

**INVESTIGATION
OF
FOREST AND RURAL WILDFIRES**



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**[Report of a study tour undertaken with a scholarship provided by the
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3. SUMMARY OF RECOMMENDATIONS

Thorough investigation of the cause of forest and rural wildfires is a powerful fire prevention tool. Better wildfire investigation will result in improved application of fire prevention resources, more reliable data for prosecution of offenders and improved ability to recover suppression costs.

These recommendations are made with the aim of improving forest and rural wildfire investigation in Victoria. The recommendations have been deduced from reference material, personal contacts and personal observations gathered during the study tour.

1. Investigate all wildfires to determine cause. (p.10)
2. Train all firefighters (including Incident Management and despatch personnel) in initial wildfire cause observations. (p. 14)
3. Liaise closely with relevant forest and rural fire services and Police at all times during wildfire investigations. (p. 27)
4. Train an appropriate number of personnel in each Region as intermediate level wildfire investigators. (p. 33)
5. Provide an advanced level wildfire investigation course for a limited number of advanced level wildfire investigators. This could be provided internally; through a National training course; or from one of a number of courses in the United States. (p. 34)
6. Form teams of investigators for use in areas of high arson activity. (p. 39)
7. Investigate the use of an anonymous public advice line that can be activated on a local or statewide basis during times of high arson activity. (p. 41)
8. Actively support programmes such as Neighbourhood Watch and Rural Watch and Bush Alert, that encourage rural and forest residents and users to note and report suspicious activity. (p. 41)
9. Investigate the use of dogs for tracking arsonists who travel on foot. (p. 42)
10. Investigate the use of video technology as a tool for recording arsonist activity. (p. 42)
11. Recover suppression costs vigorously where people have started wildfires through negligence or deliberate action, and where appropriate, prosecute offenders. (p. 44)
12. Develop wildfire investigation operational aids such as: (p. 45)
 - "aide-memoire" stickers and pamphlets to reinforce initial firefighter actions.
 - a handbook on forest and rural wildfire investigation.
 - arson fire data sheets.
 - card arrows for use in photography, indicating:
 - . direction of fire travel,
 - . direction of fire origin,
 - . fire spread indicator.
 - card signs that indicate:
 - . a fire is under investigation,
 - . a reward is offered for information regarding a fire.
 - wildfire investigation kits.

4. WHY INVESTIGATE WILDFIRES?

"How do you build a prevention programme if you don't know what causes your fires?"

- Ron Huxman, Investigator, USDA Forest Service, San Bernadino California.

The ultimate objective of wildfire investigation is to reduce the number of preventable wildfires. This is done by identifying fire causes and designing an action program that will reduce or prevent future wildfire occurrence.

Wildfire causes can be grouped as follows:

a. Natural Causes

Generally, naturally caused wildfires, such as those caused by lightning and spontaneous combustion, are not able to be prevented.

b. Human Causes

These are a result of some direct or indirect human intervention and can usually be prevented to some degree. Human caused wildfires can be further identified as:

- accidental: caused as a consequence of misadventure,
- cultural: lit in the belief that it is acceptable behaviour,
- reckless: caused as a consequence of negligence,
- malicious: lit with intent to destroy, damage or cause mischief. (This can be regarded as arson).

Table 1 indicates for the ten year period 1982 - 1991, 80% of all wildfires attended by the Department of Conservation and Environment (DCE) were human caused. The average annual area burnt by human caused wildfires was 88,683 hectares, which was 62% of the total area burnt. Human caused wildfires are a significant problem for DCE.

Table 1: Average Annual Wildfire Statistics: Wildfires Attended by DCE 1982 - 1991.

(Source DCE FIRES System 1992)

CAUSE	ANNUAL AREA BURNT		ANNUAL NUMBER OF WILDFIRES	
	Average Annual Area Burnt (ha)	% of Annual Total Area Burnt	Average Annual of Wildfires	% of Annual No. of Wildfires
Natural	55349	38%	128	20%
Malicious	21677	15%	93	15%
Other Human	67006	47%	406	65%
TOTAL	144032	100%	627	100%

These wildfires are expensive. DCE costs for suppressing wildfires exceeded \$3.5 million for the 1990/91 fire season (DCE, 1992). In addition wildfire costs can be counted in:

- people killed and injured,
- firefighters killed or injured,
- private and State assets lost and damaged,
- disruption to primary and secondary industries.

All human caused wildfires can be prevented (to some degree) by the application of one or more of the "three E's":

- **Engineering,**
- **Enforcement,**
- **Education.**

Different wildfire causes will require different actions, or different combinations of actions. In order to identify the most appropriate fire prevention action to be taken, every wildfire must be investigated. Poor investigations will result in incorrect and meaningless fire cause statistics, resulting in inappropriate application of prevention resources. Good fire investigation techniques will result in reliable data on which to develop appropriate fire prevention programs.

Where an offence has occurred, a good wildfire investigation is more likely to provide reliable evidence for prosecution of offenders. This may result in a greater recovery of suppression costs and provide a deterrent to other likely offenders.

From time to time wildfire investigations are also required for internal Departmental investigations, civil legal actions, and Coronial Inquiries.

RECOMMENDATION 1: Investigate all wildfires to determine cause.

Table 1: Average Annual Wildfire Statistics: Wildfires Attended by DCE 1982 - 1991

(Source: DCE FILES System 1992)

CAUSE	ANNUAL AREA BURNT		ANNUAL NUMBER OF WILDFIRES	
	Average Annual Area Burnt (ha)	% of Annual Total Area Burnt	Average Annual No. of Wildfires	% of Annual No. of Wildfires
Motor	25299	39%	128	20%
Match	21677	33%	92	15%
Other Human	67006	103%	406	65%
TOTAL	114002	100%	626	100%

5. INITIAL OBSERVATIONS BY FIRE-FIGHTERS

"Every successful investigation has been a result of initial attack people taking the right steps"

- Steve Lent, Fire Management Officer, USDI Bureau of Land Management, Prineville Oregon.

The key to successful wildfire investigation is the ability of initial attack personnel to recognise and protect the area of the fire origin, and to observe and note people, vehicles and suspicious circumstances in the vicinity of the fire.

The importance of the observations made during the initial attack cannot be over stated. A wildfire investigator will have an almost impossible task if the point of fire origin is damaged or destroyed. All personnel who might be involved in an initial attack should receive training in initial wildfire observations and initial investigation procedures. This should include all fire-fighter and fireline supervisors, incident management personnel and office despatch personnel.

Initial wildfire observations are made over four time periods:

- When the fire is reported.
- Travelling to the fire.
- On arrival at the fire.
- During and after suppression operations.

5.1 When the fire is reported

The officer receiving the report should note:

- date and time of report and,
- name, address, telephone number of person making the report.
- other relevant details. Was a public phone used to make the report? Were there any unusual background noises? Did the informant have an accent?

The despatching officer should:

- record times of events (eg: despatch, arrival),
- be aware of any history of wildfire from a particular cause (eg: arson, railway, children) in the area,
- advise initial attack personnel of any information that might suggest a cause and,
- be aware of access and egress routes.

5.2 Travelling to the fire

Fire crews en route to the fire should observe and record:

- details of the smoke column, weather, topography and fuels. Does the fire spread appear natural? Is it possible that there may be multiple ignition points?
- whether gates en route to the fire are open, closed, locked or broken.
- if there are any other routes providing access and egress.

- evidence of tracks, footprints or vegetation damage on the access track. In particular look for evidence of recent track use by vehicles, horses, trailbikes, pedestrians. Report and where possible cordon off tracks, footprints and vegetation damage so that fire-fighters following are aware of their presence and need for protection.
- observe vehicles seen en route, noting the location, direction of travel and time (Perry, 1990). (In a two person crew, the driver should note the first three digits of the registration and the vehicle colour, the passenger should note the last three digits of the registration, the vehicle make and number of occupants and record the observations).
- observe people seen en route, noting the location, time and activity the person was involved in (Perry 1990). (In a two person crew, the driver notes the height and facial characteristics, and the passenger notes the clothing and records the observations).

5.3 On arrival at the fire

"The first five minutes of investigation may be worth more than the next five hours"
- Anon

As initial attack crews arrive at the fire the area of origin may be obvious by the size, behaviour and location of the headfire or by the presence of machinery, equipment, vehicles or people.

If the area of origin is recognised it should be **immediately** protected by:

- cordoning off the area by using tape, rope or barriers,
- parking vehicles to protect further access by other vehicles or machinery,
- posting a guard to warn others (including fire-fighters) to stay away from the area.

The degree of protection required will depend on the size and circumstances of the fire and the potential for disturbance to the origin.

Every effort must be made to protect the area of origin and to preserve evidence as soon as practicable. If the area of origin is not obvious it may be necessary to cordon off a larger area, or to prevent access to a larger area (for example by closing a track or road).

Initial attack crews should also note:

- details of any vehicles or people at the fire scene and,
- suspicious or unusual objects that may have been used to set the fire,
- location of the head fire, flank fires and previously burned areas.

Use of an "aide-memoire" to reinforce the actions by initial attack firefighters is a good idea. The example over-leaf is from the Pennsylvania Bureau of Forestry.

WILDFIRE INVESTIGATION

1/ Locate and protect the fire origin ☒

2/ Identify people and vehicles ☒

3/ Take notes ☒

Attach notes to Fire Report

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL RESOURCES
OFFICE OF RESOURCES MANAGEMENT
BUREAU OF FORESTRY

Figure 1: Example of a dashboard sticker "aide-memoire" for initial attack firefighters

In some circumstances firefighters may be able to take photographs on arrival and during initial suppression operations. This may provide vital visual evidence that may be missed, forgotten or destroyed during the ensuring period. Disposable cameras are a cheap and effective means of encouraging initial attack firefighters to take photographs. (See 7.3 - Photographs)

5.4 During and after fire suppression operations

If the area of origin of the fire is not immediately obvious, it is possible that it may be recognised during or after the suppression operation. As soon as the area of origin is recognised it should be preserved and protected.

If possible, the area of fire origin should not be disturbed during the suppression operation. In most cases a fire will burn out and away from the point of origin and the fire intensity in the area of origin will be less. This should allow some flexibility in the timing and location of control lines constructed around the area.

Fire-fighters should:

- note the location of the headfire when suppression operations are commenced,
- note unusual flame or smoke colour or smell,
- note unusual reactions to water,
- commence control line construction away from the point of origin,
- avoid water damage in area of origin. Using a low pressure fog nozzle for mop-up will prevent scattering of evidence,
- avoid disturbance, foot traffic, unloading of machinery or parking of vehicles near the area of origin,
- report and protect suspicious or suggestive objects and,
- note suspicious people, witnesses, neighbours and onlookers.

