in Table 1.

TABLE 1

Quantity	Materials and labour	Cents
12 g	blasting powder	1.5
1 g	aluminium powder	0.5
1	electric fusehead	18.0
12 g	fire lighter	1.0
2	100 x 150 mm polythene bags	1.5
1	100 x 150 mm cellophane bags	0.5
130	incendiaries in 1-man day @ $24/day	18.5

Ancillary equipment

Equipment required to set up, test and fire a circuit needed no further development as suitable equipment was already available (Fig. 2).

The following equipment was used, adapted from the list outlined by ICI (1967).

Connecting wire - for joining the incendiaries to the electric current source along the desired ignition line. British Standard Wire Gauge No. 25 plastic-coated copper wire which has a resistance of 8.5Ω/100 m was used.

Circuit tester - for testing circuit continuity before firing is attempted. The Nobel Blast-O-Meter was used for these trials. It is a galvanometer capable of measuring a series circuit resistance of up to 1000Ω. The Nobel 'Detometer' (Nobel Notes, 1975) could be used as an alternative. It is more robust, having no moving parts, but has a lower capacity, measuring circuit resistance only to 300Ω.

Blasting machine - to generate the current for firing the electric fuseheads. The Beethoven Dynamo Condenser is the most powerful available and was selected for these trials as the most suitable. It has a rated capacity of 100 fuseheads in a series circuit and 200 in a series-parallel circuit (Nobel Notes, 1976).

For a series circuit this represents a resistance of approximately 250Ω. This machine has an inbuilt safety factor (Pine, personal communication) consequently its potential is much higher than the other machines available. Field trials have shown the Beethoven can overcome a resistance of 650Ω and Chuter and Felton (1972) put the figure at 800Ω, more than three times the rated capacity. Tests have shown that for the karri forest where the maximum coupe size is limited to 200 ha, only rarely would a circuit need to exceed 2000 m in length. With an incendiary spacing of 25 m, this would mean 80 incendiaries and a total circuit resistance of approximately 320Ω. Consequently the rated capacity can be adhered to.

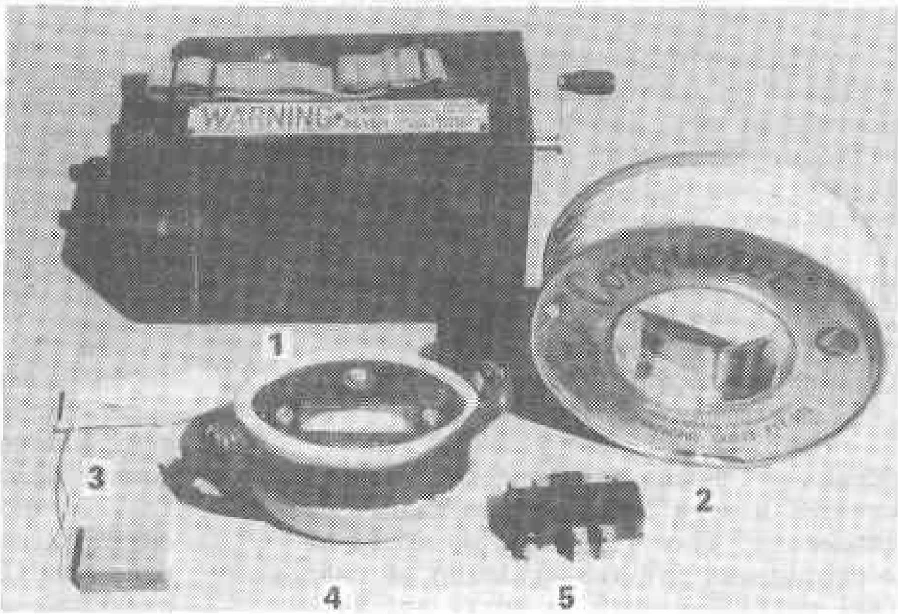

FIGURE 2: Equipment required for electrical ignition. 1, "Beethoven" blasting machine; 2, connecting wire; 3, incendiary; 4, Circuit tester; 5, fusion tester for the blasting machine.

A fusion tester is available to ensure the Beethoven is working at its rated capacity. Tests should be made immediately before use to avoid misfires caused by a faulty blasting machine.

For smaller circuits of up to 100Ω total resistance the "30 shot" rackbar type exploder would be quite suitable if the Beethoven were unavailable.

Circuit design

For this type of work it is possible to use series, parallel, or a series-parallel combination in circuit design. Parallel circuits require less power to detonate than series circuits, but power is rarely a limiting factor so this was not significant and as parallel circuits are more difficult to lay out, calculate the resistance of, and check, than series circuits, their use was not contemplated for these trials.

Wire laying

A ground plan or aerial photo of the planned burn is essential to:

(1) select the best design layout for the circuits;
(2) estimate total circuit length for material requirements, and resistance calculation.

