Wildfire Origin & Cause Determination Handbook

May 2005
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National Wildfire Coordinating Group
Fire Investigation Working Team

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Preface

Accurate origin & cause determination is an essential first step in a successful fire investigation, and successful fire investigations are necessary in preventing unwanted wildfires. Proper investigative procedures which occur with initial attack can more accurately pinpoint fire causes and can preserve valuable evidence that might otherwise be destroyed by suppression activities. If the fire is human-caused, the protective measures described in this handbook can preserve evidence that may lead to effective and fair administrative, civil, or criminal actions.

The investigation must start at the time a fire is reported or discovered. First responders play an important role in protecting evidence, so it is important for the origin and cause investigator to help train all first responders to identify and protect the area of origin of the fire. The NWCG course, FI-110, Wildland Fire Observations and Origin Scene Protection for First Responders, has been developed for first responders and helping deliver that training should be a priority for all investigators. As investigators, we must impress upon firefighters, law enforcement officers and other first responders that the preliminary protection of the general origin area and any associated evidence on any wildfire is their responsibility, and emphasize to them that they are the most important link in the subsequent origin and cause determination. Not only is it important for the first responders to recognize the need for an accurate origin and cause determination, it is important that they understand how their actions, both during and following suppression, can enable a qualified investigator to accurately determine the origin and cause.

This handbook is a supplement for the NWCG course, FI-210, Wildfire Origin and Cause Determination.

No laws have been included in this handbook, as it is intended for use by investigators operating under different authorities. However, the format is designed so that agencies, organizations, or individuals may add applicable rules, regulation or statutes if they so desire. Specific federal, state, and local laws and regulations give direction with respect to wildland fire investigations and the legislative authority to investigate wildland fires.

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Paul Steensland
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Chris Parker
Alan Carlson
Gary Hilton
James Nanamkin
Richard Woods
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Doug Williams
Gary Jagodinski
Rick Gibson
Fabian Crowe
John Barnes
Steve Grimaldi
Billy Smith
Carrie Bilbao
Sue Hickman
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Alice Forbes

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Introduction

This handbook provides instructions for identifying the point of origin of a wildland fire, protecting potentially valuable evidence, and documenting and collecting that evidence, so the cause of the wildfire can be determined accurately. These guidelines were developed to assist investigators in securing best evidence to be used for legal proceedings, to serve as the basis for administrative decisions, and for policy development. This handbook is not intended to be all-inclusive.

Purpose

The purpose of a wildland fire investigation is to determine the origin, cause, and responsible party.

There are four basic directions the results of the investigation can take:

- Administrative action to recover costs for suppression, and/or property loss.
- Court proceedings under civil law to recover costs for suppression, and/or property loss.
- Court proceedings for criminal violations of Federal, State, or local laws or regulations.
- To assist in policy development, implementation of fire prevention programs, and pre-suppression planning.

General

The guidelines presented in this handbook should be followed to the largest extent possible by the investigator in the field. These guidelines were developed to follow a science-based, systematic methodology which has been peer-reviewed and is generally accepted by the wildland fire investigation profession. The information is consistent with the guidelines contained in National Fire Protection Association (NFPA) 921, Guide for Fire and Explosion Investigations, and NFPA 1033, Professional Qualifications for Fire Investigator.

Safety

Fire scenes by their nature may be dangerous places. Fire investigators have a duty to themselves and others to exercise due caution during their investigations. The investigator should abide by safety-related policies and procedures established by Federal, State, Provincial and local governments, or industry.

Investigating the scene

When possible, fire scene examinations should not be undertaken alone. A minimum of two individuals should be present to ensure that assistance is at hand if an investigator should be injured. If it is impossible for the investigator to be accompanied by a second investigator, a firefighter or other suitable person should accompany the lead investigator. It is also critical that the investigator have communications with the suppression forces on the incident. Use of cellular phones is NOT recommended as an adequate substitute for radio communications as cellular phones frequently will not work in remote or rural areas, and may be difficult to use in emergency or high stress situations.

Hazards

Safety is a major concern on all fires. Investigating wildfires carries its own specific hazards that must be considered while on the fire scene. The investigator must be aware of areas where the fire may still be burning or where fire has been extinguished but could become active. An escape route must always be present and continually evaluated as fire conditions change. A rekindle and availability of fuels, along with a change in the wind direction may create hazards as extreme as a crown fire, which may block the previously planned escape route.

Underground burning in a smoldering stage can erupt into flaming combustion if the fire burns to the surface or if the top layer of soil is disturbed exposing the heated fuel to air. Also, a danger exists if the investigator steps into an area burned out from below such as in peat or a stump hole.

Wildland fire suppression operations may also present safety hazards to the investigators. Operation of aircraft dropping water and/or retardant, heavy equipment, and suppression tactics such as burning out or backfiring unburned fuel in and around the origin area are all potential hazards. Investigative personnel must contact the appropriate incident personnel and coordinate their planned investigative activities with them.

Other associated hazards are falling debris from charred, fire-weakened trees and limbs. Additional hazards may be present in sloped terrain. Logs or rocks can be loosened from their location as a result of the fire, from suppression operations, or from the actions of an investigator. When the root structure is destroyed by fire, the soil may begin to lose its stability, which in turn can cause slides that may injure the investigator or destroy evidence.

Investigators should always be alert to the possibility that hazardous materials (HAZMAT) is sometimes found in or near the origin of wildland fires. If HAZMAT is located or suspected the investigators should immediately take appropriate action to protect themselves and others, and notify the Incident Commander.

Power lines, railroads, and roadside fires present obvious hazards. Investigators should take appropriate precautions.

The weather can also cause or contribute to hazards. Rain can create slippery footing. Lightning may be a concern as well. During lightning conditions, follow established safety procedures.

Personal Protective Equipment (PPE)

The use of protective clothing, safety equipment and law enforcement defensive equipment will vary depending on the circumstances. The investigator shall comply with agency or industry requirements for personal protective equipment applicable to wildland fire fighting.

Investigation Team

The Investigation Team, as a minimum, should consist of a qualified and trained investigator, along with an investigator responsible for interviewing and the care and handling of evidence, or an investigator with a combination of competencies.

Initial investigations may be handled by a local law enforcement or fire management official. In complex cases, however, additional expertise may be requested.

Another investigator may be consulted for a second opinion. This can add weight to the conclusions in subsequent proceedings. Courts usually place greater weight on corroborated evidence.

Where possible, the investigation team should respond to the wildland fire scene as soon as possible. Fire scenes should be secured until arrival of the investigator to provide for the integrity of the scene.

Management of major investigations

Major fire investigation management includes control of the scene in which many interests participate simultaneously. These interests may include multiple public and private agencies and usually an investigation team for each interested party. A protocol should be developed to meet agency objectives.

While major incidents are not always large in size or magnitude, they do tend to be more complex. As a result, the primary goals in such circumstances are to preserve the evidence and to preserve the interests of parties involved.

Thorough investigations do not just happen, but instead are the result of careful planning, organization, and the ability to anticipate problems before they arise. Prior to actually beginning the scene investigation, numerous events, facts and circumstances should be identified and considered before decisions are made as to how the investigation will proceed.

Confidentiality

During an investigation, all evidence and information obtained is confidential in nature. Premature release of information prior to any adjudicative action may jeopardize the outcome.

- Investigators must assure that first responders are aware of the responsibility to maintain confidentiality of any information that they may have received relating to the origin or cause of the fire.
- Investigators will only disclose information to authorized personnel.
- Investigative reports are developed in anticipation of legal proceedings. Under no circumstances may copies be released without prior agency and/or prosecutorial approval.
- The Privacy Act, the Freedom of Information Act and similar privacy legislation apply to all investigative work products.

Common mistakes in wildfire investigations

- Not applying a systematic methodology
- Failure to establish fire behavior context
- Not operating as a team
- Misinterpreting burn patterns
- Not making 2 or more circuits around the perimeter of the origin
- Failure to examine the unburned fuels outside the origin
- Not interviewing/identifying witnesses
- Leaving the origin unsecured
- Failure to recognize and collect evidence and limiting the investigation to too small of an area
- Not properly documenting the scene
- Not conducting interviews in a timely manner
- Looking for the cause and not following indicators to the origin
- Misidentifying spot fires as the origin
- Not using a magnet/metal detector
- Not obtaining on-scene weather data
- Failing to adequately exclude/address other potential causes
- Not properly analyzing the ignition source and ignition factors
- Lack of adequate photographs
- Not entering the burn from the advancing area of the fire
- Lack of patience

Chapter 1- Fire Behavior

Principles of Fire Spread

Understanding the basic principles of fire behavior is critical for the fire investigator. The ability to recreate probable fire spread, based on knowledge of these principles will greatly assist the investigator in identifying and correctly interpreting fire direction indicators and overall burn patterns. It is strongly recommended that an investigator take additional training in this area to enhance their understanding of these principles.

For a wildfire to occur, an ignition source must contact the host fuel and have sufficient heat to raise it to its ignition temperature. The location where this ignition source contacts the material first ignited and sustained combustion occurs is referred to as the point of origin. Any physical remains of the ignition source will be most likely located at this precise point. Following ignition, the fire will progress outward from the point of origin. The initial spread of the fire will be generally circular until the fire falls under the influence of wind, slope and/or fuels. It will usually exhibit lower intensity and slower spread in this first burning phase. This area immediately surrounding the point of origin is called the specific origin. Because of the lower intensity associated with this area, it is often characterized by the presence of more unburned material. As the fire comes under the influence of the varying fire behavior factors, it will begin to spread with uneven intensities and rates. This area is referred to as the general origin area. The fire will now exhibit different areas of progression. These areas of progression will be marked by fire direction indicators that will display a distinct vector characteristic. These vectors are described below:

- **Advancing fire:** This is fire progression associated with the head (front) of the fire. Fire behavior in this area is usually characterized by more intense burning, increased flame height and length and more rapid rates of spread. Fire direction indicators in this area are generally large and very noticeable, (macro-scale indicators).

- **Backing fire:** This is fire progression associated with the heel (rear) of the fire. Fire spread in this area is normally against the wind and/or downslope. Fire behavior in this area is normally characterized by lower flame heights and shorter lengths, less intense burning and slower rates of

spread. Fire direction indicators are usually smaller and less noticeable (micro-scale indicators).

- **Lateral fire:** This is the fire progression associated with the flanks (sides) of the fire. It tends to spread outward at a 45-to-90 degree angle from the main direction of spread. Fire behavior will generally fall somewhere in between that exhibited by the advancing and backing areas. Indicators can show characteristics that are associated with both advancing and backing areas of progression. Wind influenced indicators will usually align themselves with those in the advancing areas or appear at a 45 degree angle to them. Heat exposure influenced indicators will normally appear at a 45-to-90 degree angle to those within the advancing areas.

As the fire spreads, it will create transition zones between these areas of progression. These zones can be identified by the appearance of the fire direction indicators.

Fire Behavior Factors

A wildfire is influenced by three main elements. These are weather, topography and fuels. Each of these elements has several sub-elements. It is the combination of these elements that form the fire behavior triangle. Understanding how these interact and affect the formation of fire direction indicators is crucial to properly interpreting a wildfire's burn pattern.

Weather: Wind, temperature and relative humidity are the three components that comprise weather. Wind normally has the greatest effect of all the elements on fire spread and intensity. Fire moving with the wind burns faster than a fire backing into the wind. You will be able to observe the difference in the burn patterns and the amount of fuel consumed. After the fire reaches a certain size, it will begin to create its own wind and burn even faster than before. Fires will generally spot in advance of the main fire in the direction the wind is blowing.

Relative humidity directly affects ignition probability and fire intensity. The relative humidity also controls fine dead fuel moisture, particularly in the one and ten-hour time lag fuel categories.

Temperature influences fire behavior by the drying and preheating effect it has on fuels. Weather patterns can change quickly. A switch in wind direction can substantially affect burn patterns.

- Obtain hourly weather observations from closest weather station that represents the ignition area.
- Obtain on-site weather readings taken by first responding suppression forces.
- Obtain weather observations from any other on-scene witnesses.
- Record fire behavior data which can later be used to calculate wildfire ignition and behavior potentials.
- Obtain local weather pattern information which may be used to determine conditions conducive to holdover fires or spotting.
- Use a Fire Behavior Analyst to scientifically model fire behavior.

Topography: Topography consists of slope, aspect and terrain. Following wind, slope is the next greatest potential influence on the rate and direction of fire spread. Fires will burn faster uphill than downhill because of the preheating of the uphill fuels and the influence of daytime upslope and up-canyon winds. A fire backing downslope will normally move slower than a fire advancing upslope.

Consideration of the aspect of the slope is also necessary. Generally, south-facing slopes exhibit higher intensity and more rapid rates of spread. (The converse of this is true for fires in the Southern Hemisphere.)

Terrain can also affect both intensity and rate of spread, particularly when there are either barriers or natural chimneys present. Barriers such as a log, bare dirt, or rocks, can cause a fire to slow down or even go out. Almost any barrier will at least lessen the intensity of the fire as it passes. Larger barriers often cause wind eddies which can change the fire's direction, at least for short distances. Don't confuse the effect of a barrier's temporary change of a fire's direction with the actual direction the fire came from. Natural chimneys can increase wind velocity and accelerate fire spread and increase intensity substantially.

- Documentation should note relevant slope, aspect, terrain and elevation features for the general origin area.

Fuels: Fuels are characterized by a variety of factors. These include vertical and horizontal arrangement, type, species, size and fuel moisture, both live and dead. Fires will tend to ignite more easily and spread more rapidly in fine dead fuels with low moisture contents.