Fire-fighters should not share their opinion on the fire cause with anyone else but Police or fire officials. If asked by the media, it is better to say "The fire cause is under investigation" rather than to commit yourself to a hasty conclusion.

The fire-fighter's job is to gather information on the fire cause, not to give it.

RECOMMENDATION 2: Train all firefighters (including Incident Management and despatch personnel) in initial wildfire cause observations.

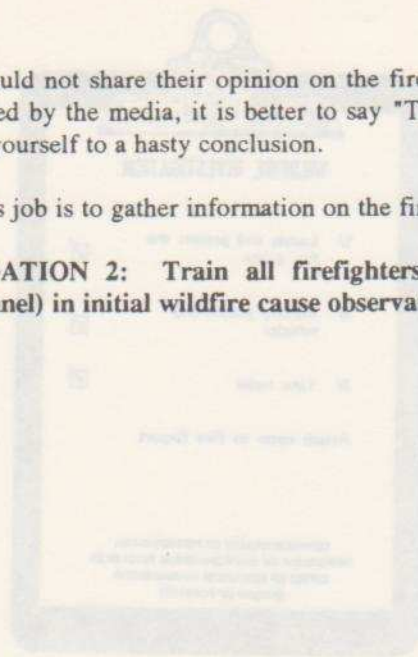


Figure 1: Example of a clipboard checklist "initial wildfire cause observations" for initial wildfire firefighters

In some circumstances firefighters may be able to take photographs on arrival and during initial suppression operations. This may provide vital visual evidence that may be missed, forgotten or destroyed during the burning period. Disposable cameras are a cheap and effective means of encouraging initial attack firefighters to take photographs. (See 7.3 - Photography)

2.4 During and after the suppression operations

If the area of origin of the fire is not immediately obvious, it is possible that it may be recognised during or after the suppression operation. As soon as the area of origin is recognised it should be preserved and protected.

If possible, the area of the origin should not be disturbed during the suppression operation. In most cases a fire will burn out and away from the point of origin and the fire intensity in the area of origin will be less. This should allow some flexibility in the timing and location of setting lines constructed around the area.

Fire-fighters should:

- note the location of the fire when suppression operations are commenced;

- note unusual flame or smoke colour or smell;

- note unusual reactions to water;

- observe whether the fire continues away from the point of origin;

- avoid water damage in area of origin. Using a low pressure fog nozzle for mop-up will prevent scattering of evidence;

- avoid disturbance, foot traffic, re-loading of machinery or parking of vehicles near the area of origin;

- report and protect suspicious or suggestive objects and;

- note suspicious people, witnesses, neighbours and onlookers.

6. FIRE ORIGIN DETERMINATION

The spread of wildfires is governed by certain basic principles. The fire investigator must understand these principles and recognise the visual evidence left behind after a wildfire has passed. This visual evidence will include burn pattern indicators, which show the direction of fire travel at a specific point. By recognising and interpreting these indicators, an investigator can follow the course of the fire back until the area of the fire origin is reached, (Ford, 1968; National Wildfire Coordinating Group, 1978; Anon, 1987 and Seidel, 1988).

6.1 Principles of fire spread

6.1.1 Fires start small.

6.1.2 Fires generally burn away from their point of origin.

6.1.3 On level ground in the absence of wind, a fire will spread from the centre in all directions; but its spread will be inhibited by the convective wind the fire creates, which blows back into the base of the flame from all directions. The fire will be slow burning and in the initial period of combustion there may be more unburnt material left in the area of ignition because the normal temperature of combustion may not have been reached. The fire will burn in a circular or an oval pattern.

6.1.4 A fire with an extended perimeter will have its direction influenced by topography, ambient wind and local winds (created as a result of the fire itself).

The presence of a wind or an upslope will result in a predominant direction of fire travel. Wind or an upslope will increase the rate of spread of a fire because the flames will tend to lean downwind and upslope and "reach" onto unburnt fuel. Leaning of the flames results in more effective pre-heating of unburnt fuels and greater flame exposure to unburnt fuels. Thus a fire burning upslope in the absence of wind will burn in a fan or a "V" pattern. An ambient wind will deflect the "V" pattern in one direction or the other.

6.1.5 The headfire is where rate of spread is fastest. This usually corresponds to a fire running upslope or under the influence of strong winds or fire whirls. Rate of spread is less on the flank fire and the back fire because flames rise more vertically and there is less flame contact and pre-heating of unburnt fuels.

6.1.6 Flames and radiant heat are blocked or deflected by any solid object. A blocking object intensifies the heat energy on the exposed side and diverts heat energy around the object. Depending on the surface area of the shield, fuel behind the object may be protected to some degree from direct exposure to the oncoming fire.

6.1.7 Surfaces exposed to flames are subjected to intense heat build-up with rapid cooling after flame passage. Combustion of fine fuels will be more complete, resulting in a white ash. Deeper charring will occur on heavy fuels.

6.1.8 Surfaces protected from direct flame exposure will receive lower, more even temperatures for a briefly longer period. Burning may not be as complete and burnt fine fuels may leave a grey or a black ash. On heavy fuels the char is not as deep.

6.1.9 The exposed face of a non-combustible object will take the full flame heat, which is often well above the ignition temperature of surrounding fuels. Vaporised fuels and heated minute particles carried in the flame area are rapidly cooled upon contact with non-combustibles such as rock, metal and glass. Some of these particles will be deposited, causing discolouration, staining and particulate deposits. The amount of discolouration, staining or deposits will be greatest on the side exposed to the oncoming flames.

6.1.10 **Burnt material shrinks.** If a small object burns unequally on opposite sides, the object may bend toward the face where the greatest burning occurred. Twisting and contorting will occur in wide objects or if uniform burning does not take place.

6.1.11 **Heated objects will char fuel downward.** A heated heavy object falling onto fine fuels will compact them, concentrating the amount of fine fuel available to start a fire. Heat from the object will be less able to escape and will be concentrated under the object. When this heat is above the ignition temperature of the fine fuel, the object will char its way through succeeding pieces of fuel until it reaches the ground. If a fire results, the heavy object will be covered by the ashes of fuels subsequently burnt. Therefore a hot metal fragment (eg: brakeshoe fragment) that causes a fire will not remain on top of burnt fuel but will tend to bury itself.

6.1.12 **New fire origins can be caused by spot fires and by burning objects rolling downhill.** Spotfires will be carried by the ambient wind, convection currents and fire whirls. In mountainous areas the effect of anabatic (upslope) and katabatic (downslope) winds should also be considered.

6.1.13 **Fires can reburn over areas where unburnt fuels remain.** In an area of cured grass with high moisture content an initial pass of a fire may burn only a portion of the total fuel, resulting in a drying effect on the residual fuels. This may render fuels available for "re-burning" if the wind shifts the fire back over the now combustible fuels.

6.1.14 **Fire spread and intensity will be affected by wind, slope, fuels and barriers.** Indicators of fire spread may cause areas of confusion created by:

- the fire dying down in intensity,
- intense radiant heat from slow burning heavy fuels,
- the fire being partially stopped at barriers, rocky outcrops and animal pads,
- the fire being split around a barrier, then joining,
- erratic convection and internal fire winds.

TABLE 2: SUMMARY OF THE PRINCIPLES OF FIRE SPREAD

FLAME EXPOSED SIDE	FLAME PROTECTED SIDE
<p>1. Can face:</p> <ul style="list-style-type: none"> - Upwind - Downslope - Toward area of origin. 	<p>1. Can face:</p> <ul style="list-style-type: none"> - Downwind (or lee) - Upslope - Direction of spread.
<p>2. More complete combustion:</p> <ul style="list-style-type: none"> - White ash on fine fuels - Deep charring on heavy fuels. 	<p>2. Less complete combustion:</p> <ul style="list-style-type: none"> - Grey or black ash on fine fuels - Shallow charring on heavy fuels.
<p>3. Discolouration, staining, deposits on non-combustibles.</p>	<p>3. Absence of discolouration on non-combustibles.</p>
<p>4. May demonstrate greater shrinkage of burnt fine fuels.</p>	<p>4. Less shrinkage of burnt fine fuels.</p>

6.2 Indicators of direction of fire travel

Once the fire investigator understands the principles of fire spread the next step is to be able to recognise individual burn pattern indicators. Common burn pattern indicators can be recognised by interpreting the fuel residue and other traces of combustion.

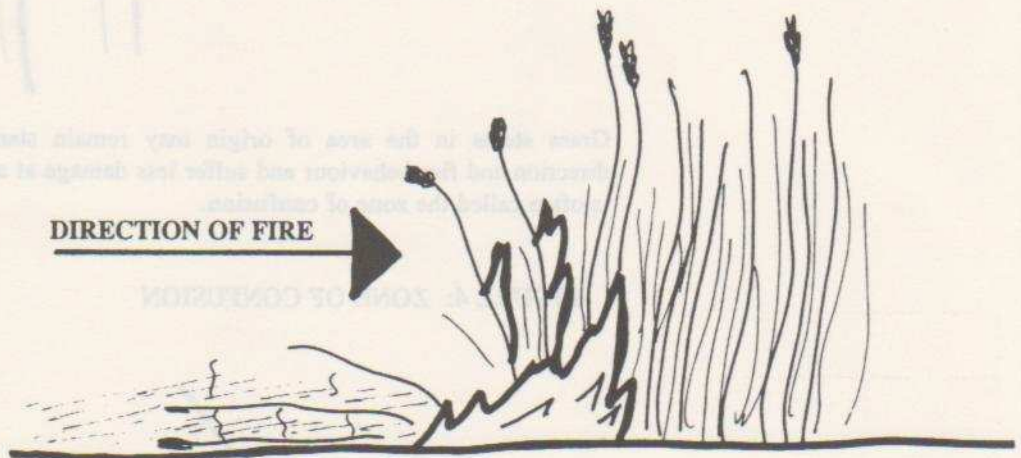
Burn pattern indicators can be grouped as follows:

- grass
- scrub
- trees
- debris and barriers
- general.

6.2.1 Grass burn pattern indicators

- a. As fire approaches a grass stem, the stem will heat and begin to char on the exposed side first. The exposed side will shrink and weaken and eventually the grass stem may fall toward the side that the fire came from. Many stems pointing in one direction provide a reliable indicator, one or two such stems are not. Grazed, curing or green grass is not reliable as an indicator.