For these trials a ground plan was used. Aerial photographs were not available although they are preferable, and have since become more readily available. Aerial photographs show internal snig track layout which could be helpful in circuit design. Scale is sometimes difficult to calculate, however, therefore a survey may be useful. A pace and compass survey is sufficiently accurate and speedy; it is possible to survey a 50 ha area in one hour.

Care needs to be taken to ensure wire layers traverse the planned route, as deviations may leave unfired gaps. A compass bearing proved the most suitable way to achieve this.

Connecting wire was laid out from a spool over the fuel on the desired route. A backpack device for laying wire was tested, but was unsatisfactory because it put too much tension on the line and did not allow the operator to move under logs. By carrying a spool containing approximately 920 m the wire layer was able to pass the wire under logs and ensure that sufficient slack was maintained.

The tests revealed that in laying wire to the best advantage the operator should:

(1) allow plenty of slack (approximately 20% of the straight line distance) to avoid tension breaks and enable the wire to be moved to the best fuel accumulations when incendiaries are placed along the circuit;

(2) keep the wire as close to the ground as possible and cross open spaces with as short a length as possible to reduce the possibility of breaks in the circuit due to animals becoming entangled in the wire;

(3) deviate within reason from the set path to take in desirable fuel accumulations

Incendiary placement

Incendiaries were placed along the main line by breaking it and splicing the legwires of the electric fusehead into the cut ends of the main wire. The loop splice was found to be the most convenient splicing method and despite the availability of combination wire cutters and strippers, a knife blade was the most suitable instrument for the cutting and stripping operation. Splices were not insulated but were well separated to avoid short circuits.

FIELD TRIAL AND RESULTS

A regeneration burn of 50 ha (Poole Coupe 4) was selected for a field trial during March 1976.

The area was broken naturally into two sections, by a snig track running approximately east-west. The smaller 10 ha section on the northern side was left to be lit by hand using kerosene torches whilst the southern 40 ha block was used for the electrical ignition trial.

The area was considered suitable for electrical ignition because a rapid light-up was planned to promote an intense fire that would cause strong inflow winds aiding control and the fuel was heavy (400 t/ha) with very little breakup suitable for hand lighting.

