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WILDFIRE CAUSE INVESTIGATION

IGNITION DEVICES

USED TO

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Ralph Smith

Department of Conservation and Land Management

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PREFACE

Wildfire investigation relies on using the indicators that result from burn patterns on vegetation, logs and barriers. The trained and competent investigator can follow the fire run from these indicators. By following the fire run the investigator is able to determine the area of origin.

The area of origin will in most instances be able to indicate to the trained investigator the probable cause of the fire. Wildfire investigation is a very complex task as wildfire investigation can only be undertaken after the fire has burnt through the area. Fire investigators can rarely prove how a fire started with direct evidence, in many cases sufficient evidence can be recovered to allow a reasonable cause to be deduced.

Very often no direct evidence of the probable cause can be recovered and so the fire investigator must eliminate all other possible causes when determining a probable cause. This is one of the most difficult tasks for the fire investigator. A fuel by itself, or an ignition source by itself, does not create a fire. The fire results from a combination of fuel and an ignition source

Ignition Devices

Ignition of the forest fuels requires an available fuel and an ignition source able to bring the fuel to the ignition temperature. The fuels are available if the moisture content is in the ignition temperature range. This is generally the minimum temperature at which the fuels must be heated in the air for them to ignite independently of the heat source. The fuel moisture content at ignition varies between species. The fuels may be present at the site, but not in the appropriate moisture content range or fuel structure for ignition to occur. For example in Western Australia *Pinus pinaster* (maritime pine) needlebed fuels able to be ignited and sustain fire at a higher moisture content range than the *Eucalyptus marginata* (jarrah) leaf litter. Leaf litter fuels will ignite at a less sustained ignition temperature than high density logs.

Ignition sources used in the forest environment can be very varied. In many instances when used for unlawful lighting the incendiary device will be designed in a manner that enables the fire setter to be some distance from the area of ignition before the fire develops and is visible. To effectively determine the cause of the wildfire the fire investigator must be able to identify the are of ignition. Contained within the area of origin will be the ignition source. In many instances of human caused fires the ignition source will leave a residue that upon careful examination can be identified. The wildfire investigator must be able to identify the items introduced into the environment, as these will frequently be a factor in the fire's ignition.

Using this Manual

This manual is designed to assist wildfire investigators identify the probable cause of a fire. There are examples in the manual of ignition devices that have been placed at the scene post fire so that comparisons with an ignition device used to start a fire can be made.

Whilst the descriptions and photographs will show what is generally expected, there are always exceptions. In all cases it is essential to inspect the scene in a methodical and systematic approach. It is also essential to ensure that the interpretation of the evidence and the assumptions you make can be substantiated.

Items featured in this manual are:

1. Matches
2. Rope
3. Mosquito coil
4. Rags
5. Candles and Cardboard
6. Cigarettes
7. Lightning
8. Flares
9. Self ignition

1. Matches

One of the most common incendiary devices used by the fire agencies is the wind and water proof match (fusee). These provide staff with the opportunity to quickly and easily ignite forest fuels. These matches can be purchased on the open retail market, so whilst they are regularly used by the forest management agencies, their use by arsonists should not be discounted.

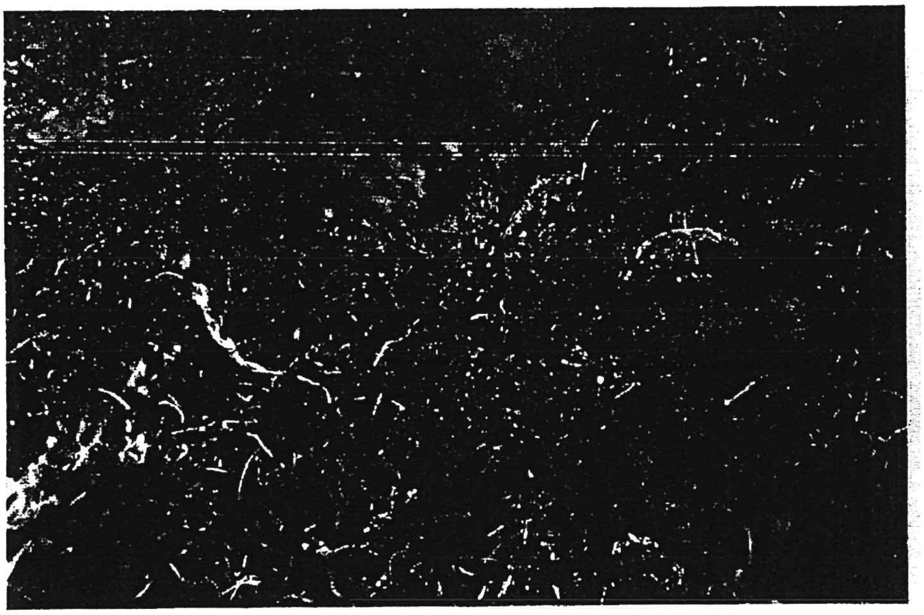
Although the fusee leaves a large head residue a standard match leaves a similar by-product although significantly smaller.

Photograph 1 Fusee

In this instance the fire was lit under very mild conditions. The head fire rate of spread was around the 20 - 30 m/hr range. The fuel type is one found in the high rainfall zone of the northern jarrah forest. Note that fuel residue in the vicinity of the match head is only partially consumed and quite a dark colour. Although not visible in this photograph, if the match was inspected at the end that had the wooden stem, it would be square.