- Document vegetation type(s) that burned within the general origin area and especially at the point of origin.
- Document unburned fuels adjacent to the burned fuels at the origin. This will assist in reconstruction of probable fuel conditions at the origin.
- Determine the current seasonal stage of the vegetation (i.e., percent cured grass, live and dead fuel moisture, etc.).
- Document fuel volumes and arrangements.

Chapter 2
Fire Direction Indicators

As a fire progresses, it will leave visible marks of its passage on combustible and non-combustible objects in its path. These markings are called fire direction indicators. An indicator's vector, (direction of travel, i.e., advancing, backing, lateral), can usually be determined by examining the appearance of the indicator. When analyzed within the context of the fire's behavior they will form distinct overall burn patterns. These patterns will identify areas of fire progression and the accompanying transition zones. Fire progression can then be traced back to the fire's precise point of origin. This procedure is the accepted and standard methodology in wildfire investigation. Refer to the most recent edition of National Fire Protection Association (NFPA) 921, Guide for Fire and Explosion Investigations for a definitive explanation of this process.

General Principles of Burn Pattern Interpretation

When analyzing a fire's progression using burn patterns, keep in mind the following general principles:

- Always base your interpretation on the majority of the indicators within an indicator class.
- Always base your interpretation on the totality of the indicators.
- A single indicator may be accurate within a 180 degree arc.
- Always interpret indicators within the context of fire behavior principles.
- Indicators will usually become less pronounced as you near the origin.
- Document the indicators as you proceed with the investigation.
- Work from the area of most intense burning, to the area of least intense burning, following the fire's advancing runs back to the origin.
- Avoid attempts to prematurely locate the origin.
- Preliminary fire shapes may be dependent on effective wind-speeds.
- Direction of fire travel will be influenced by obstacles.

Indicator Categories

Indicators are classified into 14 categories, listed below. These categories are based on how the indicator is formed and the materials upon which they are found. A category can exhibit any one of the three fire vectors, depending on the direction of the fire's progress at that point. Many of these indicators will be apparent on both large and small objects and fuels.

1. Protection
2. Grass Stem
3. Freezing
4. Degree of Damage
5. Depth of Char
6. Angle of Char
7. Spalling
8. Curling
9. Sooting
10. Staining
11. White Ash
12. Cupping
13. V Patterns
14. Die Out

1. Protection

Figure 1: Protection on log.

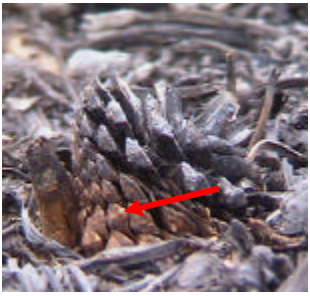


Figure 2: Protection on pinecone.

A non-combustible object or the fuel itself shields the unexposed side of a fuel from heat damage. Fuels will be unburned or exhibit less damage on the side shielded from the fire (figures 1 and 2.) Look for charring, staining, white ash and clean burn lines on exposed sides of fuels and non-combustible objects. Compare and contrast to the opposing sides of objects. Lift or remove objects to detect the degree of damage and protection. Objects resting on top of ground and surface fuels will protect the fuels on the unexposed side. Surface fuels on the exposed side will exhibit a clean burn line. Surface fuels on the protected side will appear ragged and uneven (figure 3.)

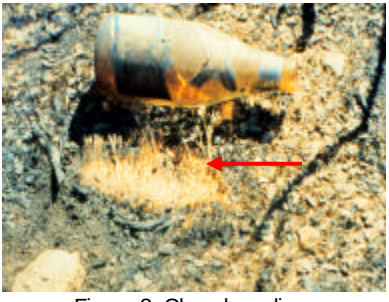


Figure 3: Clean burn line.

2. Grass Stems

Figure 4: Advancing fire.

The charred remains of grass stems left in the fire's wake will have different appearances dependent upon the direction of the fire's travel.
In advancing fire areas, the flames will attack the stem from the top and burn them to ground level, completely consuming all but the very base of the stem. Advancing areas are typically characterized by an absence of residual stems (figure 4.)

Figure 5: Advancing fire.

Grass that grows in clumps may not entirely consume, showing protection on the non-exposed side. When this occurs in advancing areas, the residual basal stalks will normally show an angle of char that is steeper than the slope and exhibit cupping on the tips, with the low side of the cup on the exposed side (figure 5.)

In areas of backing fire progression, and occasionally in the lateral areas, the flames will first attack the stalk at the base, toppling the remainder of the stalk into the burned area (figure 6.)

Figure 6: Backing fire.

Unless there is sufficient heat residency, the remainder of the unburned stem will be found on the ground, with the seed head pointing in the general direction the fire came from. Backing areas and some lateral areas will often be characterized by this littering of unburned or lightly scorched grass stems and/or seed heads (figure 7.)

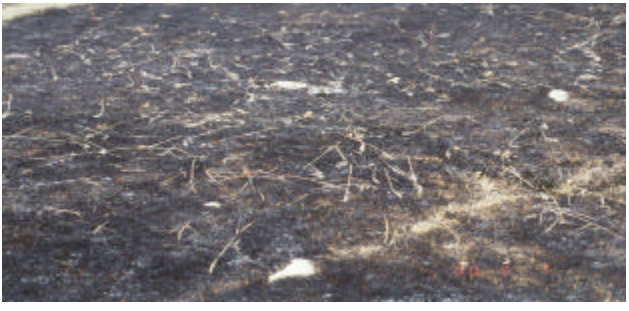


Figure 7: Backing fire.

3. Freezing

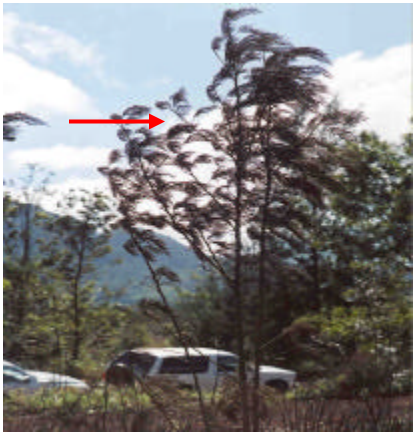


Figure 8: Freezing.

When leaves and small stems are heated (especially in the advancing areas of the fire), they tend to become soft and pliable and are easily bent in the direction of the prevailing wind or drafts created by the fire. They often remain pointed in this direction (freeze), as they cool following the passage of the flame front (figure 8.) While this indicator is almost always an accurate reflection of wind direction at that precise point, it may not always coincide with fire direction. Validate freezing indicators with other indicator categories nearby to confirm the fire's direction.

4. Degree of Damage

Figure 9: Degree of damage.

Degree of damage is the amount of fire-related destruction a combustible object sustains. Compare opposing sides of an object to assess this indicator. It is closely related to the protection indicator category and is often used in conjunction with it. As heat and flame contact an object, the side exposed to the fire will show deeper charring, more loss of material and more white ash than the unexposed side (figure 9.)

5. Depth of Char (Loss of Material or Alligatoring)

Figure 10: Depth of char.

Figure 11: Depth of char.

Char on limbs, trunks and finished lumber products exhibit a fissured or scale-like appearance (figures 10 and 11.) Wood materials lose mass and shrink as they burn, forming a scale-like surface. Compare and contrast the amount of charring on all sides of the object. The side with the deepest charring will typically be on the side facing the oncoming fire.

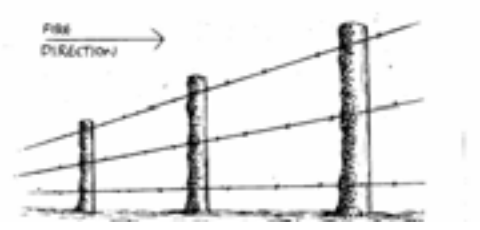


Figure 12: Char on fence posts.

Figure 12 shows that the char on the fence posts is deeper on the exposed side, as indicated by the arrow. This means that the fire moved from left to right.

6a. Angle of Char (Pole-type Fuels)

Standing, pole-type fuels are burned at an angle that corresponds to the flame angle and height associated with the area of fire progression. Reliability is generally greater on individual specimens in open canopy settings. On pole-type vertical fuels, an eddy vortex creates flame-wrap on the side opposing the oncoming fire, leaving a characteristic angle of char. On fires backing against the wind or down slope, the char angle will be parallel to the slope angle (figure 13.) Accumulation of debris may cause char up the side of the tree above the debris, but it will have little effect on the char pattern around the rest of the tree.

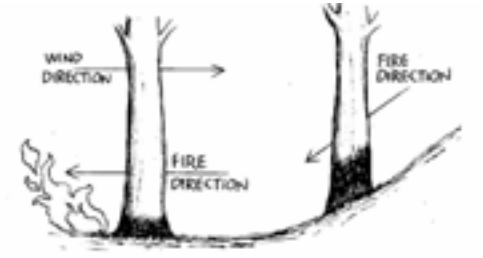


Figure 13: Backing.

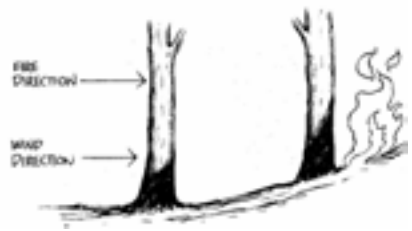


Figure 14: Advancing.

A fire advancing with the wind or upslope will exhibit a char pattern that is steeper than the slope (figures 14, 15, 16.)

Figure 15: Advancing.

Figure 16: Advancing.

6b. Angle of Char (Foliage Crowns)

On foliage crowns, the flaming front will consume or char fuels at an angle that is consistent with its fire vector. Backing fire will leave char patterns parallel to the slope (figure 17.)

Figure 17: Backing

Angle of char associated with advancing fire areas will be steeper than the slope due to the flame front entering low on the exposed side and exiting high on the back side (figures 18 and 19.) Height of char angle is often correlated to fire intensity. This pattern is best viewed from the side of the object.

Figure 18: Advancing.

Figure 19: Advancing.

Figure 20.

Figure 20 shows the typical effect on the crown of trees or brush as a fire starts at point “A” and moves out, slowly building up heat and speed. At the point of origin, the fire is still relatively cool as surface fuels are burned, but the tree’s crow n is left mostly intact. Farther from the point of origin, the fire has become hotter, and more crown is burned. All the crowns may be burned as the fire intensifies.

7. Spalling

Spalling will appear as shallow, light-colored craters or chips in the surface of rocks within the fire area (figure 21.) They will usually be accompanied by slabs or flakes exfoliated from the surface of the rock. Spalling is caused by a breakdown in the tensile strength of the rock's surface that has been exposed to heat.

Figure 21: Spalling.

Spalling is generally associated with advancing fire areas and will appear on the side of the rock exposed to the flames.

8. Curling

Figure 22: Curling.

Curling occurs when green leaves curl inward toward the heat source. They fold in the direction the fire is coming from. This usually occurs with slower moving, lighter burns associated with backing and lateral fire movement (figure 22.)

9. Sooting

Carbon soot is caused by incomplete combustion and the natural fatty oil content in some vegetation. Carbon is typically more heavily deposited on the side facing the approaching fire.

Figure 23: Sooting.

Figure 24

Soot will be deposited on the side of fence wires facing toward the origin and can be detected by rubbing your fingers along the wire. On larger objects, soot deposits can also be noticed by rubbing your hand across the surface. In many cases there will be other indicators, such as protected fuel or staining. When checking a wire fence for soot, check the lower wires as they will show more evidence of soot than higher wires (figure 24.)

10. Staining

Staining is caused by hot gases, resins and oils condensing on the surface of objects. This occurs most commonly with non-combustible objects such as metal cans or rocks. Stains will appear on the side of the object exposed to the flames. These yellow-to-dark brown stains will often feel tacky to the touch and may be covered with a thin layer of white ash (figure 25.)

Figure 25: Staining.

11. White Ash

White ash is the byproduct of complete combustion. More white ash will be created on the sides of objects exposed to greater amounts of heat and flame. Ash is often dispersed downwind and deposited on the windward sides of objects. Ash can also be used to reconstruct probable fuel volumes. Fuels facing the origin will appear lighter on the origin side, darker on the non-origin side. Ash indicators can begin to quickly degrade and lose reliability after only a few hours or when exposed to moisture or high winds.

Figure 26: Exposed side.

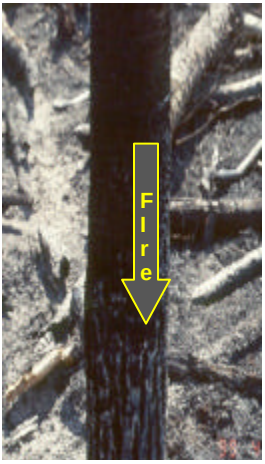


Figure 27: Shielded side.

White ash on the tree bole in figure 26 is on the side facing the oncoming advancing fire, (origin side). Figure 27 shows the back or non-origin side of the same tree. By comparing and contrasting the two opposing sides, you can distinguish that the side facing the origin has more white ash present. The arrows correspond with the direction of the advancing fire progression.

Figure 28: Looking toward head.

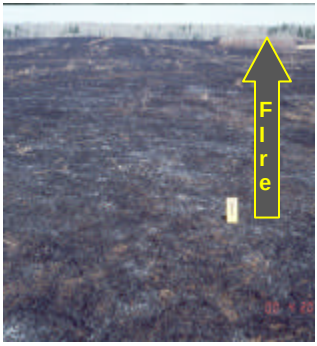


Figure 29: Looking toward origin.

White ash can also reveal the direction of fire travel in grass fuels. White ash can remain on the exposed sides of grass stems and clumps. When looking in the direction the advancing fire traveled, the burned area will appear lighter (figure 28.) When viewed looking back towards the origin, the burned area will appear darker (figure 29.) The arrows indicate direction of advancing fire progression.

