



Investigating the causes of wildfire

Background

The act of deliberately starting a wildfire is illegal and irresponsible, and is a criminal act known as arson. People who commit arson can face heavy fines and imprisonment.

As wildfires can have significant negative impacts on natural habitats, we tend to think of them as natural disasters. Whilst they can start naturally, see [Information note - Wildfire](#), it is estimated that 90% of all wildfires across the globe are caused by humans. About 30% of those are started as a deliberate act of arson, whilst 70% are started accidentally or as a direct result of human carelessness.

Wildfire has been officially recognised as a major UK hazard, with its inclusion in the National Risk Register of Civil Emergencies and has been identified as a key risk in the UK's Climate Change Risk Assessment. The likelihood of wildfires occurring may increase between 10% and 50% by the 2080's with projected warmer, drier spring and summer conditions.

To give you an indication of the impact and number of wildfires which occur in Wales, annual grassland fire data is available on the [Welsh Government's website](#). The [Met Office's Fire Severity Index](#) provides an assessment of how severe a fire could become if one were to start.

Ways in which wildfires can be started accidentally or carelessly

- Escaping embers, discarded ashes reigniting, or poorly located campfires can result in wildfires igniting.
- Burning rubbish and garden vegetation can result in out-of-control fires that escape the confines of the garden. If a bonfire is located too close to structures or trees, they can catch fire. Bonfires that are not completely extinguished may reignite so it's important that they are monitored and not left unattended.
- Land managers using controlled burns to reduce unwanted vegetation such as bracken, which crowds out other flora. Initially controlled fires can quickly get out of control and spread to other areas.
- Fire has long been used as an essential tool in the management of natural vegetation and can help to conserve and improve habitat for biodiversity, as in the case of black grouse which prefers heather moorland habitat. If left unmanaged, heather supports little wildlife, and its rank and woody branches are vulnerable to wildfires. Controlled burning of small patches of heather encourages the growth of new shoots which grouse feed on. However, even the best-laid plans sometimes go awry. Weather conditions can change quickly and unexpectedly, causing controlled fires to spread outside the planned perimeter.
- Agricultural activities like the spontaneous combustion of hay can lead to unintended wildfires. High-moisture haystacks and bales can catch fire because of chemical reactions that build heat. This occurs when bacteria in tightly packed and moist hay eats up the organic material producing heat as part of the process. Bacteria thrives when sufficient glucose (a simple sugar found in plants) is available. In the process of breaking it down into energy, aerobic bacteria catabolise the glucose, turning it into a usable form. Through the process of respiration, these bacteria completely oxidize the glucose transforming it into carbon dioxide, water, and energy. This energy is released as heat. Hay insulates, so the larger the haystack, the less cooling that occurs to offset the heat. When the hay's internal temperature rises above 55 degrees Celsius, the chemical reaction begins to produce flammable gas that can ignite if the temperature rises high enough.



- Faulty machinery can spark a wildfire. For example, heated exhaust pipes, catalytic converters and metal dragging along the ground can create sparks and one spark is all that's needed to start a wildfire.
- Electrical arcing can cause a wildfire when electricity jumps from one connection to another. Arcing can be caused by a faulty or broken cable. This flash of electricity can reach very high temperatures and has the potential to ignite a wildfire. A downed powerline can also arc, igniting nearby vegetation and other materials, particularly if it occurs in an area of elevated fire risk.
- Children playing with matches or lighters. Children sometimes associate fire with celebration and fun. For example, blowing out candles on their birthday cake, toasting marshmallows over a campfire, or watching a fireworks display. They are naturally curious about fire and find it exciting to watch a flame appear from a lighter or a match. Some children will play with fire out of sight of parents, such as in their bedroom or outside. In these places, bedding or vegetation can easily catch fire.
- Careless smokers who discard their cigarette butts can cause unintended fires. If not disposed of responsibly, discarded, smouldering, cigarettes can spark a wildfire.

What motivates someone to deliberately start a wildfire?