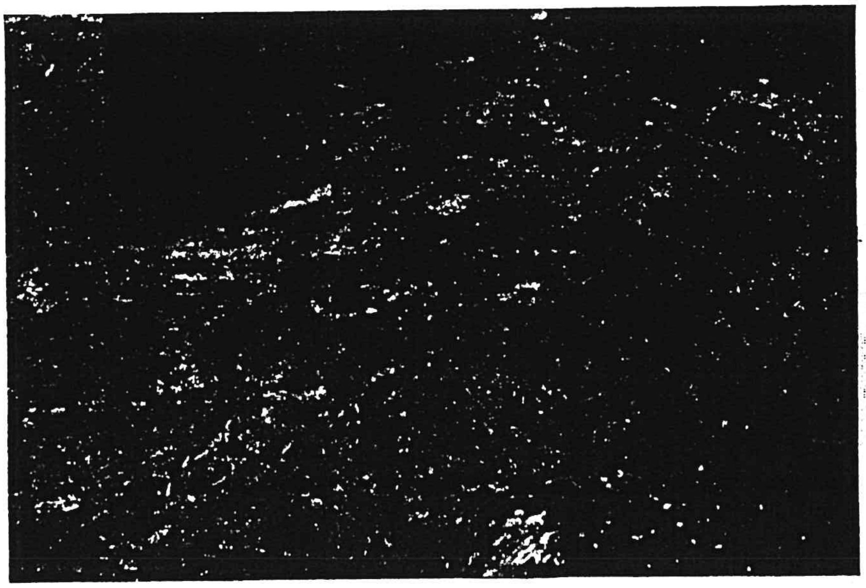
2. Rope

Other ignition devices can be the use of rope; either cotton rope or those with a component of man made fibres. Rope can be used as an ignition source by acting as a slow burning wick. As the rope burns away it must come into a zone of increased temperature so that the fuels will reach ignition temperature. Frequently this is achieved by using a match as the ignition device.



Photograph 2 Rope

In photograph 2 the fuel source was burning piece of rope. The resultant fire travelled at 60 – 80 m/hr. The fire was in the northern jarrah forest. The remnant rope is visible at the ignition point immediately after the fire was started, but broke up and dispersed very quickly.



Photograph 3 Fuel soaked poly rope

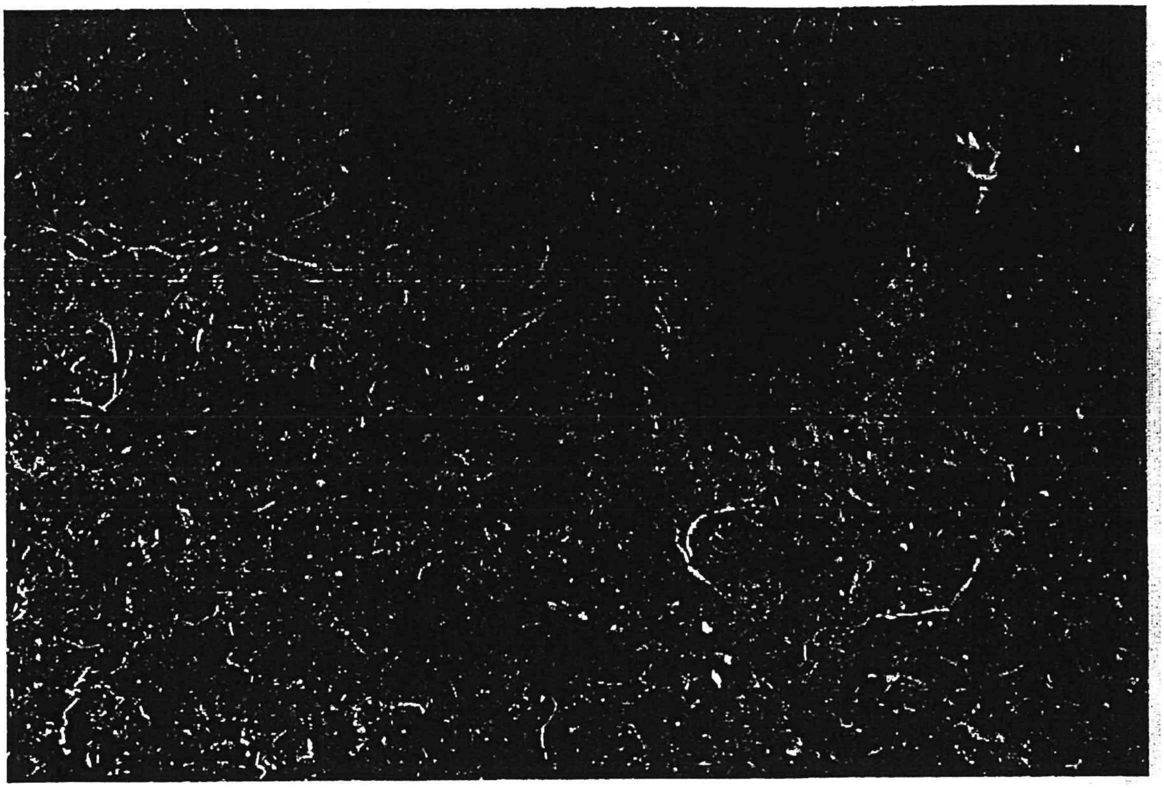
The area circled is the area of ignition using poly rope that had been soaked in an accelerant and then set on fire. The rope very quickly burnt away to nothing that was visible to the naked eye. What is obvious however is the partial combustion of the fuels in the ignition zone.

Photograph 4 Fuel soaked cotton rope

In photograph 4, again the rope has burnt away to nothing very quickly. The ignition zone again shows the expected partial combustion.