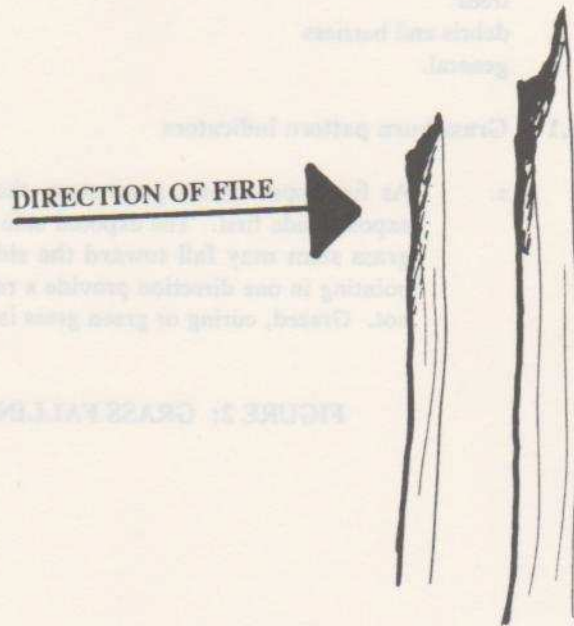
FIGURE 2: GRASS FALLING



- b. The stems of weeds and grass still standing will show more complete combustion on the face exposed to the oncoming flames, and less complete combustion on the protected side. Where an area has been burnt slowly the burnt fuel may appear lighter when looking towards the direction of fire travel, and darker when looking towards the origin. Alternatively, looking towards the origin may show considerably more unburnt fuels.
- c. There may be an increase in partially burnt grass where a fire has backed through an area.

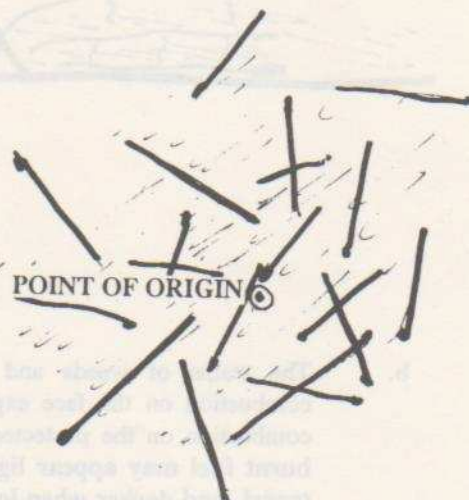
- d. Grass stubs will not burn level. On the exposed side the grass stub will burn lower, and on the protected side higher. This is called **cupping**. Grass cupping can be recognised when a sensitive skin surface (eg: the back of the hand) is brushed against grass stubs in a direction toward the area of origin it will feel pointed and rough. Brushing in the direction of fire travel has a smooth feeling. Lateral movement will not indicate anything.

FIGURE 3: CUPPING



Grass stems in the area of origin may remain standing, show erratic fire direction and fire behaviour and suffer less damage at and near the origin. This is often called the **zone of confusion**.

FIGURE 4: ZONE OF CONFUSION

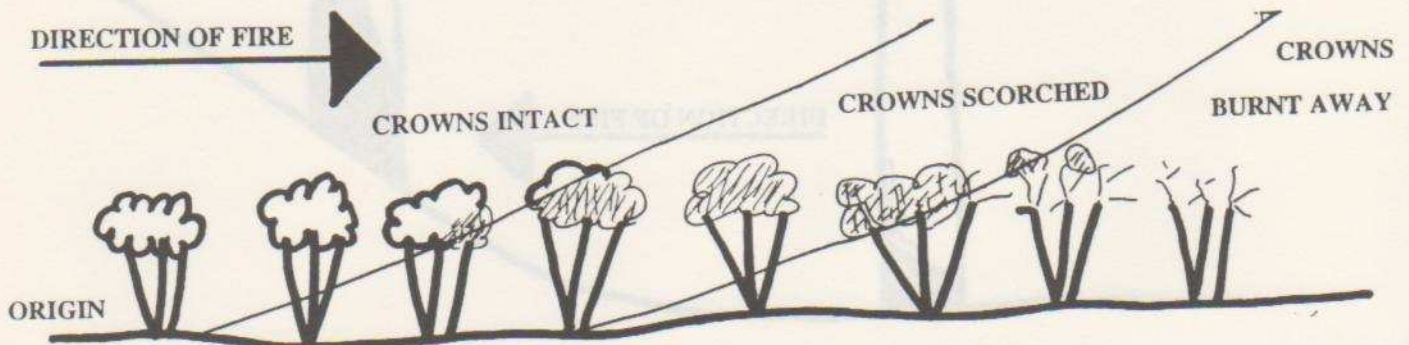


- f. Lines of unburnt or partly burnt grass may indicate failed attempts at suppression using streams of water.

6.2.2 Scrub burn pattern indicators

- a. At the origin the fire is relatively cool and scrub crowns may be left intact.
- b. As the fire moves away from the origin the fire becomes hotter and more crown is burnt. This may result in an **upsweep pattern of scorched and/or burnt scrub crowns** in one plant or over a number of plants.

FIGURE 5: SCRUB SCORCH OR BURN UPSWEEP

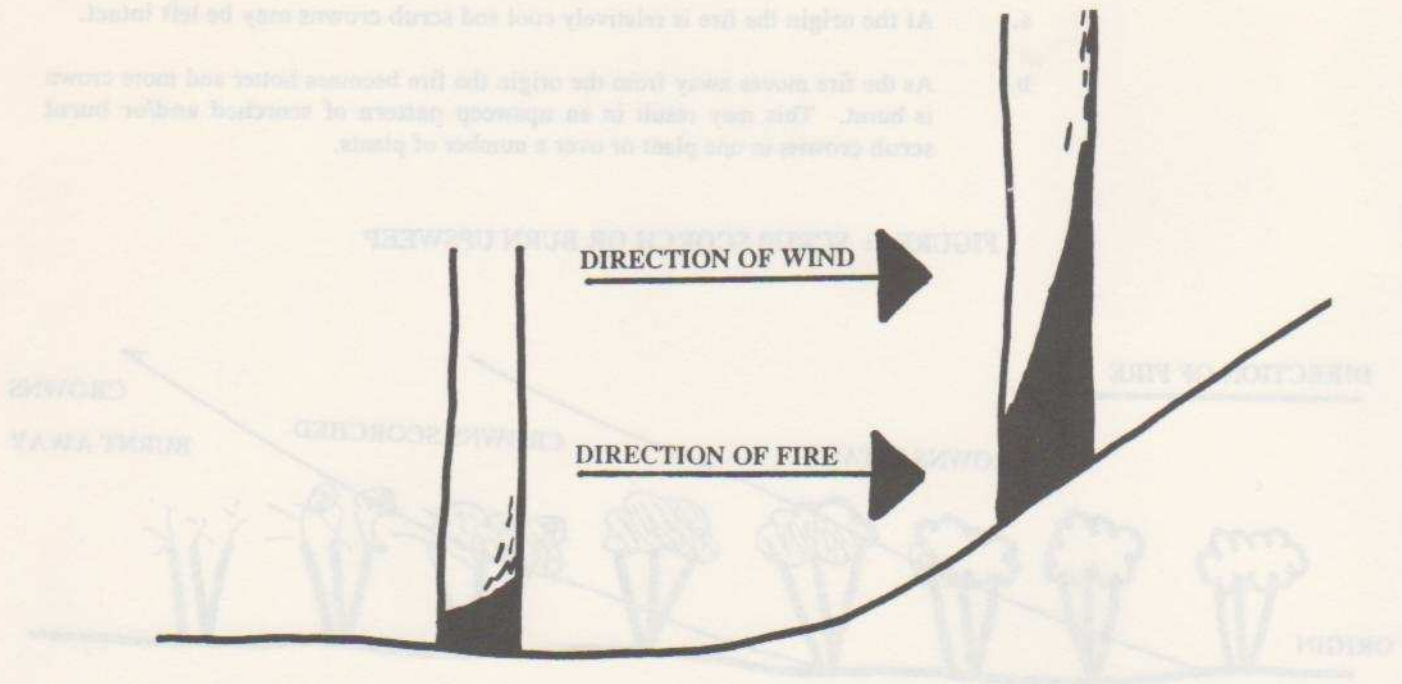


- c. The stalk on some scrub species may be burnt so that white ash appears on the side facing the origin, while a darker char is present on the side away from the origin. In some cases charring only occurs on the origin side.
- d. Burnt off stubs will be cupped. As in grass, the stub will burn lower on the exposed side and higher on the protected side.
- e. Unburnt tip ends of scrub may fall on the ground on the upwind side.

6.2.3 Tree burn pattern indicators

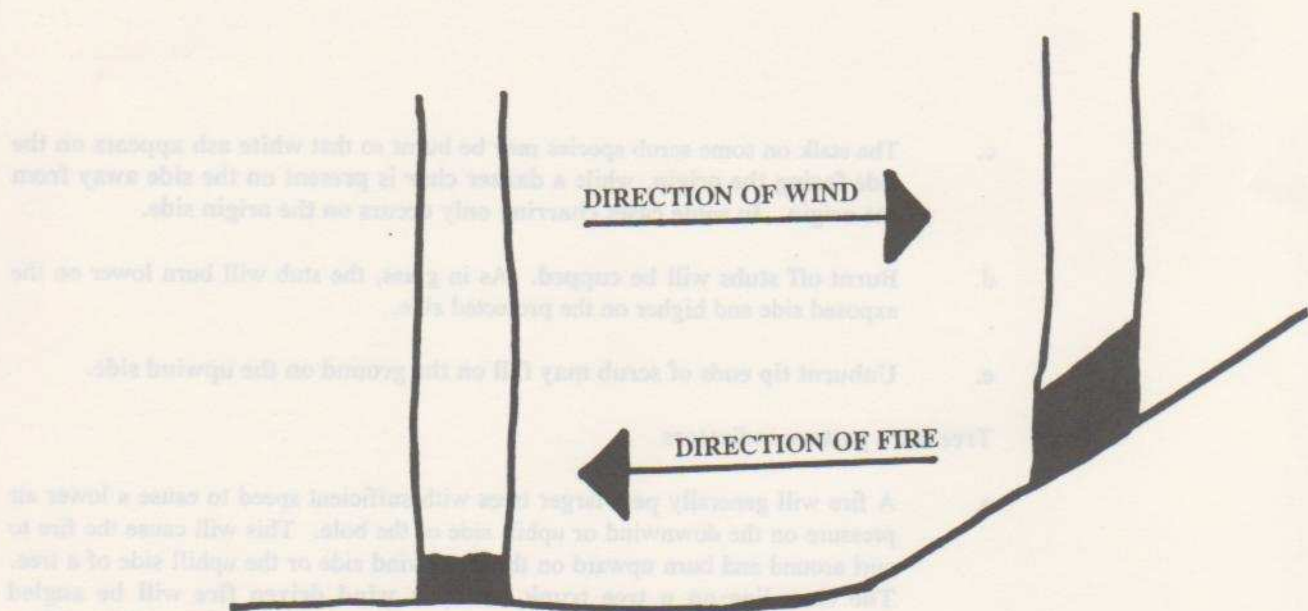
- a. A fire will generally pass larger trees with sufficient speed to cause a lower air pressure on the downwind or uphill side of the bole. This will cause the fire to curl around and burn upward on the downwind side or the uphill side of a tree. The char line on a tree trunk hit by a wind driven fire will be angled upward. The char line on a tree trunk hit by a fire moving uphill will be angled upward at an angle greater than the ground slope. On long unburnt stringy barked eucalypts this effect will become less obvious particularly when the bark is burnt under conditions of very low relative humidity. Care should be taken not to mistake burn indicators from previous fires.