- **Vandalism** - Deliberately causing damage to someone else's property, a crime that has a major effect on people's quality of life and can cost millions of pounds to repair. Individuals vandalise for a variety of reasons:
 - to convey a message
 - to express frustration
 - to seek revenge
 - to make money
 - or as part of a game or a dare.
- **Crime concealment** - To conceal another crime such as a burglary, murder or fraud, some wildfires are lit deliberately to destroy the physical, incriminating evidence or the identity of the victim.
- **An act of extremism** - An individual or group who hold extreme views, usually religious or political, may set a wildfire to gain attention or force action for their cause.
- **To make a profit** - Wildfires set with profit as the motivation, are lit for a perceived monetary or material gain. The arsonist may be trying to escape financial obligations, increase a property's value or commit insurance fraud.
- **For the thrill of it** - Wildfires are sometimes lit by thrill-seeking arsonists because they are bored, for the excitement of seeing a fire burn, or for recognition or attention.
- **To seek revenge** - Some wildfires are lit as retaliation for a real or perceived injustice. Revenge fires are often directed at people because of a fight or disagreement. The vengeful fire setter may set fire to the victim's property, vehicle or possessions which could then get out of control leading to a wildfire.
- **A mental health issue such as pyromania** - Pyromania is a type of impulse control disorder that is characterised by being unable to resist intentionally starting fires. People with pyromania know that setting a fire is harmful but feel unable to stop the behaviour. Setting fires is the only way built up tension or anxiety can be relieved with immense feelings of satisfaction, pleasure, or relief after the fire has been set.



Factors that can influence wildfires

Fuel

Fire needs fuel to burn. Anything that burns can be fuel for a wildfire. All materials have a temperature threshold that once reached will make them burst into flames. This temperature is called a material's flash point. For example, the flash point of wood is 300 degrees Celsius.

The characteristics and quantity of the fuel affects the behaviour and pattern of a wildfire and will determine how the wildfire spreads. The characteristics of fuel that affect how a wildfire burns are:

- **Size** – smaller fuels, those with a diameter of up to 6mm such as grass, pine needles and heather, are known as 'fine fuels'. Small fuels dry out more quickly than larger fuels making them easier to ignite. Larger fuels, those with a diameter of more than 6mm, such as logs, branches, and tree trunks, are known as 'coarse' fuels. Coarse fuels take longer to dry out and will require an interaction with fires of finer fuels before they will ignite.
- **Shape** – the shape of fuel dictates its available surface area and how quickly it will dry out.
- **Surface area** – fuels with a higher surface area to volume, dry quicker making them quicker to ignite. For example, a small stick's total surface area is similar to its volume which means it will ignite quickly. However, a mature tree's surface area is much smaller than its volume, so it takes more time to heat up before it will ignite.
- **Arrangement** – if fuel items are closely together, they can ignite each other, causing the fuel to burn. If fuel items are densely packed together air cannot circulate easily, and the fuel will not burn as freely.
- **Moisture content** – live vegetation burns less readily as it has a high moisture content and will slow the burning process because heat will first need to eliminate the moisture. With a low moisture content, dry, dead vegetation is more likely to catch fire, burn more quickly and more intensely, making it more difficult to control a wildfire. As a wildfire grows, the heat and smoke dries out the available fuel material just beyond it, making it easier to combust.
- **Chemical makeup** – some types of vegetation contain oils or resins that help combustion, causing them to burn more easily, quickly, or intensely compared to those without.
- **Amount** – the quantity and proportion of available fine and coarse fuels and how they are arranged can influence the speed, extent, and intensity of a wildfire. The percentage of coarse and fine fuels alter the physical interaction between them which can affect wildfire behaviour. If there is a profusion of fine fuels, but less coarse fuels, the fire will burn intensely around the edge of the wildfire, leaving little burning once the fine fuels have been consumed. A more even mix of coarse and fine fuels will see more coarse fuel being ignited.

The amount of fuel material available for the wildfire to burn is known as the fuel load, which is usually measured in tonnes of available fuel per hectare of land. A high fuel load will result in a more intense fire that spreads faster. A low fuel load will result in a less intense burn that spreads slowly. The faster the wildfire heats up the material around it, the faster those materials ignite. How dry the fuel is will also affect how a fire burns and moves.



Weather

The weather dictates the land and air temperature, wind speed, wind direction and levels of atmospheric moisture which can affect, contribute to, or hinder how a wildfire progresses. Periods of hot, dry weather can increase the intensity, scale and frequency of destructive wildfires.