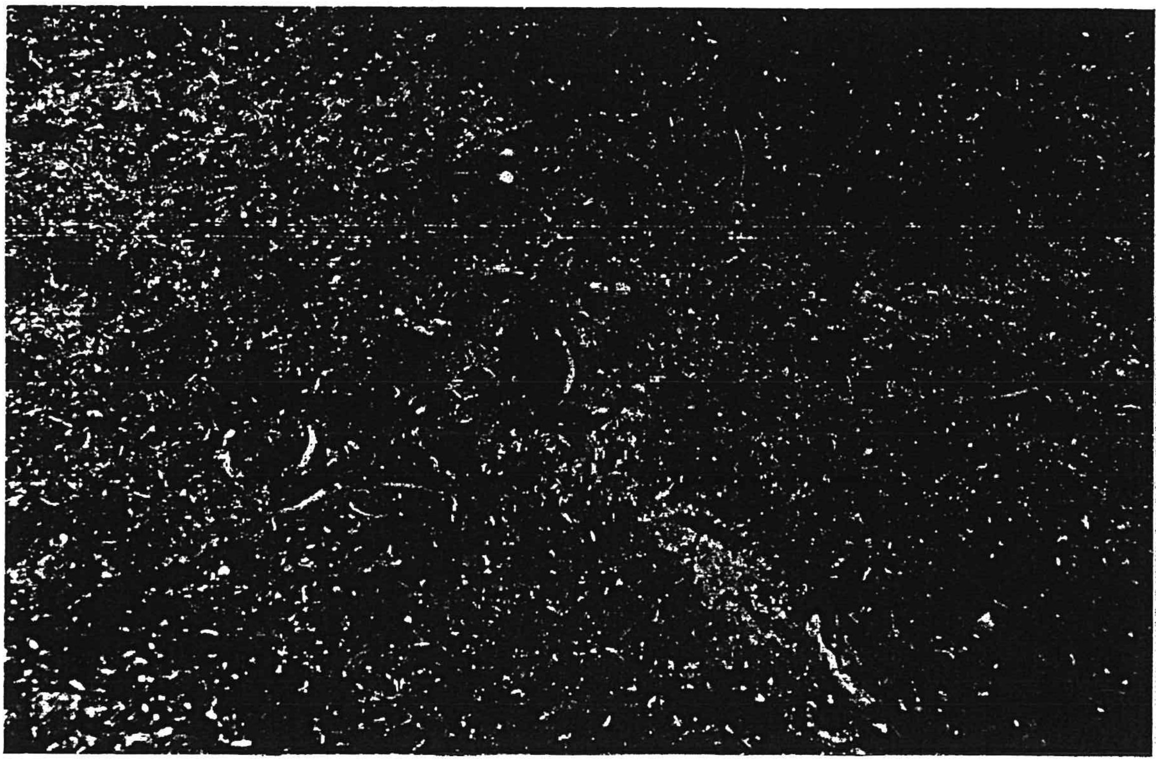
Photograph 5 Rope

The photograph 5 and 6 show the rope remnants immediately after the fire had been started and the Balga fronds had burnt away. The rope dispersed very quickly once the fire had passed.



Photograph 6 Rope

Photograph 7 shows the remnant cotton rope after the fire has burnt over the ground. This photograph is different to all the others because the rope was placed after the fire had burnt the area. The rope therefor had no involvement with the fire cause.



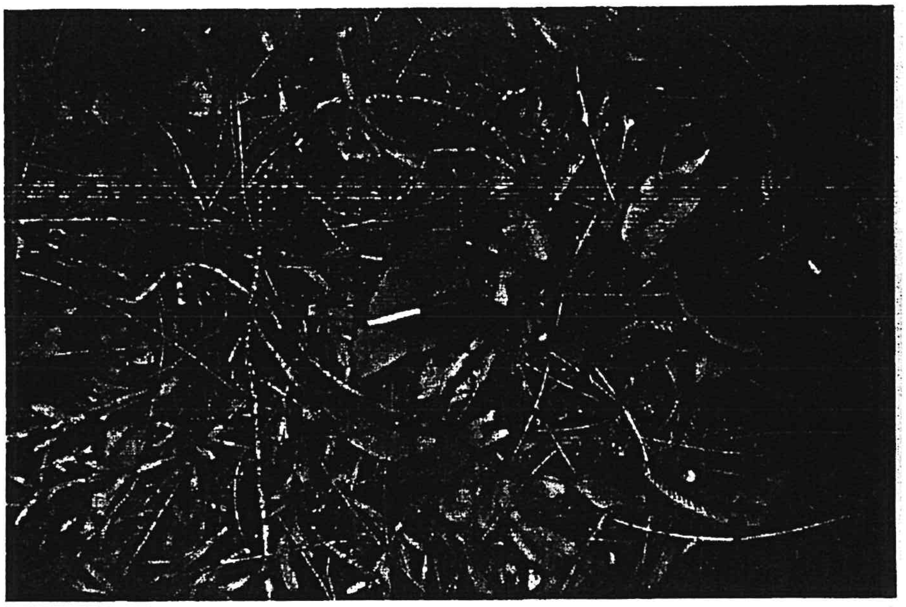
Photograph 7 Rope placed after the fire had burnt the fuels on the ground

3. Mosquito coil

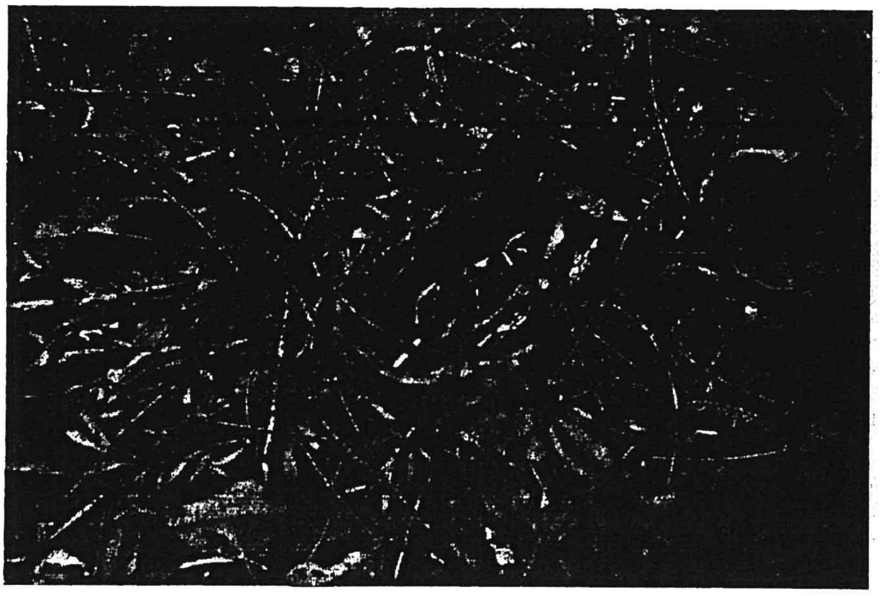
Mosquito coils can act as a slow burning wick device to an item that will raise the temperature to the ignition temperature in the forest fuels, such as a match or group of matches. The mosquito coil will generally not be able to bring the fuel to ignition temperature by itself. The different brands of mosquito coil can burn to a different coloured residue. If the wildfire investigator conducts the origin and cause investigation soon after the fire starts the evidence of the ignition device may still be present and visible. Photograph 8 is a photograph of a mosquito coil that has been placed onto burnt ground and set alight and therefore had no involvement with the fire.