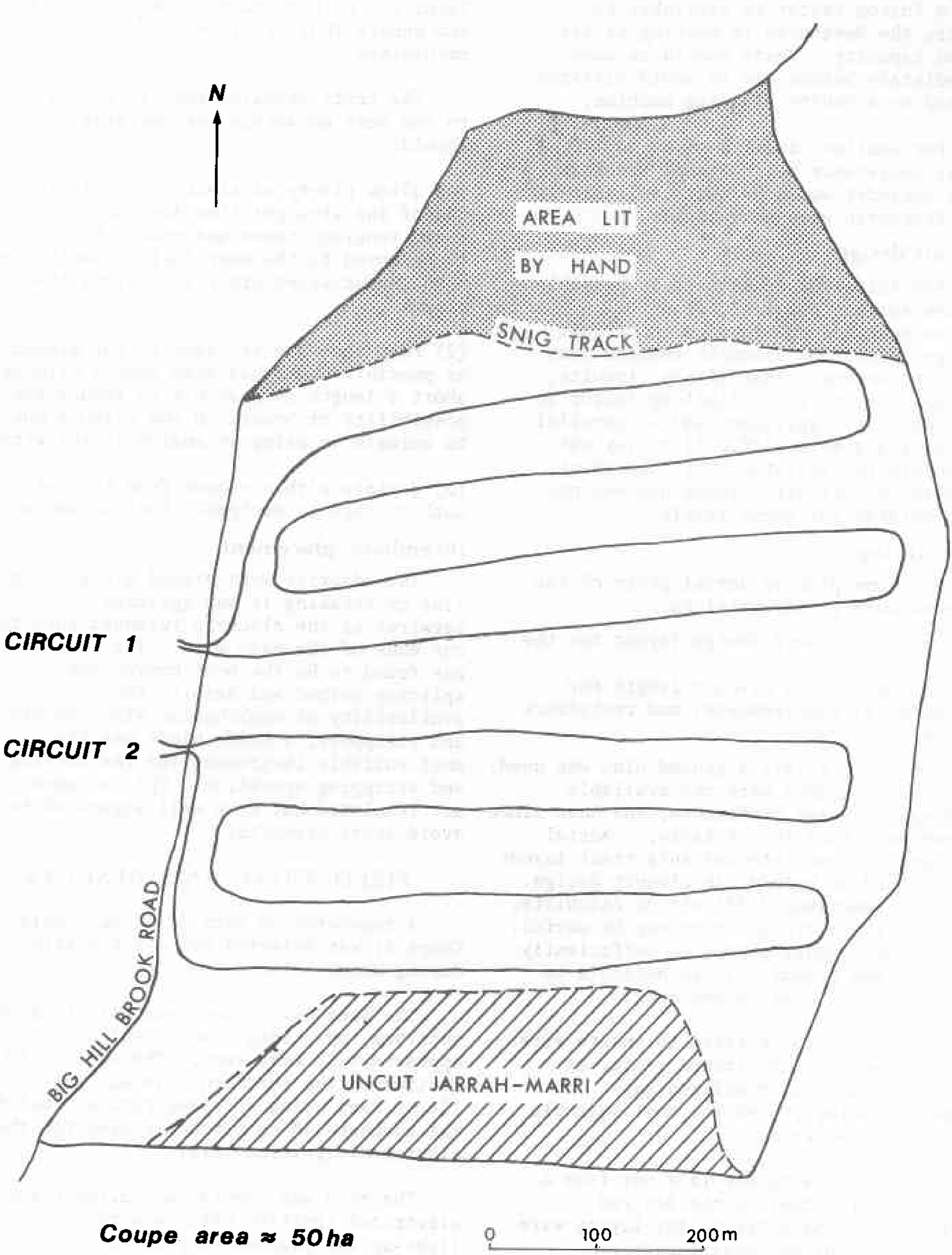

FIGURE 3: Map showing the circuit layout in Poole Coupe 4

Two circuits were laid out, each comprising four ignition lines spaced 75 m apart (Fig. 3). Two hundred incendiaries were placed along the circuits at 25 m intervals.

All preparatory work was performed on the morning of the burn. Five men took one and a half hours to lay the wire, and three men took two hours to place the incendiaries along the circuits.

The 10 ha area was lit by hand at 1515 hours. Once that fire was well established circuits 1 and 2 were fired within five minutes of each other. Both fired successfully, resulting in an intense fire after ten minutes with associated strong inflow winds on all sides.

Conditions at the time of firing are shown in Table 2.

TABLE 2

Fine fuel moisture content (sheltered)	16%
Byram Drought Index (BDI)	430
Relative Humidity	56%
Winds	SE 10-15 km/h

Three other burns were ignited wholly or partly using electrical ignition during the 1975-76 season, all with outstanding success. A summary of the relevant details is listed in Table 3.

Operational cost - Table 4 details operational costs for the Poole Coupe 4 field trial.

TABLE 4

Item	Man hours	Dollars
6000 m of wire		73
Laying the wire	7.5	30
200 incendiaries		84
Connecting incendiaries to the circuit	6.0	24
Total		$211

The cost per hectare was $5.

DISCUSSION

The circuits used in the field trial each had 2 loops (Fig. 3). It is now considered advisable to have only one loop per circuit to avoid overloading the blasting machine and reduce complexity in laying. If the two circuit ends are brought to the same point the time lost in firing the circuits one after the other is negligible in terms of fire build-up.

Factors affecting incendiary spacing

Burn objective - For a convection burn where a hot central fire is required quickly, incendiary spacing needs to be close (approximately 10 m x 10 m). A spacing of 50 m x 100 m has proven satisfactory for strip ignition where rapid fire build-up was not required. Tests indicate, however, that for average conditions requiring a moderately rapid fire build-up a spacing of 25 m x 75 m is most suitable.

TABLE 3

Coupe no.	Area (ha)	Incendiary spacing (m)	No. of incendiaries	Length of wire (m)	BDI	Fine fuel MC (per cent)	Cost/ha (dollars)
Frankland 8	30	100 x 50	60	4000	217	8	4
Swarbrick 4	18	100 x 25	70	4500	258	5	7
Gray 1	50	75 x 25	125	5500	320	16	3

MC = moisture content

Fuel distribution - Areas of very dense fuel, particularly fine fuel, require fewer ignition points than areas of light fuel because fire spread is rapid. Alternatively, areas of very dense fuel may be exploited to produce intense fires by using a large number of ignition points. It is usual, however, to close up the spacing in areas of light fuel to ensure a parity of fire build-up in all areas.

Fuel moisture content - The acceptable fine fuel moisture content range for burning slash is 18% and below for sheltered fuels. As the moisture content drops, fine fuels burn more fiercely and hence do not need as many ignition points to achieve rapid fire build-up. When moisture content is near the upper limit, however, incendiary spacing should be at its closest to ensure reasonable fire build-up.

CONCLUSION

Electrical ignition may now be considered fully operational, and when applied correctly has proven to be a very effective ignition system.

The major advantages it provides are increased safety, and more effective and economical manpower distribution: all preparatory work for the field trial was performed in conditions unsuitable for hand lighting, but by using the electrical ignition system all men were available for suppression work if necessary, thereby creating a safer and more economical distribution of manpower. The Poole Coupe 4 burn showed the advantages of strategically placed ignition points which produced a rapid, intense fire in conditions which would have been particularly hazardous to lighters on foot.

Electrical ignition is not envisaged or recommended as a substitute for other ignition techniques, merely a supplement to them. If it is used in situations where it is most advantageous, future regeneration burning programmes will be increased in safety and efficiency.

ACKNOWLEDGEMENTS

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