12. Cupping

Figure 30: Cupping on limbs.

Figure 31: Cupping on stump.

Cupping is a concave or cup-shaped char pattern on grass stem ends, small stumps and the terminal ends of brush and tree limbs. Limbs and twigs on the origin side will have their tips burned off by the approaching flames leaving a rounded or blunt end. On the opposing side, twigs and limbs will be exposed to flames from underneath, along the base to the terminal end, creating a tapered point. Therefore, in advancing areas of the fire, twigs and limbs on the non-origin side will show a sharply pointed or tapered end. Limbs on the origin side of the brush or tree will usually be blunt or rounded off (figure 30.)

Stumps, terminal ends of upright twigs and the remains of grass stems can also exhibit a tapered point, with the sharp end on the non-exposed side. The low side of the cup will face the origin (figure 31.) This indicator is usually not associated with backing areas of the fire, except in areas of steep slopes or under high wind conditions.

Partially charred branch tips may sometimes be found on the ground on the origin side of brush and small trees, where they have fallen after being burned off.

Large diameter stumps and limbs should not be considered when using this indicator due to their longer term fire residency.

13. V-Patterns

Figure 32: V-pattern.

This is the overall V- or U-shape associated with typical wildfire progression in the early stages of the fire. This pattern is based on the basic principle of fire spread, where the fire will spread outward along the flanks and head, leaving the characteristic V- or U-shape. The origin of the fire will be in the point of the V or the cup of the U. This area is also frequently characterized by less intense burning (figure 32.) View this indicator from an aerial perspective. Fire suppression tactics and fire behavior can alter the shape of this initial pattern and must be considered.

14. Die-Out Pattern

As a fire enters different fuel types, areas where there is increased fuel moisture or other locations where conditions cause a decrease in rate of spread and intensity, progress may slow or the fire may self-extinguish (figure 33.)

These areas will exhibit fingers and islands of unburned or partially burned fuels. This pattern is most often associated with the lateral and backing areas of the fire, however these areas should not be assumed to be the origin of the fire. These areas may be useful as macro-scale indicators to establish general fire progression.

Figure 33: Die-out pattern.

Chapter 3
Systematic Methodology

The Nature of Wildland Fire Investigations

A wildland fire investigation is a complex endeavor involving skill, knowledge, science and technology. The compilation of factual data, as well as an analysis of those facts, should be accomplished objectively and truthfully. The basic methodology of the fire investigation must rely on the use of a systematic process and attention to all relevant details. The use of a systematic approach often will uncover new factual data for analysis, which may require previous conclusions to be re-evaluated. With few exceptions, the proper methodology for a wildland fire investigation is to first establish the origin and then determine the cause.

Systematic approach: The systematic methodology recommended is that of the scientific method used in the physical sciences. This method provides for the organizational and analytical process desirable and necessary in a successful wildland fire investigation and is consistent with the recommendations found in NFPA 921, Guide for Fire and Explosion Investigations.

Relating fire investigation to the scientific method:
The scientific method is a form of inquiry that forms the basis for scientific and engineering processes, including fire investigations. It is applied using the following steps:

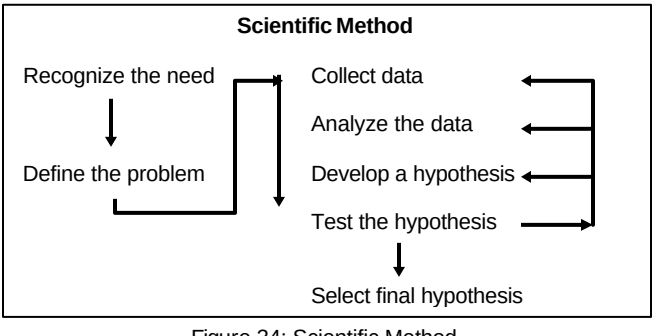


Figure 34: Scientific Method.

Use of the Scientific Method

1. **Recognize the need.** In this case, a wildland fire has occurred and the cause must be determined to identify potential responsible parties and focus future prevention efforts
2. **Define the problem.** Having determined that a wildland fire has occurred, the investigator should define how the problem can be solved. In order to determine cause, an origin investigation must be conducted first.
3. **Collect data.** Facts about the fire are collected. This includes an examination and processing of the scene, interviewing of witnesses or other knowledgeable persons, collection of physical evidence and the results of scientific testing.
4. **Analyze the data.** All of the data collected is carefully examined in the light of the investigator's knowledge, training and experience. Subjective or speculative information cannot be included in the analysis, only facts that can be proven clearly by observation or experiment.
5. **Develop a hypothesis.** Based on the data analysis, the investigator produces a hypothesis that explains all of the known facts regarding the origin and cause of the fire. This hypothesis should be based solely on the factual data that the investigator has collected.
6. **Test the hypothesis.** Test the hypothesis by comparing it against all known facts. This process should focus on attempting to disprove or falsify the hypothesis. This testing of the hypothesis may be either mental or experimental. If it cannot withstand this examination, it should be discarded, and a new hypothesis should be developed and tested. This development and testing may include the collection of new data or the reanalysis of existing data. All feasible hypotheses should be tested in this manner.
7. **Select the final hypothesis**. Select the hypothesis that best explains all of the known facts surrounding the origin of the fire. This will then become the theory of the case that your conclusions will be based upon.

Until all the data has been collected and analyzed no specific hypothesis can be reasonably formed. An investigator must not make assumptions about the cause of a fire until this process is completed.

Basic Method of a Fire Investigation

Using the scientific method in wildland fire investigation should involve the following six major steps from inception through final report. Refer to the National Fire Protection Association (NFPA) 921, Guide for Fire and Explosion Investigations, for a definitive explanation of this process.

Receive the assignment. Understand the role and what is to be accomplished.

Prepare for the investigation. Pre-plan and select the resources necessary to conduct the investigation based on the assignment.

Conduct the investigation. Collect the data necessary to complete the analysis. Each investigation may include different elements; however, the standard methodology must be followed.

Collect and preserve evidence and document the scene. Physical evidence must be recognized, collected and preserved for testing, evaluation, and/or courtroom presentation, and the scene and origin area must be documented by photographs and a diagram.

Analyze the incident. All collected and available data must be analyzed using the principles of the scientific method as discussed above. The resulting theory should explain the spread, origin, cause and responsibility for the fire.

In addition to the above, the following step must be completed to bring an investigation to its conclusion:

Report. An origin and cause investigation is not complete until the written report is done. Report format and specifics may be dictated by agency policy.

Planning the Investigation

The need to plan investigations remains constant and ongoing. Considerations for determining the number of investigators assigned include available staffing, complexity, and area of the scene to be investigated.

A minimum of two investigators is recommended to form an "investigative team" to investigate any wildland fire. However, on occasion, circumstance may dictate that one investigator will be responsible for all investigative tasks. If this is the case, for the safety of the investigator, he or she should be accompanied by a firefighter, law enforcement officer, or other official.

Basic incident information

Location: Obtain as much background information as possible from the dispatcher. The location may dictate the need for specialized equipment.

Date and time of incident: Record the day, date and time of the fire. The age of the scene may have an effect on the planning of the investigation.

Weather conditions: Document weather conditions at the time of the fire and the current weather at the scene. Current and expected weather may dictate the need for special clothing, supplies and/or equipment and may also determine the amount of time the team members can work the fire scene.

Size and complexity of incident: The complexity of the fire scene may require additional investigators. Generally, the larger and more complex the fire, the greater the length of time and assistance will be required to conduct the investigation.

Security of scene: Arrangements should be made to secure and preserve the scene until the scene is released. The investigator must know his or her legal authority to access the scene if it is not on public property.

Purpose of investigation: While planning and executing the investigation, remain aware of the scope of an origin and cause investigation and neither assume nor presume any authority beyond the required objective.

Organizing the investigation functions at the scene: There are several basic functions that are commonly performed in each wildland fire investigation: *overall coordination of the investigation, examining the burn pattern, searching the scene, photography, note taking, mapping/diagramming, interviewing witnesses, and evidence collection and preservation.* Each function may be assigned to an individual team member or a team member may be responsible for several functions, but everyone should be aware of who is performing each function. If an investigative team is established, a briefing that describes the objectives of the investigation and who will be responsible for completing the associated tasks should be held prior to the investigation. Personnel should be advised of the condition of the scene and safety precautions required. *Safety of investigators is paramount.*

Specialized personnel and technical consultants

In planning a wildland fire investigation, specialized personnel may be needed to provide technical assistance. An investigator should never hesitate to call on another fire investigation expert who has more knowledge or experience in a particular aspect of the investigation.

Wildland fire investigation is a specialized field. Those individuals not specifically trained and experienced in wildland fire investigation will usually not be qualified to render opinions regarding fire origin and cause. They may, however, be able to give the qualified investigator additional data which will aid in developing a sound theory of the origin and cause of the fire.

The following descriptions are general and should not be considered all-inclusive:

Fire Behavior Analyst: A qualified wildland fire behavior analyst may be able to develop detailed information about initial fire spread.

Canine Teams: Trained canine/handler teams may assist investigators in locating areas for collection of samples for laboratory analysis to identify the presence of ignitable liquids. Other very specialized canine/handler teams are capable of tracking the responsible person(s) to and from the general origin area of wildland fires.

Electrical Engineer: An electrical engineer may provide information regarding electrical transmission and distribution systems and other electrical systems or components.

Materials Engineer or Scientist: A person in this field can provide specialized knowledge about how materials react to different conditions, including heat and fire.

Industry Expert: When the investigation involves a specialized industry, piece of equipment, or system, an expert in that field may be needed to fully understand the processes involved.

Legal Counsel: A prosecuting attorney or agency attorney may provide needed legal assistance with regard to rules of evidence, search and seizure, gaining access to a fire scene, obtaining court orders and preparation for litigation.

Case Management Specialist: In major fire or serial arson cases it is useful to have a specialist to organize, catalog, cross reference, and evaluate the information generated through the investigation and to advise the team leader about data collection and storage.

Geographic Information Systems (GIS) Specialist: With the increasing use of Global Positioning System (GPS) data and the accuracy of GIS mapping technology, consider including a GIS specialist on the investigative team to produce maps of the fire and diagrams of the origin scene.

Other Specialists: Based on unique circumstances, other specialists may be required. Consider the conditions regarding the cause of the fire and consult as appropriate.

Field Notes

Detailed notes taken at the scene will assist in developing the final report. Notes should be taken at the time the information or facts are first brought to your attention.

Notes should be:

Readable. Notes must be readable not only by you, but also by anyone else who may need to read them. They should contain complete words to avoid misunderstanding.

Brief. Use short sentences or phrases. Avoid long, rambling sentences that could confuse a reader.

Descriptive. Use words that actually describe what you see. For example, write "burned match" rather than "burned object". Often sketches will be valuable in supplementing written descriptions.

Accurate. Notes must be accurate as to times, dates, names, addresses, weather conditions, scene description, and physical

descriptions of vehicles and property, including serial numbers and license plates. They must also have accurate map locations.
Factual. Keep your personal opinions or conclusions to yourself. Do not include them in your notes.
Complete. Answer the questions: Who?, What?, When?, Where?, Why?, How?.

What to do with completed field notes

After the report is complete, follow your agency policy with regard to the storage and disposition of your field notes. If your agency does not have a policy on notes, you should store your field notes in the original case file.

Actions on the way to the fire

Start your field notes at the time you receive the dispatch. From the time the dispatch is received until you arrive at the fire, field notes should include the following:

Identification: Write your name, unit, and title.
Time and date: Record the time and date of the assignment.
Person reporting fire: Record the complete identification, address and phone number of the reporting party. This person may be the only witness.
People and/or vehicles: Record complete description, locations, and time of any people or vehicles observed coming from the direction of the fire or parked nearby.
Gates and/or tracks: Record any gates that are broken or open or locked. Drive or walk in such a manner as to avoid disturbing tire or footwear impressions. Notify the firefighters following you of their presence and the need for protection.
Smoke columns: Note the color and characteristics of the smoke column. Note any changes in the column.
Missing items: Things that are not present may be important; note those items that you believe or know to be missing.
Miscellaneous potential evidence: Look for any indicators of recent human activity.

Actions on arrival at the fire

Record the date and time of your arrival at the fire. The conditions at each fire may be different and will dictate the order in which these actions are taken, but they all should be completed shortly after arriving on scene. Make notes of your actions.

Identify general origin. The first objective of an on-scene wildfire investigation is to identify the general origin area. Considering the factors of wind, topography and fuels, the origin is normally located close to the heel or rear of the fire. Locate and protect the general origin area of the fire by observing the macro-scale burn pattern indicators. Immediately mark and secure the general origin and evidence protection area with barricade tape or flagging. If the area has already been flagged by first-responders, validate the area and re-flag as necessary.

If needed, post a security person at the general origin. Equipment and firefighters must be routed around this area. Ensure that no one places any foreign materials in the general origin area. Log the names and times that investigators or any other persons enter and leave the secured general origin area.

If the fire is such that the general origin area is not easy to locate quickly, flag and restrict access to a larger area that you believe contains the fire's general origin area.

Identify witnesses at the scene. Interviewing or obtaining written statements from witnesses who were at the scene of a fire is a very important part of the fire investigation. Record the identifying information that may be used for investigative follow-up:

- Names and identifying information, e.g., date of birth, driver's license number, address, phone number.
- Make, license number, and description of vehicles at the scene.
- Note any remarks made by persons at the scene that are in any way related to the fire.