Photograph 8 Mosquito coil placed on burnt ground and set alight

The next series of photographs are the progression of a mosquito coil using a fusee as the ignition device. The mosquito coil burnt down until the heat of the burning coil was sufficient to set the fusee on fire, which then set the bush on fire.



Photograph 9 Fusee sitting on the lit mosquito coil



Photograph 11 Initial stages of the bush starting to burn

Photograph 12 Remnants of the fusee and mosquito coils. The fusee is to the left and parallel to the mosquito coil residue.

4. Rags

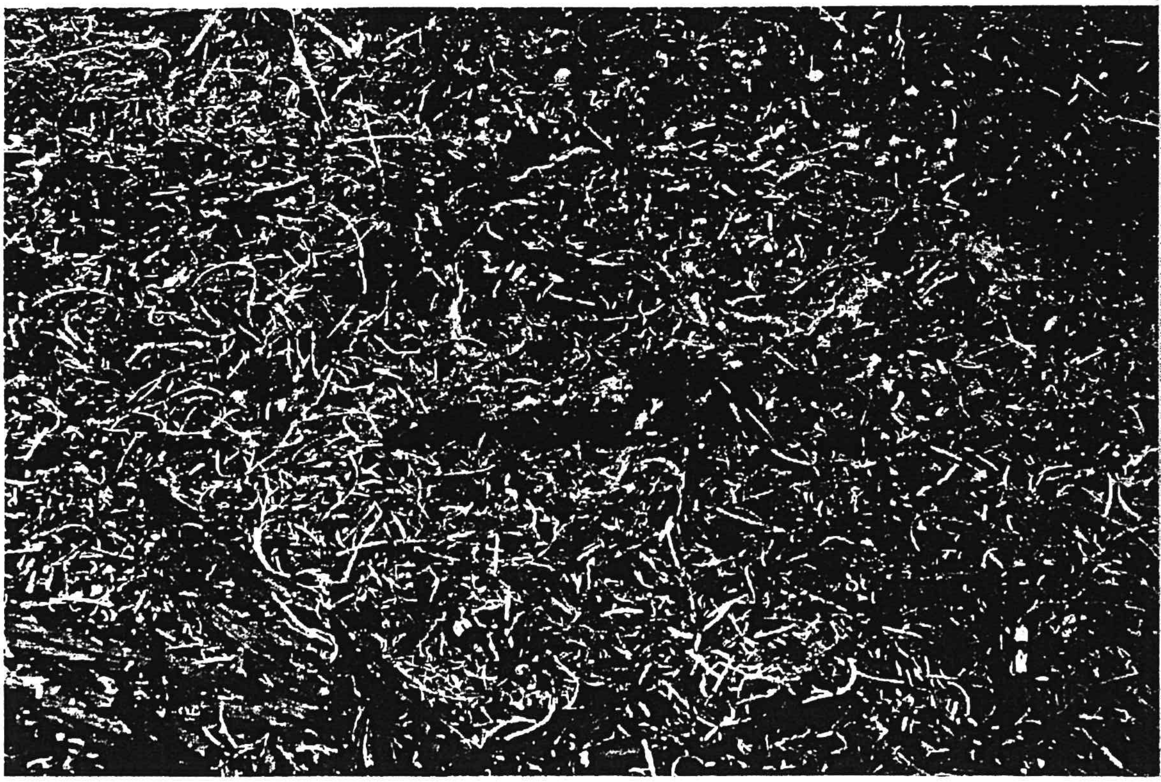
Rags soaked in an accelerant can be used as an ignition device. Placed in an appropriate location the accelerant soaked rag can ensure ignition of the forest fuels. If the wildfire investigator arrives at the scene soon after ignition it may be possible to identify the rag. If any significant time elapses between ignition and investigation the rag remnants will have dissipated into the environment.

The following series of photographs deal with fuel soaked rags.

Photograph 13 Fuel soaked rag pushed into the Balga.

Photograph 14 The Balga stem in the centre of the photograph is where the ignition took place.

Photograph 15 Photograph of the rag that has dropped from the Balga.