FIGURE 6: TREE CHAR LINES; FIRE TRAVEL WITH WIND/UPSLOPE



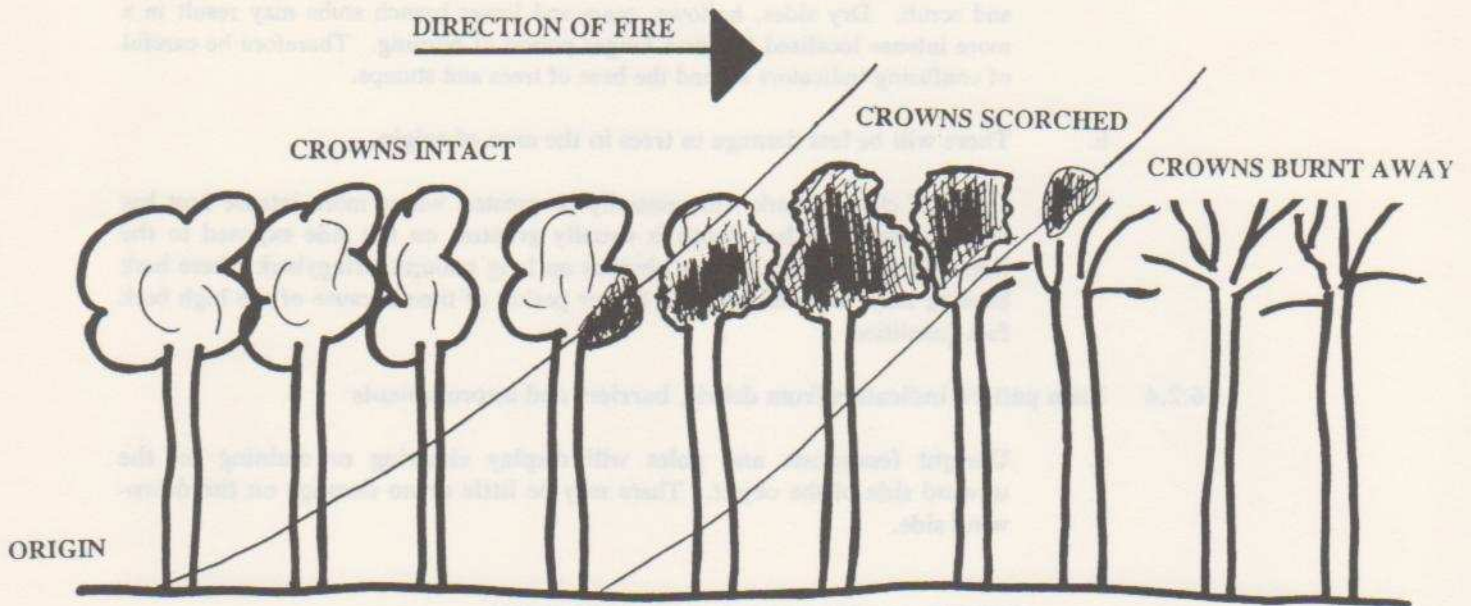
- b. A fire moving downhill past a tree will result in a char line on the trunk that is nearly parallel to the ground slope.

FIGURE 7: TREE CHAR LINES; FIRE TRAVEL AGAINST WIND/DOWNSLOPE



- c. Debris at the base of a tree can cause misleading burn indicators.
- d. Crown fires in trees will generally occur in a fan-shaped pattern with the wide part of the fan pointing in the direction of travel. Crowning burn patterns will occur in a similar way to the crowning process in scrub. Thus an upsweep pattern of scorched and/or burnt tree crowns may be apparent as the fire moves away from the origin.

FIGURE 8: TREE CROWN SCORCH OR BURN UPSWEEP



- e. A hot dry wind associated with severe scorch may result in **needles or leaves on trees freezing in a fixed direction**. The rigidity of leaves on numerous plant species is determined by the turgor within the leaf cells. Initial heating of leaves causes water stress and a reduction in turgor pressure causing leaves and smaller stems to wilt. A wind will blow the wilting leaves so that they "point" in the direction of the wind. As the heat becomes more intense, membranes will be damaged and the moisture will be rapidly extracted from the leaf and stem, resulting in "freezing" of the leaves "pointing" in the direction of the wind (usually the direction of fire spread).

FIGURE 9: "FREEZING" OF LEAVES

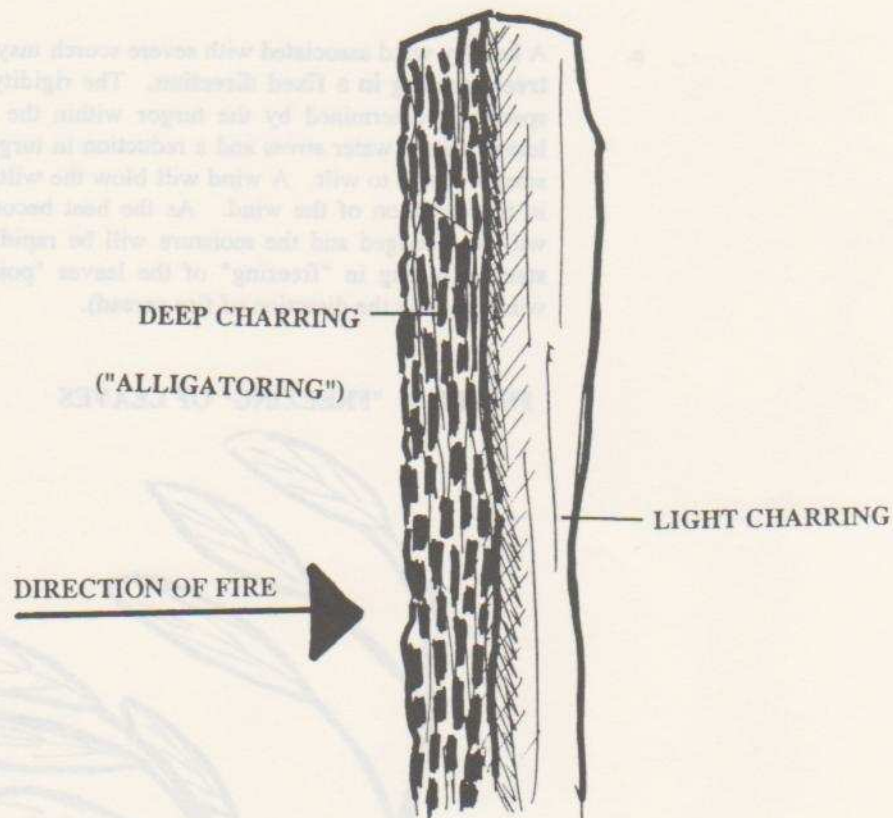


- f. Ashes from residual burning of trees will be blown down wind.
- g. **Cupping** on trees and stumps will occur in a similar process to cupping in grass and scrub. Dry sides, hollows, scars and lower branch stubs may result in a more intense localised fire or a longer period of burning. Therefore be careful of confusing indicators around the base of trees and stumps.
- h. There will be less damage to trees in the area of origin.
- i. Depth of char on bark will generally be greatest where more intense heat has been sustained. **Char depth is usually greatest on the side exposed to the fire.** This effect may be less obvious on long unburnt stringybark where bark burning may be sustained for a longer period of time because of the high bark fuel quantities.

6.2.4 Burn pattern indicators from debris, barriers and improvements

- a. Upright fenceposts and poles will display charring or staining on the upwind side of the object. There may be little or no damage on the downwind side.

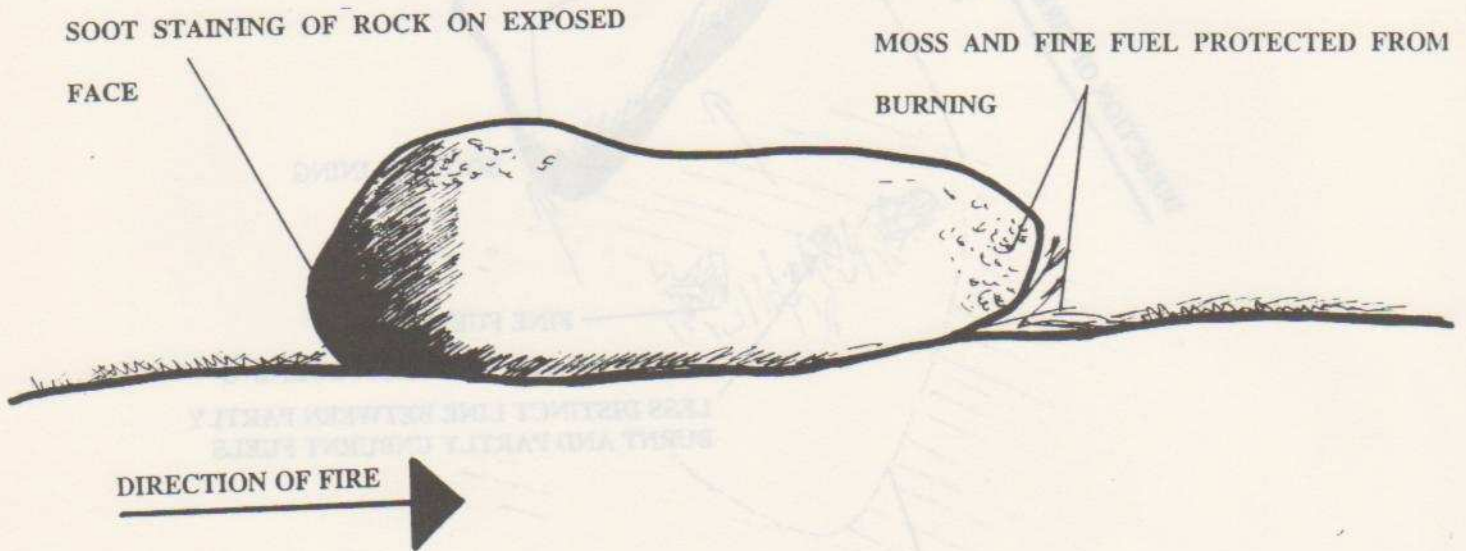
FIGURE 10: CHARRING ON FENCE POST



- b. Alligatoring is a form of charring that occurs on barriers such as fenceposts, boards, signposts and structures. Alligatoring is caused by the combined effects of deep charring and shrinking of the burnt areas, and results in a scale-like appearance. The depth of the char, or alligatoring, can be a good indicator of fire travel, with deeper alligatoring occurring on the upwind side. **A hot fast fire will result in large shiny alligatoring. A cooler slower fire will result in small and dull alligatoring.** Care must be taken not to misinterpret alligatoring resulting from previous fires.