Protect potential evidence. While protecting the origin area, look for such things as equipment, vehicles, tracks, discarded items, or any other objects or impressions that may have value as evidence. **Do not disturb these objects until they have been properly documented.** Flag or otherwise protect anything you find. Footwear impressions at or near the general origin should be protected and traffic should be re-routed around them.

Record fire behavior. Note size, direction of spread, rate of spread, flame height and length, fuel type, fuel volume, fuel arrangement, slope and aspect at the general origin area. Record the time of your observations.

Record weather. Record temperature (wet and dry bulb), relative humidity, wind speed and direction in degrees, cloud cover, etc., and/or obtain fire weather readings taken by first responders.

Assess the need for additional resources. Are the conditions at the scene sufficiently different from those anticipated that there is a need for additional or different investigative resources? If so, make arrangements to have the additional resources respond to the incident. If there is evidence of non-fire related criminal activity, immediately notify the proper authorities.

Determining the origin and cause

The suppression forces may already have flagged the general origin area prior to the arrival of the investigator. It may be anywhere from a few square yards to an acre or two in size. The investigator should re-evaluate the flagged area to ensure that it includes the fire's origin.

Even with large areas, there is a systematic method for identifying the exact point where the fire started. Fire behavior is controlled by weather, fuels, and topography. As a fire moves over an area, it leaves distinct burn patterns composed of individual fire direction indicators that will show the fire's progression. The various fire direction indicators, when taken together and analyzed within the context of fire behavior, can lead the investigator to the precise point of origin.

The origin area of a wildland fire is broken down into the following components: See figure 35.

General origin area: The area of the fire that the investigator can narrow down based on macro-scale indicators, witness statements and fire behavior. It may be a limited area on a small fire, or several acres on a large fire.

Specific origin area: The smaller area within the general origin area where the fire's direction of spread was first influenced by wind, fuel or slope. Generally this area is characterized by subtle and micro-scale fire direction indicators. It will usually be no smaller than about 5'x 5', and may be substantially larger, depending on indicators and other factors. It is typically characterized by less intense burning.

Point of origin: Contained within the specific origin area will be the precise location where the ignition source came into contact with the material first ignited and sustained combustion occurred. This is where any physical evidence of the actual ignition source is likely to be located.

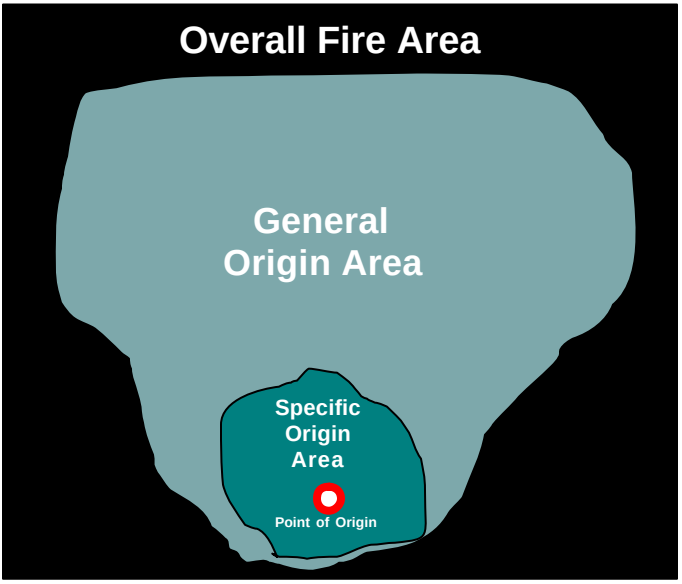


Figure 35: Overall fire area.

General Origin Area Investigation Techniques

Walk the exterior perimeter. Walk the perimeter of the general origin area at least twice: once in a clockwise direction and once in a counter clockwise direction. Look at the unburned area as well as the burned area. Examine and mark directional burn pattern indicators at the perimeter of the general origin with colored flags or other appropriate markers as they are located. Look for relevant physical evidence. If evidence is located, protect and mark it with white flags.

Identify advancing fire area. Identify the initial run that the fire made. Frequently this will be the area which shows the cleanest burn, and may be characterized by a classic "V" or "U"-shaped pattern. It is often bounded on both flanks by lateral fire spread indicators showing less complete consumption of fuels.

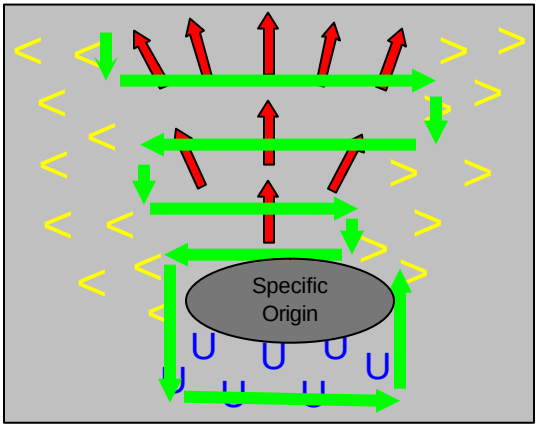
Enter the general origin area. Photograph the general origin area prior to entering. Once the initial run has been identified, the general origin area should be entered from the head or advancing side of the run; this is the side farthest away from the suspected point of origin. The reason to enter from the advancing side is that the burn pattern indicators are more obvious in this area and the investigator is less likely to "over run" the specific origin area than if the general origin area is entered from the heel or backing side of the fire. There is one exception to this rule: if the general origin is on a very steep slope where material and soil may be dislodged by the investigator and roll down hill and disturb the specific origin, then the investigator may be forced to enter from the backing or heel side of the general origin area and work up hill.

Work the general origin area.

1. Enter from advancing area.

2. Work across the run until the lateral transition zone is reached.

3. Move several feet closer towards the origin and re-cross the advancing run to the opposing lateral transition zone. Repeat above steps until specific origin area is reached (figure 36.)



Document burn pattern indicators. Document each indicator located with a visible marker. Color-coded pin flags have been found to be the most visible and easiest markers to use (figure 37.)

Standard recommended colors are:

- red-- advancing fire indicator
- yellow-- lateral fire indicator
- blue-- backing fire indicator
- white-- evidence

Figure 37: Example of general origin area with indicators marked by flags.

Work the specific origin area.
1. Walk perimeter at least twice before entering
2. Establish grid lanes
    - Use colored twine and stakes
    - Uniform width: (12”-18” apart)
    - From the advancing side of the fire
    - Lanes perpendicular to first run
    - Number and photograph each lane prior to searching
    - Measure lane ends to reference point(s) if needed
    - Continue to work towards origin

Figure 38: Searching a grid lane.

3. Search each lane (figure 38.)
    - Visually.
    - Visuallyw ith magnification.
    - Remove lightweight debris by brushing or blowing.
    - Use straight edge to focus search pattern.
    - Continue locating and marking indicators with flags.
    - Employ magnet search for ferrous metals.
    - Metal detector search for non-ferrous metals, if necessary.
    - Screen debris if necessary.
    - Continue until point of origin is reached and/or ignition source is located.

- Document and secure any evidence.
- Continue searching past point of origin or evidence until clear backing indicators are encountered.

4. Exclude/address other reasonable potential causes
5. Document the investigation.
    - Describe investigative steps in detail
    - Reconstruct methodology
    - Describe findings
    - Explain conclusions
    - Use agency format

Key Documentation Elements

- Narrative
- Photographs
- Photo Log
- Diagram
- Measurements
- Evidence Log
- Chronology

Chapter 4- Fire Scene Evidence

Refer to the NFPA 921, Guide for Fire and Explosion Investigations, *and agency policy/procedures on evidence collection.*

Documenting and Collecting Evidence

- Photograph evidence prior to handling.
- Mark and measure the location of all evidence for the fire scene diagram.
- Assign an evidence number or letter.
- Record on evidence log.
- Fill out tag or label for each item of evidence.

Collection & Preservation Procedures

Non-fragile fire cause objects

Items that are less subject to damage from heat and flame when collected.

- Metal fragments
- Catalytic converter particles
- Welding slag
- Power line hardware

Collection procedures:

- Carefully pick up & place in folded paper bindle
- Place into hard sided container
- Pack in cotton to keep fragile edges from breaking off
- Seal and tag

Fragile fire cause objects

Objects that can be easily damaged or destroyed during the collection process:

- Cigarette remains
- Matches
- Fusee slag
- Fireworks remains
- Arson devices
- Exhaust carbon

Collection procedures:
Some items can be picked up carefully by hand.

- Place in a bed of cotton in a hard sided container
- Seal and tag and hand-carry to lab

Basal area lift technique

Use to prevent damage to fragile items. Use *clean* shovel or trowel and thin piece of flexible sheet metal. Clean tools with approved cleaning materials between each collection.

1. Score line through ash & duff, down to soil around the object
2. Leave border of several inches surrounding the object
3. Work the shovel or trowel into the dirt, under the object, until the clod of dirt and ash with object has been freed.
4. Slide sheet metal under it and lift the clod intact.
5. Place the metal and clod into a cotton padded container of appropriate size.
6. Seal, mark, and hand carry to lab

Ignitable liquid residue

Indicators:

- Obvious signs of trailers and pour patterns; puddling; deep seated burning; scorching and sooting
- Strong odor of gasoline & diesel, but deodorized kerosene, lighter fluid, alcohol and others may not be detectable by smell

Search techniques:

- Search perimeter areas.
- Use a K-9 (canine) trained team to detect ignitable liquids or a portable hydrocarbon detector.

Sampling locations:

- Take samples where the K-9 or detector registers a positive reading.
- Take a comparison sample in an area that did not register a positive reading.

Areas more likely to have residual ignitable liquid:

- Areas of lower intensity fire due to lighter vegetation and in areas where the liquid may have been shielded from the heat.
- Deep compacted duff, punky logs and stumps that have not consumed completely.
- Areas of sparse vegetation or bare soil
- Testing has determined detectable residues in soil remain up to 162 hours after the fire; however, microbial action may degrade the sample quickly.

Collection procedures:

- Pick up suspected charred wood or vegetation and place in a clean metal can (no glass) or other approved container or wrapping material.
- Fill can no more than 2/3 full with material.
- Avoid cross-contamination.
- Clean collection tools with approved cleaning materials between each sample.
- Have new, unused can or packaging materials available for control sample at lab
- If delay of more than several hours in getting sample to lab, samples should be frozen
- Any containers found near or at fire scene should be collected.
- If there is still liquid present, pour a small sample into a clean container with an airtight seal.
- Seal and mark the container and hand carry to lab. If it will be several hours, store in a cool environment
- Most crime labs will be able to isolate flammable liquids by means of GC/MS analysis and other tests

Firearms

- Never submit a loaded firearm to a lab unless it is delivered in person and then with advance approval of the lab

Projectile evidence:

- If lodged in wood or other material, it is advisable to leave it there.
- If a projectile is recoverable, do not attempt to clean it.
- Wrap it separately in a paper bindle, place on cotton padding in a hard sided container, seal and mark.

Cartridge cases

- Wrap each case in a separate paper bindle and seal in separate hard sided container.
- Seal and mark accordingly.
- If comparison to a firearm is necessary, submit both to lab.
- Never submit a loaded firearm to a lab unless it is delivered in person and then with advance approval of the lab

Footwear & Tire Impression

Collection procedures:

- Photograph using a tripod to position the camera directly over the impression, a ruler alongside and in the same plane as the impression and with low angle, oblique lighting.
- Insert a golf tee with a one-inch mark in an upright position alongside the impression to provide shadow correlation.
- Photograph with the flash at different angles, between 15 and 45 degrees.
- Cast with dental stone.
- Once cast is made, do not clean it off.
- Wrap it in tissue, dirt and all, and place in a cotton padded box, pack securely, seal and mark accordingly.
- **Shoe impressions should usually be cast.**
- **Casting of a tire impression is problematic:**
  - Difficult to match impressions to an individual tire
  - Effort involved is significant.
  - Many crime labs prefer photographic documentation of tire impressions

Fingerprints

Latent fingerprint evidence may remain after a fire. Prints have been recovered from beverage containers, food wrappers, cigarette packages, and arson devices. Do not assume that the fire has rendered latent print evidence unrecoverable.

Collection procedures:

- Handle object in such a manner as not to add extra prints to it; Latex or Nitril gloves should be used.
- Package objects in a box in a manner that they will not break or roll around.
- Do not package fingerprint evidence in plastic bags.

DNA evidence

Never overlook the possibility of DNA evidence. Recent advances in DNA recovery and analysis have increased the likelihood of obtaining identifiable DNA, even on heat damaged items. Hair, blood, semen, epidermal oils and saliva are all potential sources of DNA evidence.

Collection procedures:

- Collect items believed to contain DNA evidence with a gloved hand or clean tools.
- If the item has wet blood, semen, or saliva, air dry the item prior to packaging.
- Package item in clean paper: **Do not use plastic.**
- If there are questions, contact your local crime lab for directions on correct collection and packaging procedure.

Photography

Photographs are the best method of reproducing any scene and can record facts more accurately than a word description. Photographs can provide the following advantages:

- Present facts and physical circumstances visually.
- Pictorially preserve perishable evidence.
- Permit consideration of evidence which cannot be transported into a courtroom, because of immobility, size, weight, etc.
- Verify your testimony.
- Reveal facts or evidence that you may have overlooked.

Equipment

Either a 35mm single lens reflex (SLR) or digital camera should be used for fire scene photography. In addition to the camera each investigator should have, at a minimum, a close-up lens, a zoom lens, a tripod, and a remote flash attachment.

Method

Photographs should appear natural to the eye by taking them at eye level for a general view of the whole scene; the camera should be positioned as an eyewitness would observe the scene. The photograph should give a fair and accurate representation of the scene or the subject matter. Unless taking close-up photographs of small evidence or of indicators, generally a 50mm lens, which is closest to the human eye, should be used. This is important if the photographs are later used in court proceedings.