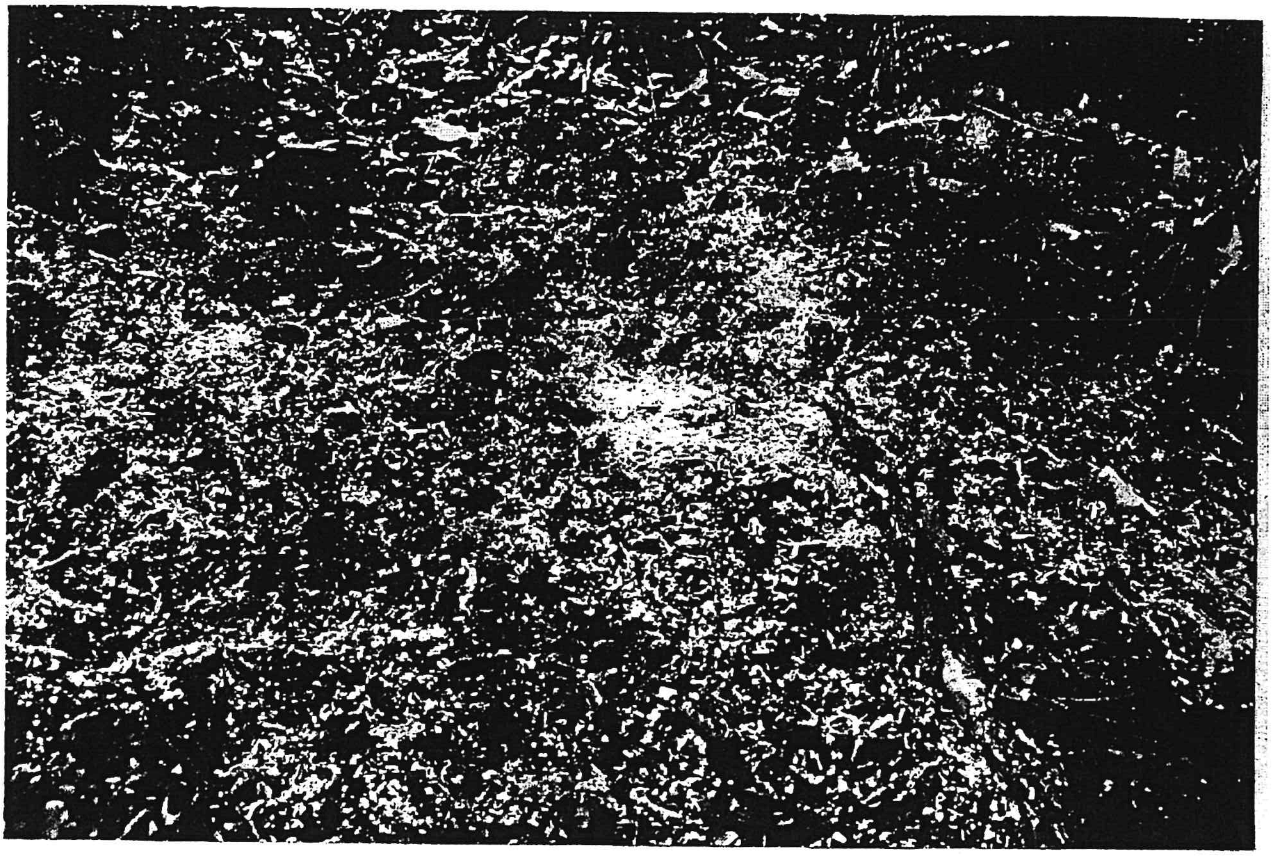
Photograph 16 Photograph of the remnants of the fuel soaked rag. The rag after a short period became unrecognisable.

4. Candles and Cardboard

The next series of photographs deal with candles being placed in a range of cardboard. The material used in the production of the cardboard appears to determine the amount and type of residue remaining after the fire has burnt through the area. In each instance the candle could not be identified.

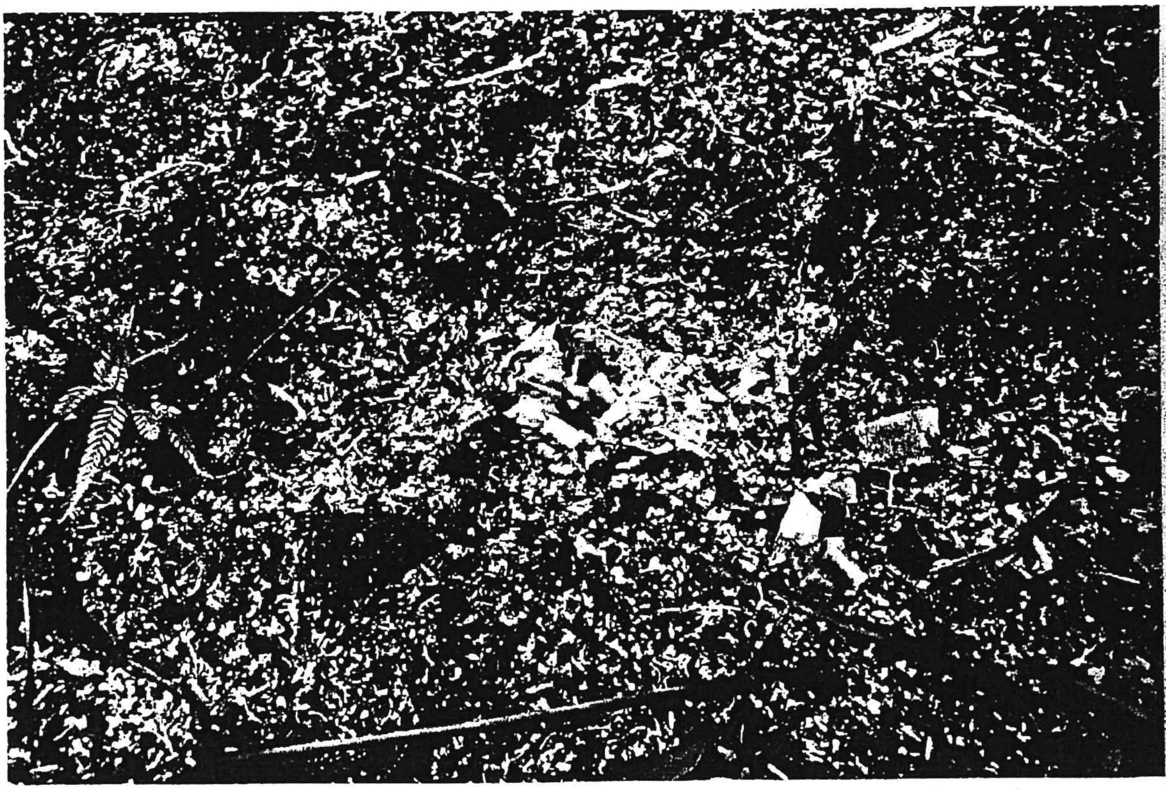
Photograph 17 Candle in a milk carton

Photograph 18 Resultant fire in the early stages of development



Photograph 19 Remains post fire. There is nothing that readily indicates that the fire was started with a milk carton and candle. Note that the area of ignition is burnt more fully than would normally be expected at the point of origin.

Photograph 20 Shows the plain cardboard carton igniting.