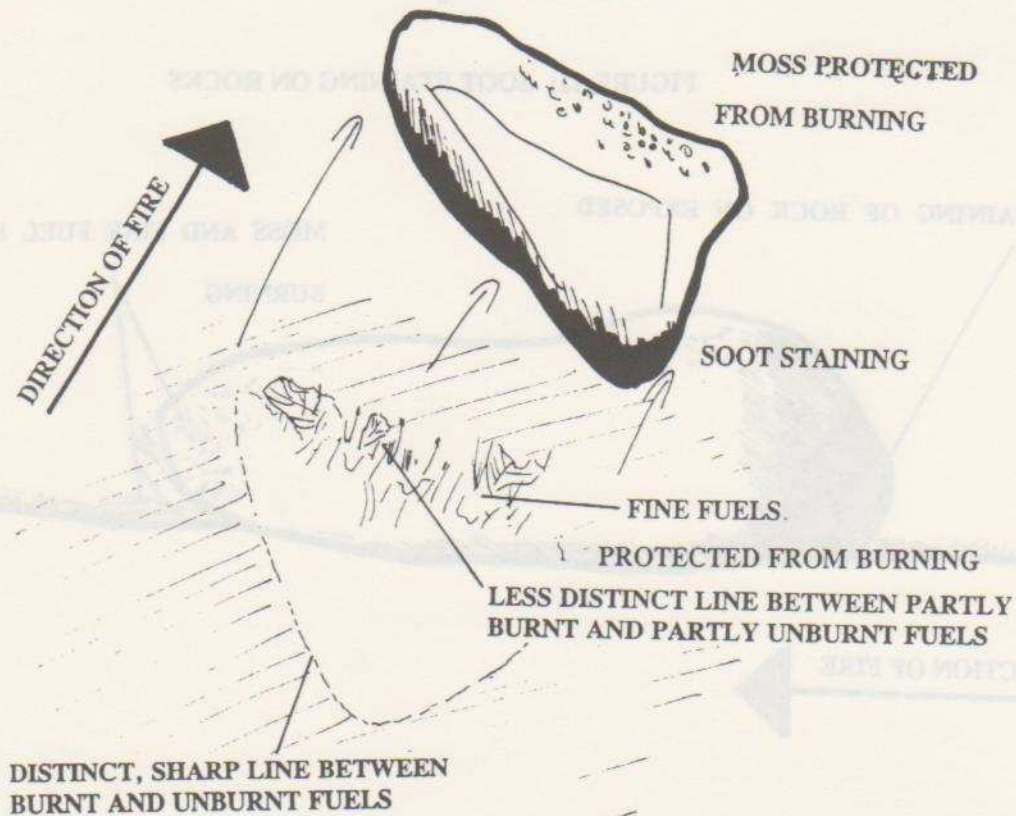
- c. Rock faces exposed to oncoming flames will have moss and lichen burned away. The rapid cooling effect when the flames impinge on the rock will result in sooting, carboning and staining as minute particles of partly burnt material adhere to the rock. The colour of the staining may vary from yellow through brown to black. The protected side of the rock will show less moss burnt and less staining.

FIGURE 11: SOOT STAINING ON ROCKS



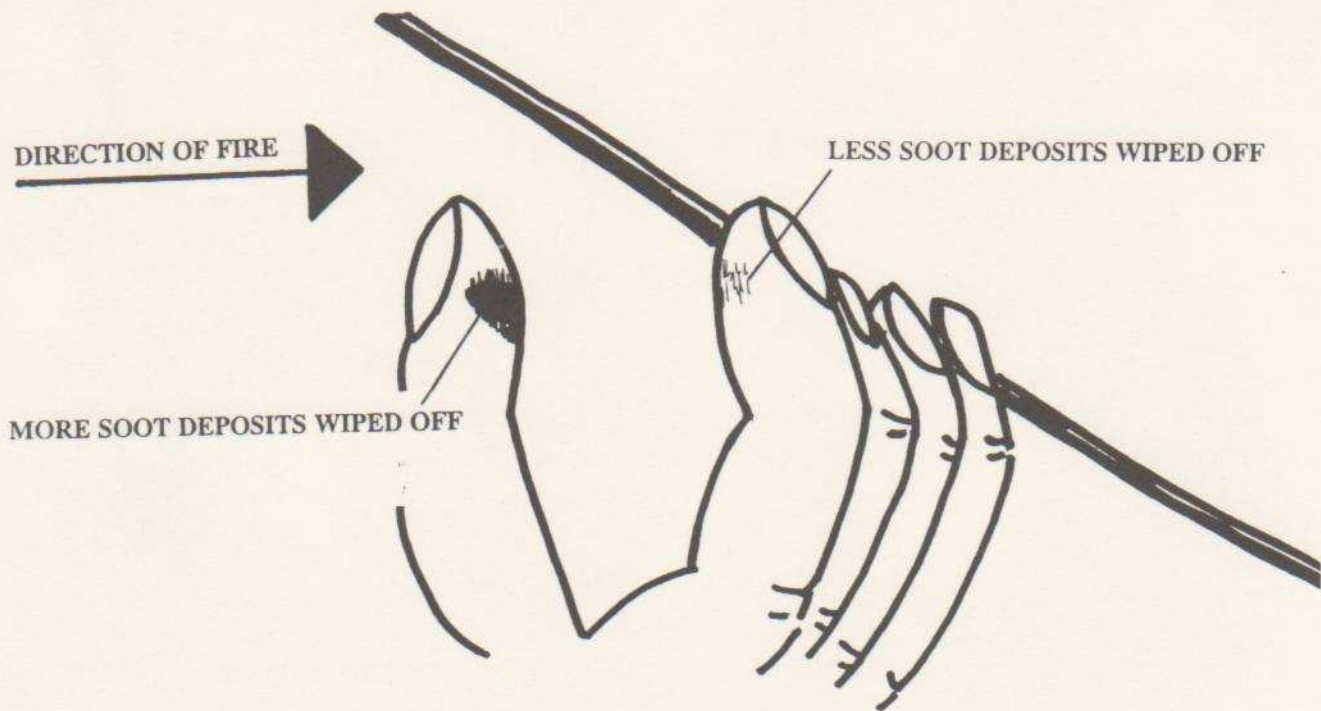
- d. If the fire is very intense the rapid heating then cooling of the rock face may result in splitting, cracking or exfoliation of layers of rock on the side exposed to the oncoming flames.
- e. Any object in the path of the fire will present an obstruction to fire travel to some degree. Logs, bottles and cans can be excellent burn pattern indicators. Flames will be lifted over and around the object, deflecting the normal lean of the flame. The exposed face of the object will show signs of staining, and fine fuels around the base on the exposed side of the object will be mostly consumed. Fuels on the protected side may have been shielded by the object, resulting in less complete ignition. If the object is lifted the transition from burnt fine fuels to the shielded unburnt fuels underneath the object will be a clear line on the side facing the fire, compared to a ragged burn line on the side away from the fire origin.

FIGURE 12: LIFTING OBJECT TO EXPOSE PROTECTED FINE FUELS



- f. Soot and carbon deposits may occur on the upwind side of metal objects such as posts, signs and fencing wire. The degree of sooting on wire can be compared by running the wire between the thumb and forefinger. More soot deposits will be evident from the side of the wire exposed to the oncoming flames.

FIGURE 13: SOOT STAINING ON FENCE WIRE



6.2.5 General comments on burn pattern indicators

- a. A slow creeping fire will not demonstrate clear or consistent indicators, and may be very difficult to interpret.
- b. Footprints and tyre prints distinguishable before the passage of the fire will still be discernible after the fire.
- c. Abnormal or high moisture contents in cured grass fuels will tend to conceal burn pattern indicators. Native tussock grasses (*Poa spp*) are particularly poor burn pattern indicators.
- d. Some fires may give the impression of multiple origins. Where there is more than one origin then each fire start will have its own origin pattern. Check uphill or upwind to determine the possibility of spotting or rolling.
- e. In general, the size of the indicator will become smaller, and less apparent closer to the origin.
- f. Always follow the majority of indicators.

7. FIRE SCENE EXAMINATION

The investigator should arrive at the fire scene as soon as possible. Fire killed/scorched leaves will quickly commence to fall, wind will blow light debris, rain may destroy ash and the passage of time generally obscures visual signs. Fire-fighters, machinery, vehicles, onlookers and sometimes Police may disrupt the area of origin and destroy burn pattern indicators.

In a situation where more than one agency is likely to become involved in the fire investigation (eg: other fire service investigators, Detectives, Coroner) it will be essential to delay the investigation until each agency has arrived at the fire scene, or has sanctioned the investigation to commence in their absence.

RECOMMENDATION 3: Liaise closely with relevant forest and rural fire services and Police at all times during wildfire investigations.

In selecting a starting place, the investigator should find out what area was already burned over and the direction of the wind from fire-fighters and early witnesses. If no-one is around, start from an initial control line.

Rather than walking straight to the area of origin, use a method of search which circles in on it. This will ensure that multiple fire ignitions are not overlooked. After the first circle is finished, narrow in to a smaller circle. Be very careful on the upwind side or lower slope because the origin may be very close.

7.1 Methods of search

There is often no second chance. Moving over an area may destroy evidence not found. Methods of search must be systematic. Where there is a lack of burn pattern indicators, or in difficult investigations, there may be a need for more than one search, or more than one searcher. Two recognised methods of search are the half concentric method (Figure 14) and the spiral method (Figure 15).