Hot temperatures heat up and dry potential fuel, aid ignition and result in faster burning times, with wildfire raging more in the afternoon when temperatures are at their hottest.

Dry and drought conditions provide favourable conditions for wildfires to ignite and increase their level of severity if a wildfire were to start. When humidity is low, it means there is less water vapour in the air, making it easier for wildfires to start and flourish. Wildfires are more severe during extended periods of hot dry weather, because due to the higher temperatures, more evaporation is occurring which dries vegetation, creating fuel for wildfires. However, higher levels of humidity and precipitation can reduce and slow down a wildfire. Damp fuel and fuels with a higher moisture content are more difficult to ignite as the moisture absorbs heat. Precipitation in the form of rain, sleet, hail and snow, can help to prevent wildfire. Rain and other precipitation raise the amount of moisture in the available fuel, which suppresses any potential wildfires from breaking out.

Wind

The wind often has the most significant impact on wildfire. The wind can:

- Supply a wildfire with more oxygen, causing it to grow swiftly and pushing it into often unpredictable patterns.
- Change the direction of the wildfire, blowing the fire across landscape into tree canopies and across the land at a faster rate.
- Blow strongly, resulting in a wildfire spreading faster and embers being blown for miles, igniting new spot fires.

Large wildfires can generate their own winds that can be up to 10 times faster than the ambient wind. Rapidly warming air, heated by the wildfire, moves upwards leaving behind empty space. Air from all around the fire rushes in to fill that gap. That movement of air creates powerful wind called an updraft. These winds can throw burning debris over considerable distances and create additional fires.

Topography

The structure of the landscape can have both a positive and negative effect on wildfire behaviour. Geographical features such as the presence of a valley, hillside, and water bodies will influence how a wildfire behaves. For example, a river is a natural firebreak. A key geographical factor is slopes - fire travels faster uphill than downhill. As wind usually flows uphill, it helps wildfire to move more quickly as the rising heat and smoke from the wildfire preheats the available fuel further uphill, allowing for quicker fuel combustion. The steeper the slope, the faster wildfire travels.

Consequences of wildfires

Tackling wildfires takes up vital resources, is very costly and endangers human health and lives. Wildfires, and the disruption they cause, have a large impact economically, socially and environmentally. For example:

Economically

- Businesses may have to close temporarily or worse, permanently, resulting in a loss of income.
- The cost of the business owner's insurance goes up.
- There is a cost to taxpayers who fund the emergency services.
- Possible cost to individuals and taxpayers for criminal proceedings.



- Loss of crops and timber leading to loss of income for land managers and those in the supply chain.
- Time and cost of clean-up operations to a wide range of individuals and organisations. For example, emergency services, local councils, landowners and managers, property owners, community members and organisations, charities, and utility providers.
- Time and cost of replanting and reinstating natural areas for landowners and managers, conservation groups, community members and recreation providers.
- Tourism affected in a range of ways. Access for holiday makers may be disrupted or tourists may feel unsafe, leading to cancelled accommodation, travel, and recreation activities. Recreation providers, tourist travel companies and businesses that rely on tourism could lose income. Tourists could also lose money if any related services are closed because of wildfire.
- Transportation networks destroyed, delayed, or disrupted. This could result in lost time and income for individuals and businesses that rely on transporting goods and staff commuting to work. A financial cost would be incurred by local councils and transport services, to repair and reinstate any infrastructure affected by a wildfire.
- Extra financial pressure on the NHS as they must deal with those affected physically or mentally by a wildfire.

Socially

- Residents might have to evacuate their homes and leave pets behind.
- Loss of recreation sites such as playing fields, school grounds, local parks and green spaces, local woodlands, and nature reserves.
- Individuals and the community feel unsafe.
- Possible loss of personal and sentimental property.
- Stress issues caused by dealing with the aftermath of a wildfire.
- Human health can be impacted. For instance, issues related to the effects of smoke from wildfires. These include eye and respiratory tract irritation, reduced lung function, bronchitis, aggravation of asthma, heart failure, and premature death.