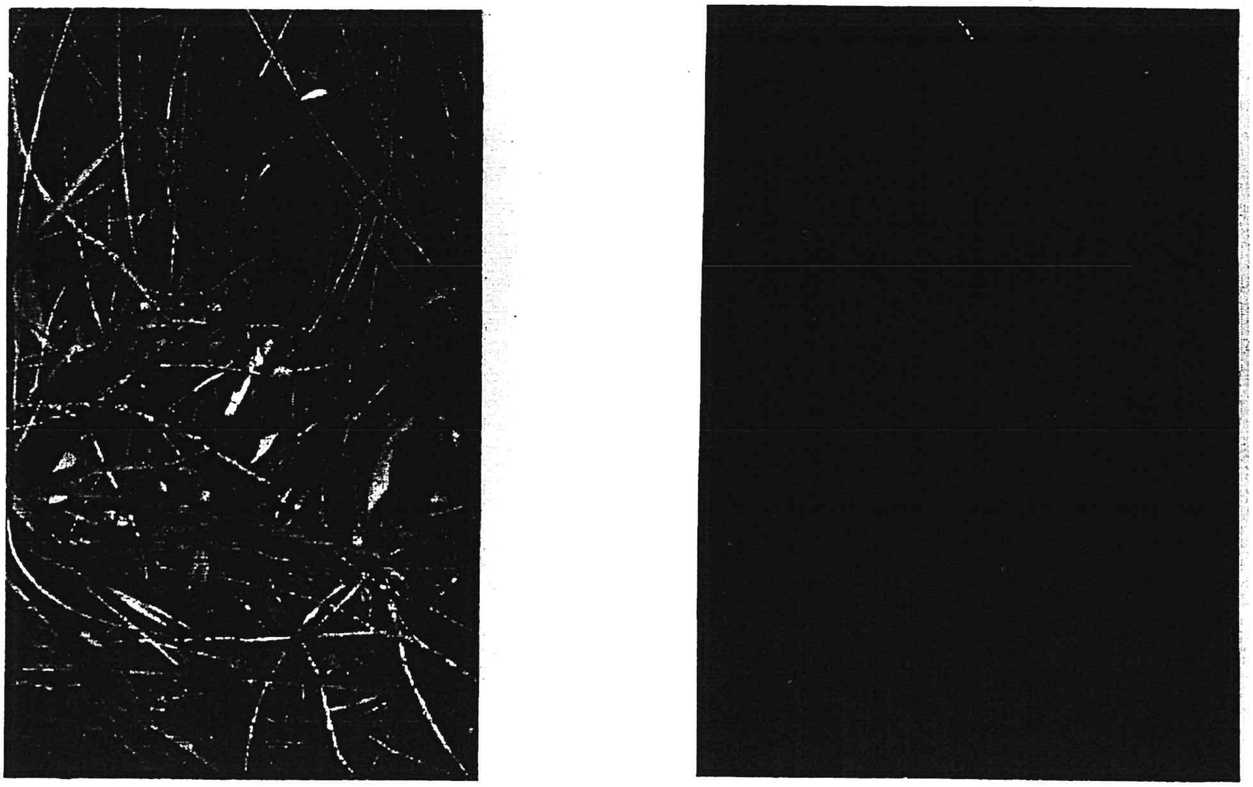


Photograph 21 Note that there is a significant quantity of ash. This ash was very light and was blown away relatively shortly post fire.

6. Cigarettes

Cigarettes are generally not able to generate sufficient sustained heat to degrade, gasify and release vapours from the forest fuels so that they reach ignition temperature. In very fine, dry and aerated fuels it may be possible for a cigarette to ignite the fuels. In the forest environment it is more likely that a cigarette will not be able to ignite a fire solely by itself. In laboratory studies it has been recognised that cigarettes are able to generate 500 – 700° C when free burning.

The cigarette when used as an incendiary device in the forest environment will generally have an ignition device such as a match or matches attached. These are required to start the fire. Depending on the depth of the available fuel and the moisture content of the fuel the amount of cigarette residue remaining will result in virtually all of the cigarette burning away and only the match residue being able to be located.



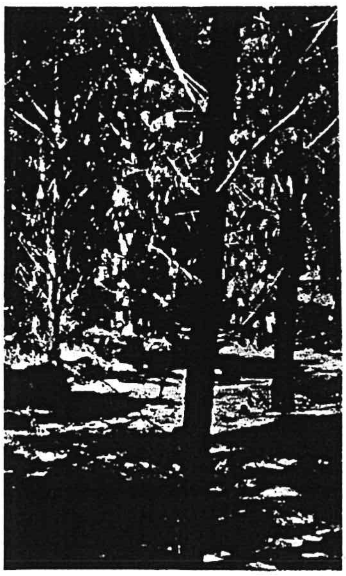
Photograph 22 Shows the remnants post ignition using a cigarette with fusees. The time between ignition and inspection was only several hours but there had been rain on the site.