FIGURE 14: ½ CONCENTRIC METHOD OF SEARCH

DIRECTION OF SEARCH

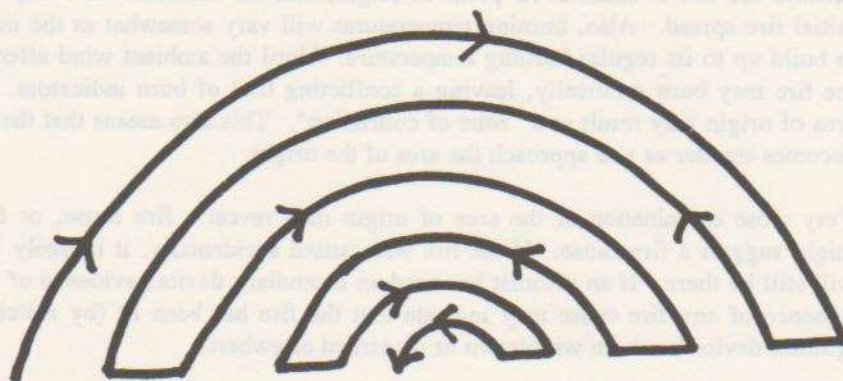
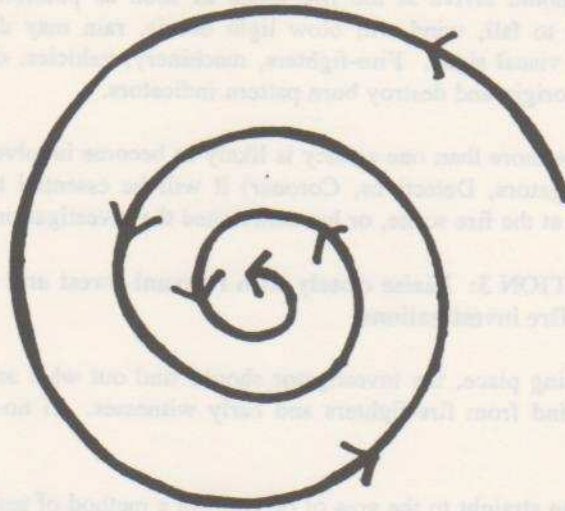


FIGURE 15: SPIRAL METHOD OF SEARCH

DIRECTION OF SEARCH



The investigator should identify burn pattern indicators and work back towards the area of origin. Extreme care must be taken when approaching the point of origin, and the area should be cordoned off. At this point you should begin over again from another starting point. Do this as often as is required to be sure of the area of origin. Don't try to get the area of origin smaller than table-top size. Exercise extreme care not to disturb the point of origin.

It is very important to always follow the majority of indicators when determining which way the fire spread.

7.2 Fire origin examination

When you are sure of the area of origin, then get on your hands and knees and study the area in minute detail. In some cases it will be necessary to use tape or string to divide the area of origin into a grid, allowing a very detailed search of one grid at a time. Where possible each grid should be searched by two investigators, or searched at least twice before moving to another area.

The immediate area around the point of origin will exhibit conflicting burn indicators. This is because the fire is small at its point of origin, and the ambient wind may be less important in initial fire spread. Also, burning temperatures will vary somewhat as the incipient fire is trying to build up to its regular burning temperature. Until the ambient wind affects the burning base, the fire may burn erratically, leaving a conflicting trail of burn indicators. For this reason the area of origin may result in a "zone of confusion". This also means that the size of the indicator becomes smaller as you approach the area of the origin.

Very close examination of the area of origin may reveal a fire cause, or further evidence that might suggest a fire cause. If the fire was caused accidentally, it is likely that the causal agent will still be there. If an arsonist has used an incendiary device, evidence of it may still be there. Absence of any fire cause may indicate that the fire has been lit (by match or lighter) and the ignition device has been withdrawn or discarded elsewhere.

Examination of the fire origin may include some or all of the following activities:

- pass a strong magnet (50lb pull) over the area to pick up wire, metal and carbonised metal fragments,
- search for specific ash deposits. Matchsticks, paper and cigarettes will usually leave easily recognised deposits,
- note any gouges, chips or disturbances to natural ground surface,

- preserve physical evidence (after taking appropriate notes, photographs and diagrams). Evidence should be placed in a sterile container and labelled. The laws for continuity of evidence should be followed from this time on,
- make plaster casts of tyre, foot and prints,
- make notes, sketches and photographs.

7.3 Photographs

Photographing the area of origin should be considered very early in the investigation, preferably before any destructive or disturbing examination has been commenced.

Initial attack firefighters can be encouraged to take photographs by providing them with "disposable" (single use) cameras.

Photos should include:-

- the overall scene,
- medium distance photos,
- close-up photos of important items.

Photographs should generally be:-

- low angle flash photos in 4 directions,
- taken at eye level,
- taken with and without cordon tape and aids.

Always record the time, date and location of each photo as well as the type of camera, lens, exposure, film speed and the photographer's name. It is also helpful to record why the photo was taken, or what the photo is meant to show.

Pay particular attention to:-

- footprints and tyre tracks,
- articles left at scene,
- campfires,
- cleared areas,
- discarded cigarettes/matches,
- food,
- excrement,
- containers.

Card arrows can be used to point to, and highlight objects and indicators of the direction of fire travel. It is helpful if arrows are labelled appropriately:-

- "direction of fire travel".
- "direction of fire origin".

- "fire spread indicator".

When gathering photographic evidence for use in court it is also important to take photographs without aids such as taping, card arrows and pointers.

Exposed films should be processed promptly and the identity of the processing agent recorded. The photographer must verify that the photos received from the processor are in fact the photographs taken at the fire scene.

7.4 Sketches

A sketch of the fire scene should always be made where the fire is likely to be human-caused with likely follow-up legal action.

Sketching will not replace photography and photography will not replace sketching. A photo will often be crowded with irrelevant details whereas a sketch will only contain important items and details.

Sketches should be complete and simple and show only important details, including the location of major burn pattern indicators. A sketch should include the four compass points, and relevant measurements so that objects can be related to fixed landmarks, and to each other. Measurements should be accurate, however if pacing is used it is important to note this (do not try to convert paces to measurements). Each sketch should have the time, date and name of the author.

8. FIRE CAUSE DETERMINATION

"You must carry out a good fire investigation to determine whether you have an arson problem or a prevention problem".

- Stan Fitzgerald, Fire Management Officer, USDA Forest Service, Toiyabe National Forest, Nevada.

8.1 Wildfire causes

Determining the cause of a fire is a matter of understanding the process by which ignition, and then subsequent combustion, occurs. The fire investigator must know what the heat source might look like and how to find it after burning has taken place. Ford (1990) recognises four categories of ignition:

8.1.1 Heated objects

When a heavy heated object falls onto fine fuels it will tend to compact the fuel. Heat is concentrated and fuel moisture may be released as steam. Smouldering and charring will occur under the heat source. Ignition of fine fuels around the edges of the object will occur if there is sufficient oxygen and the temperature of the heated object exceeds the combustion temperature of the fuel. General visual indicators include:

- fuels under large heated objects will be charred off in the same shape of the object,
- objects will char their way down through fine fuels and may be covered with considerable debris,
- super heated metals may be discoloured blue or grey or be unusually bright and polished,
- manifold carbon, and to a limited extent, exhaust carbon, may respond to a magnet because of the metal content acquired from engine wear.

8.1.2 Outside causes

When some already ignited source is introduced, igniting fuels. The ignited source may be above ignition temperature of the fuel (eg a burning match) or less than the ignition temperature (eg a burning cigarette). Flaming heat sources need only to be brought near to fine fuels to ignite them. However smouldering heat sources will require severe conditions (ie high temperature, low relative humidity) in combination with very fine dry fuels which are solidly compacted. Ignition will be boosted by the presence of a breeze and pre-heating by the sun. General visual indicators may include:

- presence of burnt match or cigarette,
- absence of any heat source (indicating that it was **withdrawn** after ignition).

8.1.3 Onsite causes

Where the facility or object that caused the fire is present at the point of origin. Usually this indicates that the fire was accidental and possibly the result of failure, malfunction or mis-use. In most cases the object that caused the fire will be apparent.

8.1.4 Transitory causes

This refers to fire causes that are introduced to the origin site. This includes vehicles and equipment being operated through the origin, aircraft crashes, and lightning. The common element is the presence of evidence such as a track, visible imprint or damaged vegetation that is left by the moving heat source.

8.2 Indicators of fire cause

Specific indicators may help to identify the actual thing or object that ignited the fire. Indicators of common fire causes are as follows:-

8.2.1 Lightning

- strike marks may occur on bark of trees, poles or cause splinters from logs, stumps and roots.
- earth may be disturbed, rock shattered.
- improbable that fire was human caused because of remoteness.
- knowledge of recent electrical storm in area.

8.2.2 Spontaneous combustion

- wet hay, damp sawdust.
- moisture, heat present, but no oxygen.
- black carbonized substance resembling charcoal left as burning residue.
- presence of glass lens, or partly water filled clear glass container.
- not common.

8.2.3 Exhaust fires

- down wind of road or railway tracks.
- numerous fires.
- usually within 6m of edge of road or rail line.
- usually start in area where engine is idling, or slowing down.
- carbon fragments present.

8.2.4 Brakeshoe fires

- downhill grades.
- fires on both sides of railway line or track.
- usually within 2m of edge of track or line.

- metal fragments present.

8.2.5 Powerline/electric fence

- fire origin on a fence line.
- moist vegetation in contact with fence or line.
- dry or flammable vegetation in area of ignition.
- broken insulators.
- electrocuted birds/animals.
- parts of transformer/fuse.

8.2.6 Equipment fires

- fragments or broken pieces of metal may be obvious.
- gouge or chip in roadway.
- welding rod or rod ends.
- vehicle tracks off roadway.
- catalytic converter will start a fire between vehicle wheel tracks.
- grinding sparks can be picked up by a magnet.

8.2.7 Cigarette fires

- fuel must be very dry.
- air relative humidity must be less than 25 % (Boarhill, 1975).
- may be other evidence of human activity.
- punky or dense fuel bed. Very compacted fine fuel.
- usually requires at least 30% of length of cigarette in contact with the fuel (Rose, pers. comm.).

8.2.8 Incendiary

- device may be found. Many variations.
- evidence of humans in area.
- may be no evidence (match/lighter is withdrawn or match is discarded in another location).

8.2.9 Elimination of causes

If the fire cause is not apparent, it may still be possible to eliminate what did not cause the fire. This is very important because it will help you to concentrate on what is a possible ignition source.

RECOMMENDATION 4: Train an appropriate number of personnel in each Region as intermediate level wildfire investigators.

RECOMMENDATION 5: Provide an advanced level wildfire investigation course for a limited number of advanced level wildfire investigators. This could be provided internally; through a National training course; or from one of a number of courses in the United States.

fire origin on a fence line.

contact vegetation in contact with fence or line.

dry or flammable vegetation in area of ignition.

broken insulation.

electrified birds/animals.

paths of transmission lines.

8.3.4 Equipment fires

fragments or broken pieces of metal may be observed.

gauge or chip in roadway.

welding rod or rod ends.

vehicle tracks off roadway.

catalytic converter will start a fire between vehicle wheel tracks.

existing sparks can be picked up by a spark.