You may want to use a photo ruler to show the relative size of important evidence in your photographs. Some courts object to unnatural objects appearing in a photograph, so take photographs both with and without rulers.

Types of photos
Carefully examine the general and specific origin areas in order to record a maximum of useful information in a series of pictures that will enable the viewer to understand where and how the fire occurred. The series should include the following:

- orientation photos (overall photos)
- relationship photos (medium distance)
- identification photos (close ups)
- examination photos (close ups with scales, special lighting, and filters).

Records
Keep careful records of each photograph you take in a photo log. The photo log should identify the:

- time
- date
- location
- type of camera and lens
- type of film
- lighting
- photographer's name
- identify the frame and roll number (photo number if using digital medium)
- describe the subject of the photo and the direction the photo was taken (e.g., view looking northwest)

Orientation photographs
First, take pictures of the overall scene in a variety of positions which show all applicable material in its relative position (figure 39.)

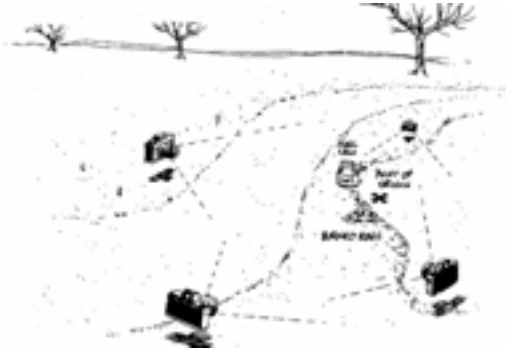


Figure 39.

Relationship photographs
Medium distance shots should be taken that show important areas in greater detail than the full-scene shots. Show the relationship of individual pieces of evidence to one another. Each area of importance should be photographed so it can be easily located in the full-scene pictures (figure 40.)

Figure 40.

Identification photos
All important items should be photographed as closely as possible to give the greatest possible detail. Shows detail of a specific item of evidence or an indicator. Document such things as tire or shoe impressions, sources of ignition, or other evidence. Add identifying numbers to show location of evidence or indicators after taking picture without numbers (figure 41.)

Figure 41.

Examination photographs
Examination photographs are taken close-up with a scale ruler or scale that is designed for evidence photography to clearly establish the size of the evidence. Scaling may help with examination if a positive identification is made later. A scale is not always necessary but is recommended. Consider using special lenses and/or lighting techniques (figure 42.)

Figure 42.

Photographic guidelines:

- Begin photographing as soon as possible.
- Create a photo log.
- Record the type of equipment, film and/or storage medium used.
- Number and describe each photograph.
- Taking more pictures is better than not enough
- Do not write on the pictures.
- Photos should be an accurate and fair representation of the scene.
- Establish the positional relationship between the investigator taking the photo and item(s).
- Document photo points on a photo diagram with the appropriate symbols.

Videography

Videography can provide overall fire scene footage, supplement photographs, document interviews and interrogations, and document surveillance operations. Using video exclusively without accompanying still camera photographs is not recommended.

Subjects to be videotaped:

- The fire in progress in early stages
- Bystanders and vehicles at the fire area
- Fire suppression activities relevant to the investigation
- Aerial views documenting direction of fire spread from general origin area
- Witness viewpoints

Sketching & Diagramming

Fire scene sketching and diagramming plays as important a role as photography in investigations. Other members of the investigation and litigation team will rely upon these sketches and diagrams repeatedly.

The finished diagram will be prepared from the rough sketches made at the fire scene. A rough fire scene sketch need not be neat, artistic or to scale; however, it must be accurate as to dimensions and location of evidence. Therefore, the fire scene sketch and the investigator's notes support one another. Use right angle transect, intersecting arc, or azimuth method to accurately measure all points to plotted. Laser measuring devices have also been used with some success. Investigators should be familiar with the relevant portions of NFPA 921, Guide for Fire and Explosion Investigations, concerning fire scene diagramming.

After the rough sketch is prepared at the fire scene, the investigator should prepare a scale diagram for the written report.

If the completed fire scene diagram becomes too cluttered with information, a separate photo location diagram may be needed to supplement the fire scene diagram.

Items to be diagrammed:

- reference points
- fire direction and burn pattern indicators
- point of origin
- ignition source
- all items of evidence
- roadways and intersections
- fire edge
- witness locations
- any other relevant items and landmarks
- photo points: location from where photograph was taken

Diagram preparation

- Plot all relevant points, including land marks.
- Plot fire progression using color coded symbols:
    - red arrow – advancing
    - yellow/orange triangle--lateral
    - blue "U"--backing
- Mark all evidence, sample, and photo points using standard NFPA symbols. (See current edition of NFPA 921.)
- Diagram should give the reader a clear understanding of the fire scene.
- Final diagram should be drawn to scale.
- Measurements should be attached to the final diagram in table format (figure 43.)

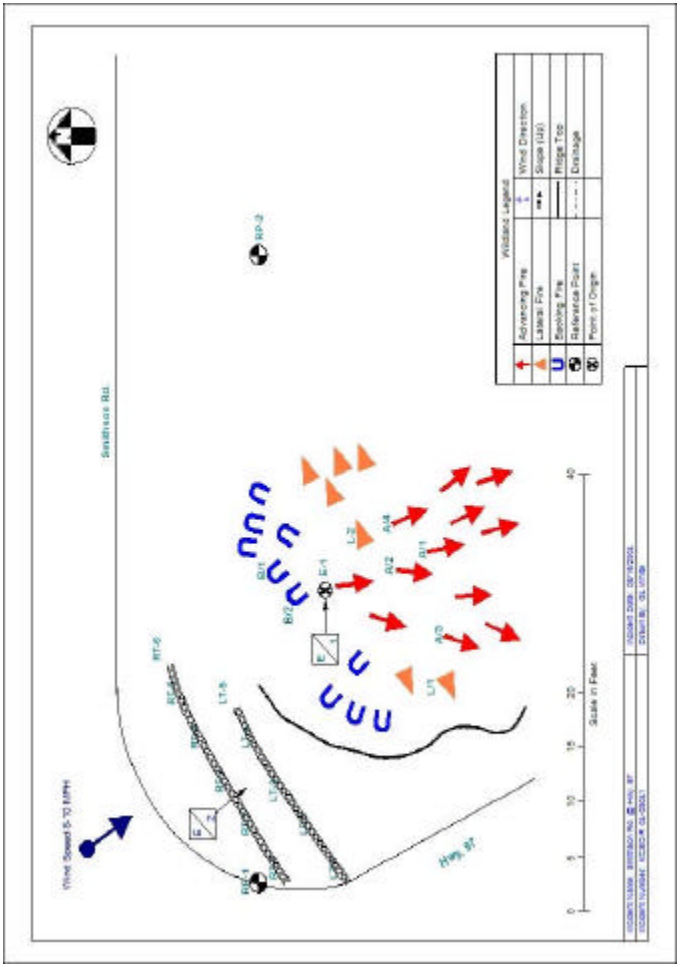


Figure 43: Example of a completed fire scene diagram.

Chapter 5
Witness Statements and Interviews

Voluntary Statements

Generally, persons at the scene will give a written statement voluntarily, but may be reluctant to do so at a later date. This should not be confused with an actual witness interview; the investigator is merely asking these persons to record any observations or other knowledge they are willing to give in their own handwriting.

The following guidelines can be used when obtaining voluntary statements:

- Have the person write the facts in detail.
- If possible, provide the person with some degree of privacy, so this can be accomplished uninterrupted.
- The statement should be read back to the witness.
- Have the person number, date, and sign each page.
- The investigator should initial each page.
- Ensure that all identifying information is obtained from the witness.

Interviews

Definition: An interview is the consensual questioning of a witness. It differs from a voluntary statement in that the investigator is asking the witness specific questions about the incident rather than having the witness write a voluntary statement.

Witnesses should be interviewed as soon as possible. If possible, prevent witnesses from discussing what they saw with other witnesses. Information obtained from a witness should not be discussed with anyone other than persons who have a legitimate right to know. Information obtained from witnesses should be recorded by:

- notes of the interview made by the investigator which are later reduced to a formal record of the interview, or
- a statement prepared by the witness or interviewer and signed by the witness and interviewer, or
- a tape or digital recording which is transcribed at a later date.

Regardless of how the information is recorded, the final interview report should contain the name, address, identifying information, and phone number(s) of the witness. Follow your agency's policy regarding forms, format and use of recording devices.

If there is a need to interview minors, a parent or guardian should be present during the interview. The investigator must follow the law in the jurisdiction and his/her agency policy regarding interviews of minors. It is also a good policy to have another person present as a witness during the interview of a minor.

Interview guidelines:

- Identify yourself.
- Explain purpose of the interview.
- Ask the subject to tell you what they saw.
- Allow the subject to tell their story without interruption, from start to finish. Don't take any notes and don't ask any questions, just listen to the story and w atch the witness.
- Have the witness tell the story a second time.
- Take notes (even if you are recording the interview).
- Ask them to pause or repeat if you need to catch up in note taking or you did not understand a comment.
- Ask specific questions on key points the witness did not voluntarily provide or if you don't understand a point.
- Do not lead the witness.
- Questions may be interjected to get the witness back on track.
- Record all visual and audible expressions.
- Make a note of questions the subject asks the interviewer.
- Summarize and review important points.
- If the witness is capable and willing, have them prepare a written statement.
- The investigator may write the statement for the subject, if necessary.
- Have the witness review, correct, sign and date the statement.
- Make sure the witness initials any corrections.
- The investigator should also initial each page.
- Where applicable, have witness draw a sketch showing where they were in relation to what they observed. (Follow this up with witness viewpoint photographs.)
- Thank the witness for their assistance.
- Give them contact information in case they remember any other important information.

Potential sources of information

Reporting parties: The reporting party may have seen the fire at an early stage and may be able to provide valuable information that will assist in determining the general origin area. Their observations are important because the origin investigation can be narrowed to the area burned at the time of the report. They may also be able to corroborate the information obtained from other witnesses. Keep in mind, however that occasionally, the reporting party may also be the person responsible for causing the fire.

Initial attack crew: The initial attack crew plays a vital role by making observations while en-route and upon arrival on the scene. Crew members may be able to provide valuable information pertaining to the general origin area, fire behavior conditions, identification of people, vehicles in the area, weather, damaged locks and gates, and other abnormal conditions. Also, initial attack resources can document initial suppression tactics, including water and retardant drops, hand line and/or hose lay locations and most importantly, any backfire or burn out operations.

Air resources: Air crews can make the same types of observations as ground crews regarding the potential area of origin, direction of fire spread, and people or vehicles leaving the area. Photographs of the fire taken by the air crew personnel often prove invaluable in showing areas burned, direction of spread, and intensity. Always check with first responder air resources to see if they did take photographs.

Civilian witnesses: Witnesses can provide information about unfamiliar vehicles or people that may have been in the area. They can also provide information on the condition of the fire, such as smoke conditions, intensity, rate of spread, and weather. They may have also taken photographs.

In a situation were there is a need to conduct multiple interviews in a short period of time, for example, a fire has started adjacent to a full campground, strongly consider requesting additional resources to assist with the interviews. As a minimum, obtain basic identification and contact information before potential witnesses leave the area so that they may be interviewed at a later time.

Do not share your opinions of what you have seen at the fire or information about the person or thing that may have started it to anyone other than officials who need to have the information. Remember, your job is to gather information, not to give it.

Chapter 6
Ignition Factors and Sources

Fire Cause Determination - General

The objective of every fire investigation is to establish the cause of the fire and to confirm this finding by identifying and, if possible, recovering the ignition source. If the fire was ignited intentionally, the ignition source may have been discarded nearby or removed from the scene.

If the fire is found to be human-caused with some indication of civil or criminal liability, follow the instructions of the law enforcement representative and/or your supervisor.

Fire Cause Categories

General cause: Classify the fire cause according to the ignition source or to the general human related activity which started the fire. The following categories are used to describe various causes . If applicable, use the agency's cause category as appropriate.

- Lightning
- Campfire
- Smoking
- Debris Burning
- Incendiary (Arson)
- Equipment Use
- Railroad
- Children
- Miscellaneous
    - Power lines
    - Fireworks
    - Cutting, welding, and grinding
    - Firearms use
    - Blasting
    - Structures
    - Glass refraction/magnification
    - Spontaneous combustion
    - Flare stack/pit fires

Lightning

Definition: Any wildland fire started as a result of lightning activity. Lightning occurrence maps are a significant tool to be utilized in suspected lightning caused fires.

Cause indicators:

- Lightning scars or other damage to objects such as trees, shrubs or brush, posts, poles, or structures (figure 44.)
- Blow holes in the ground and possible presence of fulgurites.
- May smolder undetected for as long as several days and/or weeks after a lightning strike before transitioning to an active wildfire.

Figure 44: Lightning scar.

Recommended actions:

- Interview all available local area witnesses as to whether they observed lightning or storm activity in the fire area. Have them recall dates and location of sightings.
- Obtain and review lightning detection maps and data for the last 15 days. Extend this analysis to 30 or more days if weather or fuel conditions warrant. Track and attempt to locate all strikes within a one mile radius of the fire area.
- Examine physical evidence within or close to the origin area that may support witness statements or be suspect as a source of electrical contact.
- Use binoculars or spotting scope to examine tops of tall trees.