7. Lightning

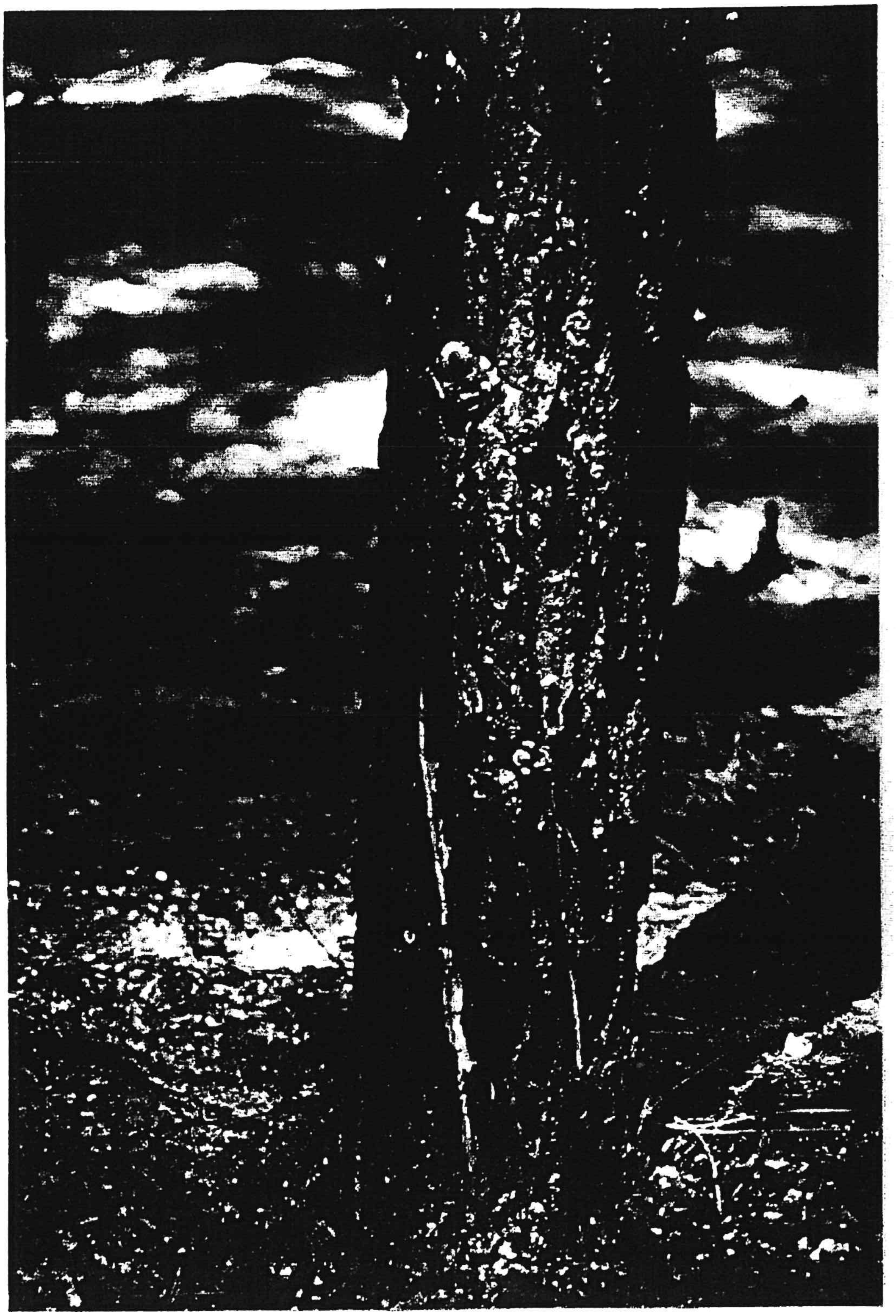
Lightning can occur when there is an unstable moist atmosphere. An unstable atmosphere is characterised by gusty erratic winds, cumulus clouds, good visibility and smoke columns continue to rise and there is no temperature inversion. Atmospheric stability is defined as the resistance of the atmosphere to vertical motion.

Lightning can occur with or without a rainfall event. Lightning that occurs without rainfall is referred to as dry lightning. Dry lightning that strikes the ground during periods of dry fuel is likely to result in a wildfire. Lightning associated with a brief shower of rainfall can still cause a wildfire but the full effects of the ignition may not become obvious until after the rainfall effects have diminished.

Photograph 23 Shows a lightning strike in a jarrah tree



Photograph 24 Shows a lightning strike in *Pinus pinaster*. The photograph on the left is of a lightning strike that did not cause a fire. The photograph on the right is a strike that did cause a fire.

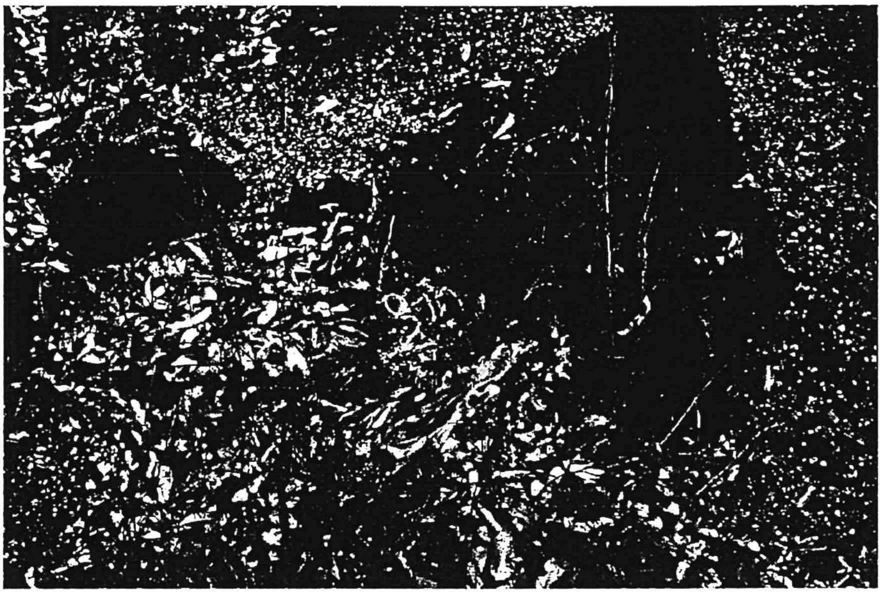


Photograph 25 Photograph of a lightning caused fire in the *P pinaster*. Note the minimal damage to the stem.