8.3.5 Cigarette fires

fuel must be very dry.

air relative humidity must be less than 25% (Howarth, 1975).

may be other evidence of human activity.

poorly or dense fuel bed. Very compacted fuel bed.

usually requires at least 30% of length of cigarette in contact with the fuel (Hosie pers. comm.).

8.3.6 Secondary

devices may be found. Many variations.

evidence of humans in area.

may be no evidence (investigator is withdrawn or path is discarded in another location).

8.3.7 Examination of cases

If the case is not reported, it may still be possible to eliminate what did not cause the fire. This is very important because it will help you to concentrate on what is a possible ignition source.

RECOMMENDATION 4: Train an appropriate number of personnel in each Region as intermediate level wildfire investigators.

9. INVESTIGATION OF DELIBERATELY LIT WILDFIRES (ARSON)

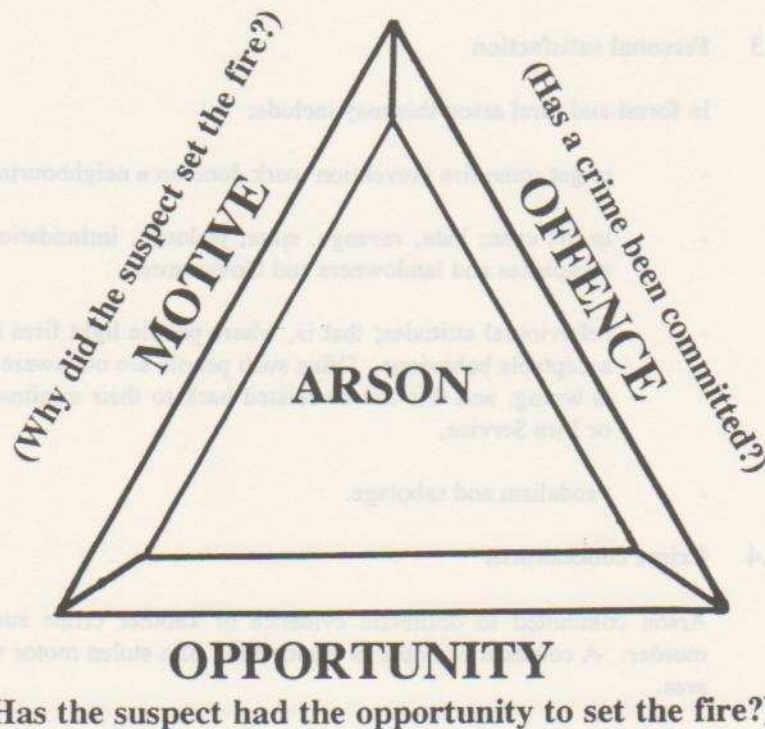
9.1 Arson and the arson triangle

Deliberately lit forest and rural wildfires share many features in common with other, more recognised, arson problems (such as arson in motor vehicles and structures). The fuel type, means of ignition and burning indicators may vary somewhat, but all arson problems share similar motives, characteristics and investigation strategies.

Evidence gathered in an arson investigation will include **direct** evidence (from eyewitnesses), and **indirect** or **circumstantial** evidence which will be more abundant. The significance of indirect evidence depends on the amount of it, and whether or not it corroborates with other evidence. In most cases arson investigations will require an expert to determine the presence of and significance of indirect evidence.

Arson can be considered as requiring three elements: motive, opportunity and an offence (or a crime). Considered together, these elements form the arson triangle.

FIGURE 16: THE ARSON TRIANGLE



In some cases, it may be possible to eliminate potential suspects by considering their opportunity, motive, profile and other supporting evidence.

9.2 Motives for arson

"Motive" is some inner drive or impulse that causes a person to do something or act in a certain way. In a legal context, motive explains "why" the offender has committed an unlawful act.

Establishing a motive generally assists an investigator in an investigation and often focuses attention on likely suspects. However fire setting is often a highly complex behavioural problem, therefore the actual motive may not be readily apparent (Victoria Police, 1990).

Many motives for arson can be related to the growth of severe economic, social and psychological strains on communities.

Common motives exist for deliberately lighting forest and rural wildfires and other types of arson fire (eg structural/vehicle arson). In fact the relationship is so close that the types of arson often blend, for example a deliberately lit vehicle causes a wildfire, or a wildfire is lit to destroy a structure.

The Victoria Police (1990) recognise five general motives for arson:

9.2.1 Direct profit

Where the assured benefits directly from the fire. This often involves the rapid realization of the value of the asset affected by the fire. It is usually achieved by defrauding the insurance company.

9.2.2 Indirect profit

Where the assured is the innocent party, but the perpetrator benefits indirectly. The arson fire will result in the perpetrator eliminating business rivals, or stimulating his own business relative to other competitors. In the United States where illicit drug producers set up in remote forest wildlands, numerous wildfires are set by drug producers trying to burn out their competition. (Huxman, pers. comm.).

9.2.3 Personal satisfaction

In forest and rural arson this may include:

- to get some fire prevention work done on a neighbouring property,
- to get even; hate, revenge, spite, jealousy, intimidation of neighbours, private companies and landowners and Government,
- behavioural attitudes; that is, where people light fires because they believe it is acceptable behaviour. Often such people are not aware that what they are doing is wrong, and this can be related back to their minimal contact with the Forest or Fire Service,
- vandalism and sabotage.

9.2.4 Crime concealment

Arson committed to obliterate evidence of another crime such as burglary, larceny, murder. A common example is the torching of a stolen motor vehicle in a remote forest area.

9.2.5 Mental or emotional disorder

Persons motivated by certain mental afflictions. This may include:

- persons suffering from some form of insanity, eg pyromania (no rational motive), paranoia, delusion, melancholia,
- persons who are mentally or emotionally unstable and exhibit abnormal social behaviour. The motive stems from vanity, excitement, ego, and wanting to draw attention, and includes persons under the influence of drugs or alcohol, and mentally defective persons.

A proportion of deliberately lit wildfires in the United States are lit by fire service personnel (Huxman, pers. comm.). This includes professional urban firefighters, forest and rural firefighters and volunteer firefighters. The motivation for firefighter arson may include **indirect profit** (eg: the Incident Command Logistics Chief who lit fires to share in the profits gained from preferred suppliers); **vanity** (eg: the son of a Forest Service Fire Management Officer who while working on a fire "hot shot" crew, lit fires to impress his father); and **pyromania**. There is no

reason to expect a different trend in Australia, therefore fire investigators should always consider the possibility of fire service personnel when looking for an arsonist.

9.3 Investigation strategies for arson problem areas

"The greatest deterrent to arson is found in the successful completion of an arson investigation".

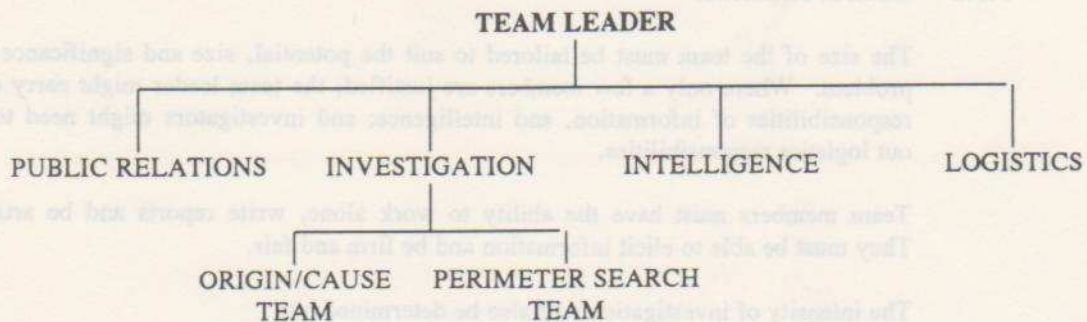
- AETNA, Arson Prevention Series.

Special strategies may be required to manage and investigate arson problem areas, or specific series of arson.

A multi-agency approach is required when the problem involves the jurisdiction of more than one agency. Co-operative inter-agency efforts can often be more effective, more cost efficient and result in greater information sharing. In Australia, special efforts must be made between the fire service investigator (rural or forest) who in most cases will have the best fire behaviour skills to determine fire origin, and the Police (particularly the Criminal Investigation Branch) who will have the best investigation and interviewing skills. The two agencies must work together from an early stage and share all their information throughout the investigation.

9.3.1 Arson investigation team structure

The aim of an arson investigation team is to investigate all fires that occur in the problem area, to determine origin and cause and to identify the party responsible. A number of management structures could be adopted. An example is (after Faulk 1981):



Roles and responsibilities of the team are as follows:

Team Leader:

- Responsible for overall direction of the team.
- Must have access to senior agency managers.
- Reviews progress periodically.
- Authorises expenditure, rewards etc.

Public Relations:

- Provides public information.
- Compiles reports for team leader.
- Distributes information on rewards.

Intelligence:

- Surveillance.
- Data collation and analysis.
- Information management.
- Liaison with participating agencies.

Logistics:

- Procure and maintain equipment.
- Clerical and administrative support.
- Expenditure.
- Housing, accommodation.

Investigation:

- All relevant agencies with statutory responsibilities should be represented.
- Collect data and evidence.
- Investigate all fires in the area of investigation.
- **Origin/Cause Team:** Determine point of origin and cause. Preserve origin. Gather origin evidence. Take photographs and make sketches. Wear protective clothing at the fire.
- **Perimeter Search Team:** Pursue leads and make general area observations and enquiries regarding persons and vehicles associated with the fire. Erect "fire under investigation" posters. Conduct interviews. Carry out follow-up work. Wear either a uniform or plain clothes at the fire.
- Data from each fire must be collected and recorded in a systematic way. An example of the data that can be collected from an arson incident is attached as Appendix 1.

9.3.2 General comments

The size of the team must be tailored to suit the potential, size and significance of the problem. Where only a few members are justified, the team leader might carry out the responsibilities of information, and intelligence; and investigators might need to carry out logistics responsibilities.

Team members must have the ability to work alone, write reports and be articulate. They must be able to elicit information and be firm and fair.

The intensity of investigation will also be determined by:

- the potential for loss of life or damage to property,
- the possibility of preventing further fires,
- the possibility of a successful result,
- the impact of the investigation on normal duties and work loads.

Each investigation will have two phases:

- **During the initial attack:** When the origin/cause team and the perimeter search team are collecting evidence and data. Despatch of these investigators should be pre-planned and investigators should arrive at the fire scene as quickly as possible. In some situations a preventative tool is to "swamp" the area with investigators.
- **Follow-up:** When information is massed, sorted into intelligence, information requirements are identified and followed up, and information is stored.