- Examine all old lightning damage pathways for signs of recent pathway activity. Charred or discolored surface splinters in the old pathway may indicate recent activity.
- Conduct searches for macro effects and micro effects of lighting pathway activity, i.e., spiral bark rips, freshly precipitated sap, and needle showers.
- Examine tree species that are prone to center-rot decay and subsequent lighting pathway effects, i.e., white fir. If necessary, fell and open suspect tree boles. Follow evidence procedures and avoid unnecessary cutting of trees.
- On suspect trees, inspect the root collar area and the integrity of roots near the surface and in shallow soil. Look for discolored tissue, swollen girth, or separated structure.
- Examine suspect contact points for fulgurites or other similar effects related to the fusing of soil particles or rock by lightning.
- Fully document and locate lightning damage by photographing, sketching and diagramming.
- Exclude or analyze other reasonable potential causes.

Campfires

Definition: Any fire kindled for warmth, cooking, light, religious or ceremonial purpose. Campfires may occur at any location. Responsible parties may be hunters, campers, fisherman or hikers.

Cause indicators:

- Circles of rocks or pits with a large amount of ash and coals, or a pile of wood are good indicators of a campfire (figure 45.)
- Signs of recent camping activity, including discarded food containers, metal tent stakes or metal grommets from a tent indicating the possibility of a campfire.
- Wet ash and/or ash being mixed with soil in a failed effort to extinguish the fire.

Figure 45: Escaped campfire.

Recommended actions:

- Determine who was responsible for the construction and use of the campfire before the escape took place.
- Determine what safety precautions and tools were used to safeguard against an escape during use of the campfire. Determine when the fire was constructed and how long it was used. Take pictures of the fire ring up close and from a distance, showing proximity to point of origin and spread direction.
- Determine what materials were burned during the use of the campfire. Collect samples, if necessary. Examine the interior of the campfire to determine if there is any residual heat. Measure the ring dimensions, including the average

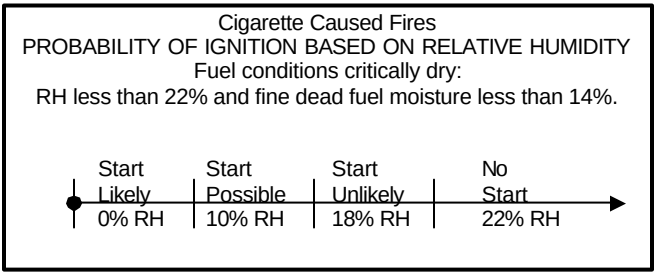
ash depth, making note of color, size and condition of ash/charcoal.

- Determine what actions, if any, were taken to extinguish the campfire. Be specific with details and persons that took such actions. In cases of juveniles involved with an escaped campfire, determine what parental supervision was involved. If there was prior parental knowledge, did the parents oversee the use and subsequent extinguishment of the campfire?
- Examine the construction of the campfire ring and the clearing of ground to mineral soil and the continuity of fuels around and above the campfire. Char and ash residue often reveals if the construction was fire safe. Document the fire ring condition. Examine organic soil layers surrounding the fire ring for ground fire transmission to surface fuels.
- Review weather records for conditions that would be consistent with holdover of smoldering material in the campfire bed.
- Thoroughly examine the ashes in campfire bed for signs of proper extinguishment or material involved with slow smoldering combustion.
- Determine if the campfire users left the fire unattended at any time or allowed it to spread from the fire ring at any time, regardless of whether the escape took place at that time or not.
- Document the purpose of having the campfire and include identification information of all persons at or near the campfire during its use.
- Interview witnesses who observed people at the campfire and their actions.
- Contact the landowner to verify the campfire user had permission to have a campfire on the property.
- Determine if the use of the campfire was in violation of any fire regulation and document what enforcement action and subsequent disposition took place.
- Campfire site - search for and note:
    - bottles, cans or other consumer debris
    - circle of rocks (fire retainer) within burned area
    - seating, i.e. logs around “circle of rocks”
    - pile of unused firewood
    - campsite registration information
    - accessibility
    - ashes from firewood in definite pattern
- Exclude or analyze other reasonable potential causes.

Smoking

Definition: Wildfires caused by smoking activities or accoutrements, including matches, cigarettes, cigars, pipes, etc.

Cause indicators:



- Cigarettes, under normal conditions, generally do not start wildland fires unless the RH is under 22%, it is windy, and a continuous, cured, finely-particulated fuel-bed exists. Exceptions to this basic rule are expected; let the strength of the evidence support the cause.
- Average full-length cigarette burns for 13 to 15 minutes (1" in 4 minutes).
    - Most people discard cigarette almost totally burned, therefore, 62 to 122 seconds exposed to fuel bed.
- The following circumstances must usually occur in order for a cigarette to start a wildfire:
    - RH less than 22%
    - 30% of glowing tip exposed to extremely fine fuel.
    - Favorable tip orientation with wind (wind will assist ignition).
    - Cigarette comes to rest in fuels at angle where lit end is facing down.
    - Burned match heads, cigarette butt, cigarette ash column found within a few feet of the exact point of origin may suggest malicious or willful intent (figure 46.)
- Other evidence of human activity in area.

Figure 46:-Cigarette at origin.

Recommended actions:

- Carefully examine all cigarette butts located at or near the point of origin before touching or moving them. Use a hand lens to determine if any alteration or modification has occurred that may indicate the cigarette was used as a fuse component in a time delay incendiary device. If so, proceed with the investigation as a suspected arson.
- Before moving the remains, measure its location in reference to point of origin or other relevant points including distance from any nearby roadway. Measure length of ash and unburned product. Note distinguishing markings and whether a filter is present and if product is hand rolled. Examine condition of remains for indications of crushing. Photograph and collect the cigarette residue and butt from the origin using a basal-area lift technique.
- Carefully examine and gently remove ash layers to reveal their structure. Size and weight ratios of cigarettes (and matches) usually prevent them from burning to the ground surface; however, surrounding ash may obscure them.
- Package, label and store the sample for future use as evidence.
- Determine the specific weather conditions at the suspected time the cigarette butt was delivered to the fuel bed. Document wind speed and direction, relative humidity, temperature and state of weather (% sunshine).
- Determine what the fine dead fuel moisture would have been at ignition time.

- Determine what the depth, arrangement and cure state of the “fine” (1 hour time lag) fuel bed would have been at time of ignition. Examination of unburned fuels near the general origin area may give you an idea of the fine fuel factors.
- Contact witnesseswho may have been near the ignition area at the time the cigarette may have been discarded. Do not overlook residents that may have observed someone walking or driving by at the time. Generally focus on the time period from one hour before ignition up to the time the fire was reported. (Extend this time as needed based on fire behavior conditions).
- Using interview and scene information, attempt to estimate the source from which the cigarette butt came and the estimated trajectory it may have taken when discarded.
- Determine if any fire prevention regulation was violated and what enforcement action and subsequent disposition took place.
- Exclude or analyze other reasonable potential causes.

Debris Burning

Definition: Wildfires caused by fires started for purposes of burning slash, garbage, stubble, right-of-way, or other controlled burning.

Cause indicators:

- Fires occur at dumpsites, as well as at residences from garbage and other debris set on fire. Often, fire or sparks from these operations spread to the neighboring vegetation.
- Burn barrels or incinerators may be a consideration as a fire cause (figure 47.) In windy conditions, hot ash and debris can be transported aerially and start a fire some distance away, especially if corrugated cardboard is being burned.
- Witnesses often are the best way to confirm whether or not debris burning was the cause of the fire.

Figure 47: Burn barrel escaped fire.

Recommended actions:

- Determine if the point of origin or source of ignition is the burn pile, and if burn patterns support the determination.
- Conduct thorough interviews of subjects that may have observed the burning or were involved in the burning.
- Examine the residual pile material for size, depth and composition. Fully document what materials were burned and if any residual heat was retained in the pile.
- Determine what control barriers were constructed, what tools and water source were relied on, and if the subject attended the burn at all times. Fully document all conditions and deficiencies that existed.
- Determine the time frame from ignition of the pile to escape; often this is measured in days. Be specific on dates and times.

- Determine what the weather conditions were during the entire burn time and specifically at time of escape.
- Determine the proximity of the burn pile to surrounding fuels or near-by fuel hazards. Include slope, aspect and proximity to fuels.
- If an incinerator or burn barrel was used, document the amount of vegetative clearance around the unit, integrity of the screen and barrel container, proximity of the unit to near-by fuel hazards, and whether the user monitored the burning and had sufficient tools on hand.
- If juveniles were involved, determine if they acted as the parents' agent to burn the material.
- Was burning conducted during times of restriction or closure? Document any permit or prevention violations that were involved, enforcement actions taken and subsequent dispositions.
- Collect samples of burn material, if necessary, and always take several photos of the burn pile or barrel from various angles and distances. Photographs should show proximity to surrounding fuels, the subject's residence, control lines, tools and water, suppression attempts, other piles and material burned.
- Summarize all refuse/yard debris burning evidence, validated and/or eliminated, in the investigation.
- Exclude or analyze other reasonable potential causes.

Debris burning--Slash

Escaped fires originating from large slash burning operations should be treated generally the same as other debris burns. Their size, and the fact that they may hold over for an entire winter do create additional considerations.

Recommended actions:

- Document the type and extent of fuel material burned, expressed in species, fuels, sizes, acreage, pile sizes or tons per acre.
- Determine the extent of broadcast and pile burning, and diagram perimeters of burn areas. Transcribe this information on to topographic maps. Take aerial photos when necessary.
- Document the extent of pre-planning, site preparation and proper burn execution for the burn operation. Extent of control barriers planned and appropriately constructed, fuel hazard reduction near control lines (both sides), personnel and equipment for control, emergency

contingencies, weather monitoring, ignition and lighting equipment and techniques, communications, supervision and training. Fully document all commendations and deficiencies.

- Document the ignition method employed and its sequence. Document any situations where ignition sequences failed or were partially successful. Record the extent of unburned fuel from these actions and the extent of subsequent re-burn, follow-up actions as they related to escape or hampering control efforts.
- Document the extent of agency involvement in the approval of burn plans, pre-burn, burn and post burn inspections, follow-up on non-compliance issues, permits, record of fire and district control actions. Fully document all conditions and deficiencies.
- Document weather information 30 days in advance of the fire, during the escape and the suppression period. Determine fuel moistures for all size classes of fuels involved. Obtain copies of any pre-planned fire behavior prediction estimates.
- Document the areas or points of fire escape and any situations where spotting may have occurred. Document all physical evidence and relevant human actions related to the escape or ignitions.
- Document all relevant human actions that took place after the escape was discovered. Document the extent of control resources available and the extent of which it was effectively used.
- Document the timeline of large piles burned or broadcast burns that included piles. Include time of year ignition took place, extent of monitoring, patrol or mop-up efforts. Fully document all conditions and deficiencies.

Holdover fires
Fires may surface from clearing and brushing activity well after the original materials were burned. They may also surface from burning in the ground where no brush pile exists. There are numerous documented instances where these fires have escaped the following spring after being originally burned the preceding fall.

Recommended actions:
The investigation should include (if the brush pile has not been scattered during suppression):

- Photograph, video and measure the brush pile and commence sketch initially during examination.
- Probe the pile to identify "hot spots".
- Obtain a detailed statement from the landowner or property holder, including the date the location was brushed, burned and re-piled.
- Commence examination at an identified location of the brush pile.
- Have the landowner present if possible.
- Use a skidder/tractor/Cat to dissect the pile.
- Measure each "cut" into the brush pile.
- When dissecting the pile, examine and document not only the "hot" core of the pile, but look for areas of cold charcoal and determine if they connect to the burning core. Note debris color as this can determine intensity of heat.
- Video and photograph the procedure.
- Sketch the scene with appropriate measurements.
- If initial burn was within the fire season, obtain a copy of the fire permit.
- Confirm the permit conditions with the issuing agency.
- If a ground fire, a careful examination of the area to determine depth of burn and fire movement will be necessary to confirm cause.

Arson/Incendiary

Definition: Wildfires deliberately and/or maliciously set with the intent to damage or defraud. Refer to your jurisdiction's legal definition of arson.

Cause indicators:

- These fires are often set in more than one location and in areas that are frequently traveled.
- Fires set in locations where detection is limited and may be set after hours of darkness. Origins will most often be near roads and trails.
- Matches, cigarette lighters, fireworks, and other ignition devices may be found in the area of origin.
- The fire-setter may use a time-delay ignition device. Items to look for include cigarettes, matches, rope, rubber bands, candles and wire (figure 48.)
- Arson ignition sources:
    - o direct – hand carried and placed.
    - o remote – those which can be thrown or projected to another location (i.e., fireworks, Molotov cocktail).
    - o hot set – those which involve an open flame source and start a fire immediately.
    - o time delay – those which incorporate a timer or delay mechanism before being triggered (i.e., candle, slow match, etc).

Figure 48:-Time delay device.

Recommended actions:

- Notify law enforcement according to your agency policy.
- It will be necessary to prove:
    - intent
    - means
    - exclusive opportunity
    - motive (not necessary, but valuable evidence)
- Verify there is an evidentiary basis to support that the fire is of suspicious origin or definite arson. An undetermined cause does not make the fire cause is arson.
- Protect the area of origin and keep security on scene until it is processed.
- Conduct a thorough burn pattern search and determine point (s) of origin. Effectively eliminate other possible causes.
- Make a thorough listing of all possible witnesses to be interviewed.
- Document all potential evidence by photographing, sketching and notation before collecting. Always maintain chain of evidence.
- Co-operate to the fullest extent possible with other agencies.
- In the event of multiple or large fires believed to be arson, do not hesitate to recommend a team or task force investigation.
- Maintain the strictest level of confidentiality and share information only with those that have a genuine need to know.
- Do not release any case file information to the public, media, or non-assisting agency.
- Exclude or analyze other reasonable potential causes.