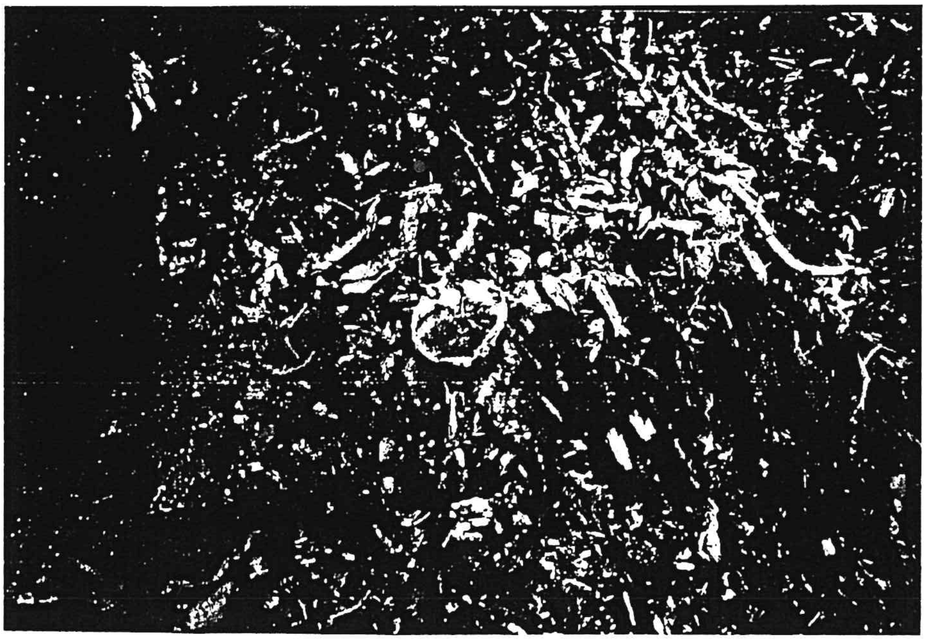
8. Flares

Flares are designed to burn at very high temperatures and produce very bright light. Flares that are fired into the air will frequently burn out prior to returning to the ground. Flares fired at a lower projectory can reach the fuels whilst still burning. In these instances there may be residue remaining after ignition to identify the flare as a source of ignition.

Flares that burn out prior to reaching the ground will not, unless they are parachute flares, leave a residue. Equally it is unlikely that these flares will have ignited the fire.



Photograph 26 Fire in the initial phase. Note the circular object in the centre of the burnt area.



Photograph 27 Residue of the flare.

9. Self Ignition

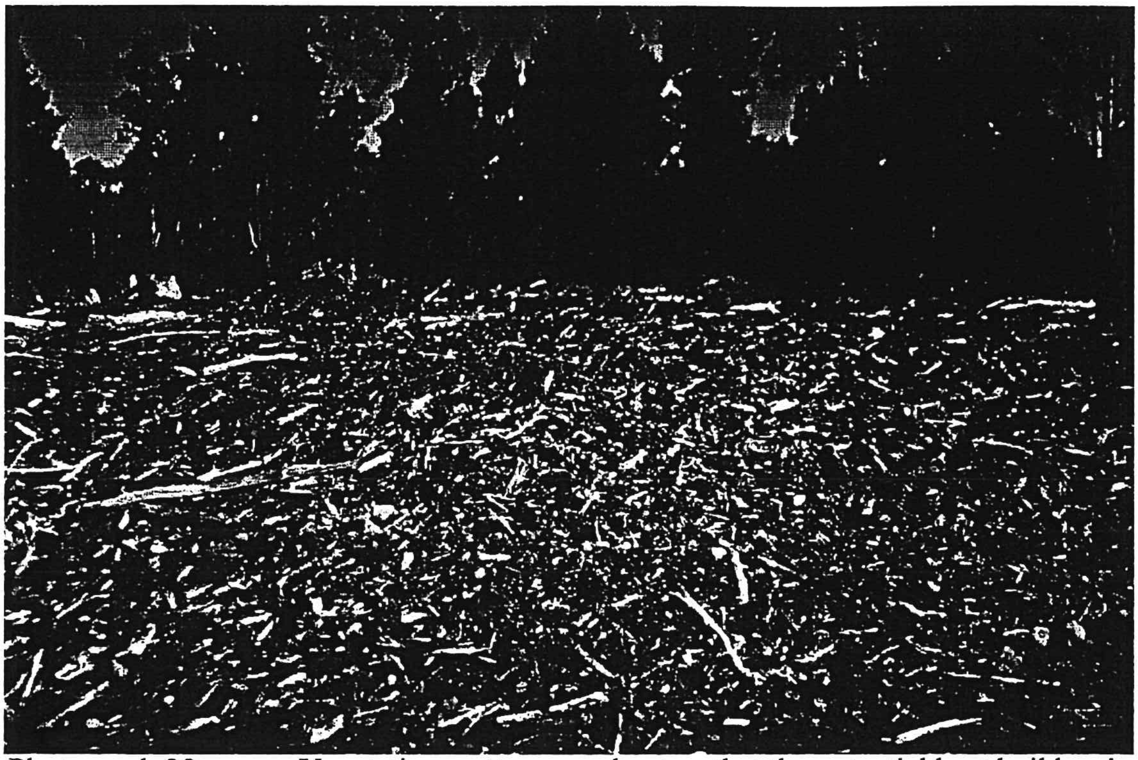
Self-ignition in the wildfire environment is generally initially commenced through the respiration of living materials. The respiration process can increase the fuels to 100° C. At this temperature the living cells die. With appropriate moisture content a fermentation process can begin. This process can only increase the temperature to a certain level, but a level not able to reach the ignition temperature. Other factors determine whether the ignition temperature is achieved.

Self-ignition results when the exothermic (self-heating) reaction generates heat and the mass of the material prevent that heat from being dissipated quickly enough to prevent an increase in the temperature. The reaction rate doubles with every 10° C increase, and the reaction itself continues to generate heat that in turn continues to make the process go faster and generate more heat.

Low density materials will burn faster than high density materials of a similar base composition. The high density materials conduct the energy away from the ignition source more rapidly than low density material.

Factors that will assist the wildfire investigator in determining whether the fire originated within the matter or external to the material include the time period from stacking to the time of the fire. In a hay fire it will be no sooner than 10 –14 days after stacking and will generally require between 5 –10 weeks. The fire will burn from within the middle to the exterior. Usually there will be some form of chimney to the exterior. The unburnt fuel will be very dark in colour. In hay there may be a glassy, irregular mass that is grey to green and normally found near the centre of the heap where temperatures were the highest for the longest period.

Photograph 28 Large quantity of vegetative matter



Photograph 29 Vegetative matter spread out so that the potential heat build up is minimised.