Data collected should be analysed by:

- time of day,
- day of week,
- week of month,
- month of year,
- occurrence of special events, school holidays, public holidays etc,
- location,
- situation of origin,
- fire danger index at ignition.

Information collection and analysis should aim at trying to provide answers to the following questions relating to the arson:

- Who?
- What?
- When?
- Where?
- Why?

Where possible the follow-up activities of the arson investigation team should be covert. Members should be strict in keeping only those who "need to know" informed of progress and developments.

RECOMMENDATION 6: Form teams of investigators for use in areas of high arson activity.

9.3.3 Special strategies

- a. **Draw attention to the investigation:** Card signs can be used to make people aware that a fire has occurred and that it is under investigation. (see Figures 17 and 18) Note pads or self addressed envelopes seeking information can be left at houses in or near the fire area. (see Figure 19)

FIGURE 17: EXAMPLE OF A "FIRE UNDER INVESTIGATION POSTER"
(Source: North Carolina Division of Forest Resources)



FIGURE 18: EXAMPLE OF A "REWARD" POSTER
(Source: Pennsylvania Bureau of Forestry)

REWARD

DEPARTMENT OF ENVIRONMENTAL RESOURCES COMMONWEALTH OF PENNSYLVANIA

will pay a REWARD, not to exceed \$500.00 for the FIRST
Information leading to the arrest and conviction of
the person or persons responsible for setting THE FOREST
FIRE of _____ on _____


(ACT of June 14, 1923, PL. 761, No. 300)

Information shall be provided to District Forester _____
at _____ Penna.

John H. Bitzer
Chief Forest Fire Warden

ER FP 6.2/88

FIGURE 19: EXAMPLE OF AN ARSON INFORMATION NOTE PAD
(Source: California Division of Forestry and Fire Protection)

	ARSON ALERT
IF YOU SEE A SUSPICIOUS PERSON, HIS/HER VEHICLE, OR ANY OTHER RELATED SUSPICIOUS ACTIVITY, PRIOR TO, DURING, OR AFTER A FIRE, WRITE DOWN THE INFORMATION AND CALL YOUR FIRE OR POLICE DEPARTMENT	
LICENSE # _____	
VEHICLE DESCRIPTION: MAKE _____	
MODEL _____	COLOR _____ YEAR _____
SUSPECT DESCRIPTION: _____	
HEIGHT _____	WEIGHT _____ SEX _____ RACE _____ HAIR COLOR _____
EYES _____	OTHER (Distinguishing Marks) _____
CALL: _____	
W.A.R. WILDLIFE ARSON RESPONSE CALIFORNIA INTERAGENCY WILDLAND ARSON PREVENTION COMMITTEE	
<small>Author 4/85</small>	<small>PRINTED BY LAKE TAHOE KIWANIS</small>

- b. Use an anonymous tip-off telephone advice line: After arson activity, people may be willing to give information anonymously. In some circumstances it may

be appropriate to define specific times and dates for a "phone-in" to try to gather information from the public about arsonists.

RECOMMENDATION 7: Investigate the use of an anonymous public advice line that can be activated on a local or statewide basis during times of high arson activity.

- c. **Set up a rural watch or bush alert program:** This will encourage rural and forest residents and legitimate users in the problem area to note and report suspicious activities and people.

RECOMMENDATION 8: Actively support programmes such as Neighbourhood Watch and Rural Watch and Bush Alert.

- d. **Tell the media about the problem:** Great care must be taken with this approach. The aim is to create awareness and elicit support for the investigation, and perhaps even change the attitude of the arsonist. The result may be the opposite. Media reports may increase the arsonist's activities (answering the challenge set down by the media). Copy-cat arsonists can be stimulated by media reports. Sometimes the media will focus on one particular (often undesirable) aspect of the situation and the aim will not be achieved.

One strategy is to simply state that "the fire is under investigation". Where more detail is requested then highlight some negative aspect of the fire (eg: public safety, suppression cost, damage, firefighter safety). Deal in facts, not theories or opinions.

When there is a grave threat to life or property it is possible that a high profile media coverage may help create public awareness about the problem; however, depending on the motive for the fire setting, this may not affect the arsonist's activities.

- e. **Rewards:** Use a reward only when all avenues of investigation have drawn a blank, or in a situation where the activities of the arsonist present an imminent and grave threat to life or property.
- f. **Tracker dogs:** Dogs are used to:-

- deter arsonists,
- track down who is responsible.

Dogs are particularly suitable where an arsonist travels on foot. Dogs are very visible. The use of dogs often elicits confession very quickly because the offender often believes that the dog will inevitably find him.

The aim is for the dog to pick up a lone scent and follow it. Scents cannot be followed through a burnt area, but dogs have been used on 24 hour old trails and distances up to 3 miles. (Creelman pers. comm.).

Dogs may be available from:

- Clubs and Contractors (should have accreditation or dog history)
- Police
- Prison Service
- Military.

RECOMMENDATION 9: Investigate the use of dogs for tracking arsonists who travel on foot.

g. **Video cameras:**

Video cameras can be used to identify vehicle registration plate numbers on roads leading into or out of areas having serial arson activity. Once set up, the camera records for a 12 hour period then rewinds. When an incident occurs, the videotape is removed before the next recording event.

Analysis of vehicle registration plates over time help to identify persons responsible for arson. This technique has provided good results when used, but is only suitable for daytime use, and is restricted to areas where improvements and utilities are present.

RECOMMENDATION 10: Investigate the use of video technology as a tool for recording arsonist activity.

9.4 Arson prevention strategies

"The purpose of fire law enforcement is fire prevention".

- Larry Barnes, Investigator North Carolina Div. Forest Resources.

The motives for deliberately setting fires may be quite complex. Arson can be a result of economic, social and psychological strains in community, or it may be the result of long and deeply held cultural beliefs.

Not all arson is preventable; however, it is possible to create awareness and change attitudes and beliefs and deter some motives for arson.

Arson prevention strategies are particularly appropriate where there is a cultural belief that lighting of fires for some reason, acceptable. (For example to encourage fresh grazing fodder, to get fire prevention work done, to remove weeds or vermin and to improve hunting prospects).

Doolittle et al (1976) suggests that steps in an arson prevention strategy include:-

9.4.1 Analyse the problem

- identify problem areas.
- determine priorities.
- describe local residents.

9.4.2 Direct prevention

- remove the motive for fire setting.
- claim damage and suppression costs against fire-setters (deterrent).
- use of rewards and punishment.
- develop friendly relationships with local residents and community groups.
- law enforcement.
- highlight opinions of residents opposed to deliberately lit wildfires.
- publicise each fire soon after it occurs. Emphasise the fact that wildfire has an adverse effect (jobs, damage, public safety, suppression cost etc.).
- carry out work to achieve the arsonist's motive using legal means. (For example, conducting prescribed burns).

9.4.3 Indirect prevention

- use when all residents support deliberately lit wildfires.
- elementary and secondary school education.
- adult education programmes and publicity.
- use credible community organisations to help sponsor your prevention message.
- law enforcement and publicity.

9.4.4 Juveniles

The problem with juvenile firesetters compounds if they mature into adult firesetters (Anon, 1989). Depending on the level of concern, individual juveniles might be referred to social services for education and follow-up. Contact with fire service personnel acting as mentors may also assist in educating and changing the attitudes of juvenile fire setters.

9.4.5 Policy

The lesson that an individual who causes a fire may be caught, prosecuted and pay for a fire he starts will not be lost upon others in the community.

Many State agencies and the USDA Forest Service in the United States have a policy where persons who cause a fire are charged for the damage and suppression costs. About 26% of fires attended by the US Forest Service resulted in charges for costs, and of these, about half were settled (Christiansen and Folkman, 1971). Vigorous and skillful fire investigation and prosecution will result in successful cost recovery. The net result is that a consistent policy of cost recovery becomes a very strong fire prevention tool, and good fire investigation is necessary to make this happen.

RECOMMENDATION 11: Recover suppression costs vigorously where people have started wildfires through negligence or deliberate action and where appropriate, prosecute offenders.

10. FIRE INVESTIGATION MATERIALS

The following basic fire investigation materials should accompany the fire investigator to the fire. Additional items may be required for very detailed investigations.

- Cordoning off tape. Forest marking tape, rope or hazard tape is satisfactory
- Straight edge metal ruler approximately 1.0m length
- Wire Pegs
- String
- Magnet (50lb pull)
- Camera and colour print film (may be a disposable camera)
- Writing materials
- Steel tape measure (minimum 20m)
- Compass
- Arrow markers to show direction of spread, area of origin, and to point out features
- Magnifying glass
- Plaster of Paris and frame
- Tweezers
- Probe tool
- Evidence containers such as: plastic sealable bags, assorted jars and tins
- Labels for evidence.

Additional aides to fire investigation that need development include:

- "aide-memoire" stickers and pamphlets to instruct and reinforce initial attack firefighters in initial observations and scene preservation.
- a handbook on forest and rural wildfire investigation that can be used as a standard text for forest fire service and Police investigators.
- data sheets for recording standard data on deliberately lit wildfires. (A data sheet will act as an aide-memoire for intermediate level fire investigators). (See Appendix 1)
- card signs that indicate that:-
 - . the fire is under investigation,
 - . a reward is offered for information regarding the fire.

RECOMMENDATION 12: Develop wildfire investigation operational aides

Appendix 1.

ARSON INVESTIGATION RECORD SHEET

Date of Occurrence:		Time:		Day of Week:	
Location:	Adjacent to (Rd/Tk):		Distance from (Rd/Tk):		
Topography:					
Incendiary Device: (Y/N)					
Size (\$ (hectares):					
Evidence description (& tag numbers):					
Photos taken: (Y/N)			Diagram drawn: (Y/N)		
Suspect:	Sex:	Descent:	Age:	Height:	Weight:
	Hair:		Eyes:	Last seen direction:	
Vehicle:	Year:	Make:	Model:	Colour:	
Irregularities:					
Weather:					
Multiple fires: (Y/N), number:					
Unusual Method of Operation:					
Damage:					
Reported to:		Reported Date:		Time:	
Victim)	Name, address, telephone home/business			
Reportee)	Alias, D.O.B., Drivers Licence No:			
Witness)	Race, Sex, Height, Weight			
Suspect)				
Other)				
Vehicle:	Licence No., State, Vehicle Identification Number, Year, Make, Model, Style, Colour, other.				
Event sequence:		Date and time			
Time of Origin: Reported: 1st unit arrival: Investigator on scene: Origin protected: Searched:					
Origin determined by: Eyewitness account/Fire Spread Indicators (note main indicators)/Other (explain)/Not found.					

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Pim/ue-fire/Travel Award