Equipment Use

Definition: Wildland fires resulting from the operation of mechanical equipment excluding railroads. Types of mechanical equipment range from heavy construction to small portable engines.

Cause indicators:

- The presence of the actual equipment or signs of any types of equipment use such as construction, logging, land clearing, harvesting, mowing, grading, etc. (figure 49.)
- Ignition mechanisms include: exhaust system particles, friction, fuel, lubricant, fluids, mechanical breakdown or other malfunction, rock strike, vegetation buildup on hot surfaces and radiant or conductive heat transfer.
- Charred material on the exhaust or other hot surfaces.

Figure 49: Equipment at origin.

Recommended actions:

- Make a thorough listing of all equipment that is believed to have been near the area of origin at or about the time that the ignition took place. Expand this time period for the duration it is believed a fire could have held over. When listing equipment, include make, model, serial number, age and general description. Isolate problem equipment.
- Identify who owns each piece of equipment and who was operating it at the time. Determine dates and times of operation and any change of operators. Sketch on a map the location and time of operation.
- In addition to listing the equipment, be sure to photograph each item near origin area at time of ignition, prior to being moved or inspected.
- Identify and document any tracks leading from the origin to the equipment.

- Interview each operator and each person that performed maintenance on the equipment. Obtain detailed witness statements from each subject.
- Inspect each piece of equipment with qualified equipment mechanic if necessary. Examine the fuel system, electrical system, exhaust system and any friction contact surfaces and bearings. Photograph and fully describe any and all parts that appear to be deficient or show excessive wear or damage. Obtain written reports from assisting mechanics. Look for debris around exhaust system.
- Follow up equipment inspections with professional service centers or distributors for details of maintenance schedules or specific hazards or problems associated with operation of a specific piece of equipment. Obtain witness statements from representatives that offer information on cause and effect.
- When evidence collection is not possible or practical, obtain photographs of the item and close ups of the area of deficiencies or damage.
- Check all internal combustion engines for spark arrestor compliance. Inspect spark arrestors and document any deficiencies.
- Document any deficiencies in maintenance, including buildup of debris on hot surfaces.
- Document all deficiencies for fire protection requirements relating to use of such equipment (i.e., fire extinguishers, water source, watchman service).
- Determine the terrain over which the equipment was used.
- Exclude or analyze other reasonable potential causes.

Railroad

Definition: Fires caused by any rail road operations, personnel, rolling stock and can include track and right-of-way maintenance.

Cause indicators:

- Will be located along active railroad lines and could have multiple starts.
- Special arrangement will need to be made to obtain the records from the locomotive data recorder ("black box") and samples from the locomotive (oil and soot from exhaust system).
- Witnesses may have seen train pass recently.
- Look for signs of recent track maintenance, including welding and grinding.

Figure 50: Diesel exhaust carbon.

Recommended actions:

- Determine if a train has passed recently or if any recent track maintenance has occurred.
- Obtain track elevation and topography maps
- Identify the train number, locomotive engine(s) numbers, train crew, train schedule including time, direction of travel, and rail road mile post marker numbers.
- Have the train inspected by a qualified inspector for any suspected deficiencies.
- Interview the train crew and/or maintenance crew.
- Use the nearest mile post marker as a fixed reference point from which to base measurements and identify photo locations.
- Rolling stock may ignite multiple fires in close proximity, so ensure the examination includes a search for more than one point of origin.
- Search the nearby area on both sides of the track for ignition mechanisms that may not have started a fire. This includes exhaust carbon particles (figure 50), brake shoe

particles, grinder residue, burn piles, track heating, flares, metal fragments, dynamic grid fragments, track damage, etc.

- At the origin, search for, document and collect the actual remains of any of these ignition sources. These are usually recoverable.
- Check records for earlier fires along track at different locations. These may be in another agency's jurisdiction.
- Obtain train maintenance records as necessary.
- Obtain train data recorder and infrared detector information as soon as possible, as these files are often automatically purged from the equipment.
- Exclude or analyze other reasonable potential causes.

Children

Definition: Wildfires started by persons 12 years of age or younger. The child may be motivated by normal curiosity and use fire in experimental or play fashion. Matches or lighters are the most frequent ignition source. Often involves multiple children.

Cause indicators:

- Fires located near play areas, footpaths or homes.
- Multiple matches, fireworks, etc. found around origin (figure 51.)
- Time indicates after school or school break.
- Fort and/or toys found in origin area.
- Children's foot prints or bicycle tracks.

Figure 51: Matches and matchbook.

Recommended actions:

- Look for an origin away from adult supervision, but likely close to home, school, campgrounds, footpaths or playgrounds. Check for hidden "secret" areas or play forts. Locations normally frequented by children.
- Look for signs of fire play such as numerous matches.
- Look for signs of any attempt to suppress the fire.
- Do a neighborhood canvas for witnesses.
- Determine if there have been other similar fires near by.
- Contacts and interviews of children must be conducted in accordance with appropriate legal process.
- Look for and identify children watching the fire.
- Interview children in the area; even if not suspects: they may have information about other children.
- Determine if the actions are due to normal curiosity or a pathological behavior.
- Consider referral to juvenile authorities and/or an intervention program.
- Exclude or analyze other reasonable potential causes.

Miscellaneous

Definition: Wildfires that cannot by properly classified under other standard causes. Some of these are listed below:

- Power lines
- Fireworks
- Cutting, welding, and grinding
- Firearms use
- Blasting
- Structures
- Glass refraction/magnification
- Spontaneous combustion
- Flare stack/pit fires

Power lines

Definition: Fires normally result from conductor failure or faulting, insulator failure, hardware failure, birds and small animals, and Mylar balloons.

Cause indicators:

- power lines located in or near the area of origin
- downed power lines
- trees or other vegetation in contact with power lines (figure 52)
- recently downed tree limb located on ground under or near lines and area of origin.
- discoloration of line and/or signs of arcing or other equipment failure
- circuit breakers in open position
- blown fuses
- recently dead bird found in area of origin
- high winds and or high temperatures prior to the fire
- recent power outages or brownouts
- pole damage or vehicle accident

Figure 52: Arc charring.

Recommended actions:

- Before entering the area under or near the power lines, first determine if it is safe to do so.
- Determine origin area.
- Determine height of tree (if caused by tree falling on line).
- Search area for human activity such as shooting, vehicle traffic and/or recently dead birds or other animals etc.

- Examine power lines and equipment for damage or failure in and near the area of origin. Look for remains of failed equipment on ground.
- Determine distance of nearby limbs to conductors.
- Determine if legal clearances are present or not.
- Determine general age, size and condition of any vegetation that has fallen on the line. Measure debris on the ground.
- Determine height of power line.
- Determine height of surrounding forest canopy.
- Determine ownership of power line.
- Determine location of the right-of-way boundary for the power line near the area or origin of fire. Record the distance from the point of origin to the edge of the right-of-way, indicating whether it is inside or outside.
- Locate and record the identification numbers of power poles on both sides of the area near the origin.
- Obtain witness statements from power company. maintenance crew regarding what caused the power line failure or ignition from the failure.
- Samples of tree:
  - Take into possession area of tree that shows contact with the line.
  - Sample of root – if deterioration or rot noted.
  - Sample at germination point.
  - Circumference of tree at breast height.
- Video, photograph and sketch area and point of origin.
- Note: The fire may not have started where the tree is on the line. For example, a fuse may have been activated or malfunctioned, causing a fire at a different location.
- Examine all poles, lines, fuses, transformers, insulators, splices, connectors and grounding devices in the area of origin. Take photos and collect samples as needed. Request administrative warrant if needed.
- If a fuse or other mechanical malfunction, it may be necessary to obtain the services of an electrical engineer or power line expert.
- Examine the scene with the power line expert and take into possession exhibits.
- If there is a direct short to the ground, examine the area for fulgurites.
- Obtain line data and maintenance records from the power company.
- Exclude or analyze other reasonable potential causes.

Fireworks

Definition: Fireworks are classified as ground based, handheld (figure 53), aerial and explosive.

Figure 53: Sparklers.

Cause indicators:

- location of the fire start
- presence of spent fireworks remains at the point of origin
- fire occurrence near holiday period

Recommended actions:

- Search area for launch site, packaging materials.
- Canvass area for witnesses who may have seen or heard recent fireworks activity.
- Document distance from discharge of fireworks and fire origin along with clearances around discharge area.
- If found off roadway, document distance and describe fuel configuration to determine if fireworks item was thrown.
- Photograph and collect fireworks evidence in such a manner to avoid adding fingerprints or DNA.
- Identify type of fireworks used and note any identifying markings.
- Determine if firework was of a legal type in jurisdiction.
- Consider a motive of arson.
- Exclude or analyze other reasonable potential causes.

Cutting, Welding, and Grinding

Definition: These types of ignitions are normally caused by an industrial or agricultural operation, but may also result from an individual or residential activity.

Cause indicators:

- Location in relation to equipment or an equipment use area
- Presence of slag, welding rod, metal fragments, or grinder disks (figure 54)
- Welding cart wheel impressions or fire extinguisher residue present

Figure 54: Welding debris.

Recommended actions:

- Document clearances, if any.
- Check permit compliance.
- Use magnet and/or metal detector.
- Exclude or analyze other reasonable potential causes.

Firearms

Definition: Black powder discharge, tracer, incendiary and steel core ammunition (figure 55) are capable of causing wildfires.

Cause indicators:

- areas used for target shooting
- evidence consisting of targets, spent shell cases, and ammo boxes
- strike marks on rocks or other hard objects in origin area

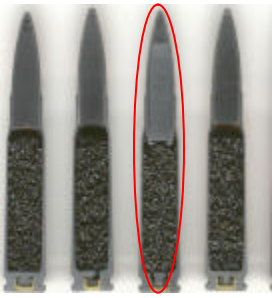


Figure 55: X-ray of steel core ammunition.

Recommended actions:

- Thoroughly search of origin area (impact site) and firing point.
- Canvass area for witnesses.
- Collect evidence such as casings in such a manner to avoid adding fingerprints or DNA. Projectile may be buried in dirt or tree; use metal detector for recovery.
- Exclude or analyze other reasonable potential causes.

Blasting

Definition: Fires started by flaming debris associated with blasting activities.

Cause indicators:

- normally near or in blast perimeter
- fire ignition may be delayed due to smoldering combustion

Recommended actions:

- Document blasting activities prior to the fire.
- Consider potential of additional explosions and explosive devices in area and take appropriate safety measures. Consult with persons using blasting materials.
- Look for blasting/burned material remains at point of origin.
- Determine if permits were obtained and conditions followed
- Exclude or analyze other reasonable potential causes.

Electric Fences

Definition: Fires originating from electric fences used to contain domestic animals. Rapid electric pulse cycle does not allow fuel to cool down.

Cause indicators:

- fire origin along electric fence line
- vegetation in contact with fence line
- charred vegetation transfer and discoloring on wire (figure 56)

Figure 56: Vegetation transfer.

Recommended actions:

- Determine if origin is near fence wire.
- Determine fence line condition and maintenance.
- Determine whether line was electrified.
- Observe and document power supply line from source to fence and document any contact with vegetation, lack of insulators, etc.
- Examine entire line and look for other areas where vegetation has charred, but not started a fire.
- Document any tripped circuit breakers.
- Identify manufacturer make and model.
- Evaluate vegetative maintenance along fence line.
- Examine fence wire for discoloration or presence of charred vegetation
- Exclude or analyze other reasonable potential causes.

Structures

Definition: Fire spreading to the wildland due to failures or activities associated with a structure.

Structure fire investigation is a specialized task requiring specialized training and skills. Consider need for additional and/or specialized resources. Do not attempt to conduct an independent origin and cause determination of the structure unless you are trained and have the appropriate authority.

Cause indicators:

- burn indicators which show spread originated at or in structure
- smoke or flame coming from chimney
- power failure to structure or nearby area
- human activity in the area

Recommended actions:

- Identify need for specialized investigator resource.
- Photograph burning structure early on to document where and to what degree fire is burning in each portion of the structure.
- Conduct walk around of burning structure documenting degree of burn.
- Locate and document condition of gas service.
- Locate and document condition of electric service.
- Examine exterior for evidence of activity including containers or spill patterns which may indicate the use of an ignitable liquid.
- Interview occupant, if home, and/or reporting party and other locals in the area to determined earliest sighting of fire, its location, and size.
- Examine doorway access for signs of forced entry.
- Examine windows for signs of forced entry and/or explosion indicators.
- Work from least burn to determine burn indicators and identify the room of origin.
- Examine room of origin for indicators of a specific area of origin.
- Examine specific area of origin for ignition sources.
- Identify ignition source and eliminate other ignition sources in room of origin and other rooms if need be.

Flares

Definition: Fires resulting from commercial, industrial, or military flares. Compound is usually a mixture of sawdust, wax, sulphur, strontium nitrate, and potassium perchlorate. Flares burn at approximately 3600 degrees.

Cause indicators:

- grayish-white slag residue at point of origin (figure 57)
- fires that occur along rail roads or highways
- military ground or air operations in the area
- flare debris present in the form of caps, strikers, and slag. Cap and striker may have rolled or blown away from origin.

Figure 57: Flare slag.

Recommended actions:

- Submit slag residue to laboratory for possible content analysis of strontium nitrates or other suspected chemicals.
- Evaluate recent activities at this location.
- If an aerial flare, attempt to trace trajectory back to launch site.
- Exclude or analyze other reasonable potential causes.

Glass Refraction

Definition: The sun's rays can be focused to a point of intense heat if concentrated by certain glass or shiny objects. This refraction process bends light rays, similar to that which occurs through a magnifying glass. The shiny, concave end of a metal-can may focus sunlight, but its short focal distance makes the potential as a possible cause highly unlikely. Fires started by these items are extremely rare occurrences; however, objects possessing these characteristics recovered from the specific origin area may need to be carefully examined for purposes of exclusion.

Cause indicators:

- clear glass or reflective objects capable of refraction are located at precise point of origin (figure 58)
- specific environmental conditions that support ignition

Figure 58: Cut crystal wine glass.

Recommended actions:

- Document point of origin in relation to objects location and orientation of the sun.
- Identify reflective items or concave glass in origin area.
    - Note: Broken flat glass will not start fires.
- Collect and test under similar conditions, any reflective objects suspected of causing a fire.
- Determine amount of sunlight at time of ignition.
- May have to be affirmatively excluded due to its presence.
- Exclude or analyze other reasonable potential causes.

Spontaneous Combustion

Definition: Certain fuels will self heat and ignite spontaneouslywhen conditions support a combination of biological and chemical processes. This action is most likely to occur after periods ofwarm humid days in decomposing piles of organic material such as hay, grains, feeds, manure, sawdust, wood chip piles, and piled peat moss.

Cause indicators:

- materials present which may spontaneously combust
- areas that exhibit outward burning from the interior of the pile (figure 59)
- vents (steam holes) are present and are associated with a strong pungent odor

Figure 59: Interior burning.

Recommended actions:

- Utilize photography and videotaping as much as possible when documenting suspect self-heating forest residue piles (including sawdust piles).
- Examine debris piles for species composition and particle size. Susceptible piles usually have a significant percentage of fines and the pile is compacted.
- Determine the process by which the piles were created. Usually a grinding following a de-limbing process creates sufficient fines that will compact.
- Determine if live or dead foliage was involved during the process period and to what extent: the greater the live foliage, the greater the likelihood of the pile self heating.
- Determine the time period from pile creation to present time. Record this information in your notes.

- Determine the extent that machinery was used in pushing up the piles and the degree of soil mixing involved in this process. Usually a soil inoculation is consistent with strong bacterial levels in the piles.
- Document any venting (steam holes) present and any associated pungent odor. Document creosote leakage, fungal activity and any strong odors associated with the exterior of the pile.
- Attempt to locate any materials that have been involved with pyrolysis, yet have not been associated with open free burning.
- Determine if the pile burned from the inside-out or the outside-in. The degree of particle consumption, burned versus unburned material, type and distribution of ash/charcoal and general heat distribution within the pile, are elements to examine. Examine the interior of the pile for fused silica residue (clinkers).
- Record the weather leading up to pile ignition. Look for cool periods, followed by a significant change in weather that would suggest the pile experienced a strong exposure of exothermic heating. This element is thought to cause some form of thermal feedback that may quickly change pile conditions in favor of ignition.
- Make a determination if the piles were self-heating by examining unburned piles. If no unburned piles are available, make this determination by examining the residue of the burned piles and interviewing the operator and/or landowner.
- Document the operations that generated the residue piles and document other locations where suspect piles may exist. Inspect all associated piles and locations for evidence to support spontaneous combustion.
- Exclude or analyze other reasonable potential causes.

Flare Pit Fires

Definition: Flare pit and stack operations are designed to burn of excess or unwanted petroleum by products. Occasionally these will start fires from direct flame impingement, the igniter flare or stack particles.

Cause indicators:

- flare stack or pit near origin
- remains of flare or carbon particles at origin
- evidence or witness reports of recent flaring

Recommended actions:

- Identify if an H^2S battery/well.
- Determine when flare was last lit and how (electric igniter or flare gun).
- Determine distance from battery.
- Commence preparation of sketch.
- Shoot a close-up photograph of stem of the pipe at the flare pit.
- Determine when the battery was last shut down for repairs.
- Examine the well site Daily Recorder to identify specific/significant changes in flow.
- Interview the operators to determine history of the battery site, i.e., similar incidents.
- Obtain a sample emission from the flare (if possible). This may be compared to the composition of material on the ground.
- Determine distance from stem of pipe in the flare pit to the berm surrounding the flare pit.
- Determine the distance from the edge of the berm and the stem of the pipe to vegetation.
- Exclude or analyze other reasonable potential causes.

Flare Stack Fires

- Identify if an H^2S battery/well.
- Determine when flare was last lit and how (electric igniter, flare gun, or other method).
- Was flare burning when first witness arrived?
- Is the flare monitored?
- Sketch site.
- Height of the stack.
- Base of stack to ground fuels (minimum 2½ times height of stack).
- Is there a “knockout drum” (a “sediment bowl” like tank to prevent condensate getting to the stack)?
- Close-up photograph of top of stack to identify carbon build-up.
- Examine the area for materials that may have “burped” from the flare stack or carbon dislodged from top of stack.
- Examine the well site Daily Recorder to identify specific/significant changes in flow.
- Interview operators to determine history of the battery site, i.e., similar incidents.
- Obtain a sample emission from the flare, if possible. This can be compared to the composition of material on the ground. Determine weather conditions from site personnel.
- Exclude or analyze other reasonable potential causes.



Figure 60.

Appendix 1
Investigation Checklists

At the time of dispatch

Collect as much of the following information as possible:

Date of dispatch call
Time of dispatch call
Caller
Call back #
Assignment
Order #:
P Code/ Accounting Code
Incident name
Incident #
Controlling agency
Agency unit
Incident size/acres
Fuels
On-scene contact
Contact radio frequency
Contact phone #
Incident location
Directions to the incident
Origin date
Origin/report time
Reporting party
Special equipment/personnel

On scene

At the scene all of the following tasks must be completed. In general, this list is in the order which the tasks should be completed, however circumstances at the scene may dictate a different order for some tasks such as photography, collection of evidence in danger of destruction, or taking statements from witnesses before they leave the area.

Protect general origin
Take weather observations
Identify witnesses
Identify and protect evidence
Walk general origin perimeter (twice)
Mark macro-scale indicators
Identify initial run
Walk initial run & mark indicators
Identify specific oriigin
Walk specific origin perimeter (twice)
Grid lanes
- Visual
- Visual with magnification
- Magnet
- Metal detector (if needed)
- Screened (if needed)

Take photographs & complete photo log
Sketch & take measurements
Collect evidence
Take witness statements

Post scene

Collect other data
- Lightning records
- RAWS weather data
- Initial attack fire reports
- Dispatch logs
- Supplemental reports & lab reports
- Suppression cost estimates
- Damage & loss estimates
- Fire behavior input and output documents

Prepare vicinity map

Prepare location map

Prepare scene diagram with measurement table

Prepare evidence/property log

Conduct any follow-up interviews & prepare any interview reports

Follow-up on any leads or tips

Write the origin and cause report. *The investigation is not complete until the report is written.*

Appendix 2
Investigation Kit

Equipment

Items as outlined below may be required for any wildland fire investigation. Additional items may be required. A unique situation may require a phone call to Federal, State, or local crimes labs as to storage and transportation of the samples or to obtain specialized equipment.

- Case or backpack
- Compass
- Clinometer
- GPS
- Digital (4 MP or higher) or 35 mm SLR camera, adequate film
- Video camera, tapes and batteries
- Flagging
- Tape measures (2 each -100')
- Notebook/paper
- Forms
- Pen(s) & Pencil(s)
- Markers
- Ruler
- Latex and/or nitril gloves
- Plastic bags (clear)
- Paper bags (variety of sizes)
- Metal cans (quart & gallon)
- Ignitable liquid residue packaging material
- Pill tins
- Cardboard boxes (variety of sizes)
- Evidence tape
- Evidence tags
- Tape recorder (optional)
- Grid lane pins & string
- Flashlight
- Paintbrush (fine)
- Probe

- Magnet
- Magnifying glass
- Metal detector (optional)
- Binoculars
- Tweezers
- Scissors
- Adhesive tape
- Knife or multi-purpose tool
- High temperature digital thermometer (optional)
- Hard hat
- Knee pads
- Coveralls
- Personal protective equipment
- Colored pin flags
    - The use of flags or markers is used to visually indicate the direction the fire spread. Both are acceptable methods. The following colors are used to indicate a specific direction or item.
    - Red……..advancing fire (head)
    - Yellow……..lateral fire (flank)
    - Blue……..backing fire (rear)
    - White……evidence

Appendix 3
Sample Case Report Format

Case Type: Human Caused Fire	**Investigative Period :** From date investigation began to date investigation completed
Case Status: Closed	**Report Type:** Origin & Cause
Fire Name : Sample Fire, OR-XXX-123	**Investigated By :** Sam Smith & Bill Jones

SYNOPSIS

Write a brief synopsis of the incident including the findings and conclusions. The synopsis must not be more than two or three paragraphs and never extend beyond the cover page.

INTRODUCTION

Set the scene . Who was the reporting party, how did they discover the fire, where were they when they discovered the fire, give date and time of dispatch, who was the first unit on scene, exact location, land status, what relevant suppression action was taken.

All investigative documents and reports that are referenced throughout the narrative must be cited as exhibits and attached to the origin and cause report, e.g. vicinity and location maps, RAWS weather data print outs, investigative checklists and notes, fire behavior software input and output data, lightning occurrence maps and data, dispatch logs, initial attack fire reports, law enforcement supplemental reports, forensic testing reports, crime lab reports, witness statements and interview reports, photographs and photo logs, fire scene and photo location diagrams and measurements table, etc.

DETAILS OF THE INVESTIGATION

Probable Weather Conditions at the Fire Origin

When and where were weather observations taken?

RAWS Weather station used for meteorological data.
Describe the proximity of the RAWS station to the point of origin.

List weather data:

- Temperature
- Relative Humidity
- Wind Speed
- Wind Direction
- 10 Hr. Fuel Moisture
- 100 Hr. Fuel Moisture

Compare RAWS weather data to weather observations taken at the scene.

Smith's Observations	2030 Hrs.
High Butte RAWS	2010 Hrs.
Temperature	50° F
Temperature	51° F
Relative Humidity	52 %
Relative Humidity	47%
Eye level Wind Speed	0 – 4
20 Ft. Wind Speed	0 - 6
Wind Direction	North
Wind Direction	North

Probable Fuel Conditions
Discuss how you determined what **fuel model** represented the area of origin.

Describe the **fuel conditions** used for fire behavior calculations and how you arrived at those values:

Fine Dead Fuel Moisture	8 % (per NWCG Fireline Handbook, Appendix B, Tables 2 & 4)
10 Hr. Fuel Moisture	9 % (High Butte RAWS 1710 Hrs Observations)
100 Hr. Fuel Moisture	10% (High Butte RAWS NFDR Observation Archive)
Live Herbaceous Moisture	50% (per NWCG Fireline Handbook, Appendix B, Table 6)

Probable Fire Behavior
Describe the conditions at the general origin area and how the probable fire behavior calculations were done.

List the fire behavior outputs:

Rate of Spread	5.1 chains/hour (maximum)
Heat per unit area	475 BTU/Ft.2
Fireline Intensity	45 BTU/ft/sec
Flame Length	2.6 feet
Area	0.6 Ac.
Probability of Ignition	40%

Discuss how the calculated fire behavior values compare with the actual fire behavior observed.

Describe the actual burning index and energy release component for the point of origin.

Origin & Cause Determination by Smith and Jones

Give the exact date and time of the arrival of the investigators and who was already on the scene.

Describe in detail how you conducted the investigation, including:

1. Witnesses interviewed or identified
2. Protection of the general origin
3. Weather observations
4. Describe any evidence found and protected
5. Perimeter of general origin walked and observations
6. Describe the macro indicators observed and marked
7. Describe how the initial run was identified and marked
8. Describe how the specific origin was identified
9. Describe any observations during the walk of the perimeter of the specific origin.
10. Describe the process of gridding the lanes in the specific origin and any evidence located.
11. Describe when and by whom photographs were taken
12. Describe when and by whom the sketch & measurements were made

Determination of Specific Fire Cause
List each of the cause categories and state how or why each category was included or excluded. Also, list any of the miscellaneous causes that are common and/or possible for the origin area.

Lightning:
Campfire:
Smoking:
Debris Burn:
Incendiary:
Equipment use:
Railroad:
Children:
Miscellaneous:
- Powerlines:
- Fireworks:
- Firearms:
- Cutting\Welding\Grinding:
- Spontaneous heating
- Reflective glass
- Etc.

OPINIONS & CONCLUSION

Describe in detail how the ignition source came into contact with the material first ignited, and who was responsible.

PERSONS INVOLVED

List the names, addresses, and contact information for all persons involved including agency personnel and witnesses

Name:	Smith, Sam	Work Telephone:	541.333.9712
Address:	Anytown Fire Department 4321 SW Simple Anytown, OR 97759		
Name:	Jones, Bill	Work Telephone:	541.383.5300
Address:	Your National Forest 1234 Hwy. 40 E Anytown,		
Name:	Jackson, Joe	Work Telephone:	541.333.9712
Address:	Anytown Fire Department 4321 SW Simple Anytown, OR 97759		

JUDICIAL ACTION
List any pending or planned judicial action; if none, state “none”.

ADMINISTRATIVE ACTION
List any pending or planned administrative action; if none, state “none”.

DISPOSITION OF CASE
State if the case is open, closed, cleared, pending, etc.; based on the controlling agency’s policy.

Appendix 4
Fire Assignment Information Sheet

Date _____Time_____

Caller _____Call Back #_____

Assignment _____

Order #_____ P Code_____

Incident Name _____ Inc # _____

Agency:_____ Unit_____

Size _____Fuels_____

Contact_____ Phone_____

Location_____
_____

Directions_____
_____
_____

Origin Date_____ Origin Time_____

Reporting Party_____
_____
_____

Special Equipment _____
_____

Other_____
_____
_____
_____