Environmentally

- Following a wildfire, water quality may be affected as ash, sediment, nutrients, and contaminants are washed into streams, rivers, and downstream reservoirs, polluting water-based habitats, and water sources.
- The heat from a wildfire can affect soil structure, reducing soil's ability to retain and store moisture which can lead to a reduction in soil quality, making it less suitable to grow plants and crops. There may also be an impact on the biodiversity that depends on the affected soil for survival.
- Loss of habitat for wildlife as wildfire destroys the main three things needed for survival: food, water, and shelter.
- Wildfire burns away the vegetation and other organic material that holds soil in place. This leaves the affected area at greater risk of flooding, landslides, and soil erosion.



Investigating wildfires

Looking for clues

To the untrained eye, the scene where a wildfire has raged can look like a scorched, bleak, landscape. Finding out how the wildfire started will surely be impossible? Not to the trained eye of a wildfire forensic investigator. Although wildfires destroy the landscapes they burn across, they also leave behind clues as to where, and how, they started. These clues may be incredibly small but trained, forensic, wildfire investigators can detect them. Once a wildfire has been contained or extinguished, their work of finding out the cause of the wildfire begins.

Working the scene

Usually, a wildfire investigator will start his investigation by putting up hazard tape to conserve any remaining evidence, interviewing witnesses and taking photographs.

The wildfire investigator has the difficult job of tracking the path taken by the wildfire, working out where the wildfire started, how it gathered strength and the extent of the spread.

To find the origin of a wildfire, the wildfire investigator begins at the most heavily burnt area, where the wildfire was at its hottest. Then, the investigator works backwards to find the ignition site.

The ignition site, where the fire begins, is usually a small area, just a few metres wide. This contains the ignition point and is the best place to find any intact evidence. The ignition area may include signs of smouldering or flaming material. Any physical remains of the ignition source will most likely be located within this area, if it has not been removed, completely burnt, or destroyed by someone trying to remove evidence. Items such as matches, matchboxes, cigarettes, and so on, which may have been responsible for igniting a deliberately set wildfire, may be found at or near the ignition site.

Wildfires usually burn outwards from the point of ignition in a V-or U-shaped pattern with the wildfire moving forward in the direction of the prevailing wind. Locating the site of the initial ignition would seem to be a simple matter of moving to the lowest point of the "V" or "U". However, wildfires sometimes have multiple points of ignition, especially if they have been deliberately set.

Wildfire investigators know that whilst wildfires appear to be chaotic, like any planned, supervised fire, they obey the laws of nature and burn in patterns, often very complex ones. There are a range of factors that contribute to the pattern or behaviour of a wildfire. These determine if a wildfire will turn into a raging blaze or will simply fizzle out. The main three factors are fuel, weather, and topography.

What do the charred remains reveal?

Investigators must examine multiple, subtle clues to guide them to the ignition site such as:

- Surfaces facing into the oncoming flames being more heavily charred and coated with soot, while the sheltered sides of fire touched objects often survive undamaged. This tells them the direction the fire came from.
- Leaves on plants can remain in place like small flags, curling towards the heat of the fire. This tells them the direction the fire came from.
- Where a fire 'backs' - a low, weaker burn moving away from the direction of the main wildfire, the fire eats away at the base of plant stalks, leading them to fall over and lie unburnt on the charred ground, pointing towards the site of origin.

Needle in a haystack

Once the origin site of a wildfire has been found, the investigator will minutely investigate the surrounding area, sifting through the scorched earth with microscopes, to look for evidence. They will use close up photography to record any recovered objects, from small twigs to man-made debris which might shine a light on how the wildfire started, whether it was set deliberately, and if so, by who.



'Who dunnit?'

Preventing, managing, and extinguishing wildfire is incredibly costly, often with long lasting effects on individuals, communities, and the environment. It's important to work out if a wildfire was caused by natural or manmade means to try to prevent it recurring.

For those searching for evidence in the sooty remains of wildfires, there are often clues that can lead to the cause of the inferno. If the investigation discovers that the fire was started naturally then no further action may be required. If the investigation discovers that the wildfire broke out because of human carelessness or was started deliberately by an individual or group, the perpetrator(s) must be identified and held to account for his/her/their actions.

Our [Activity plan - Catch a wildfire setter](#) looks at what happens next.

Learning in, learning about, and learning for the natural environment.

Looking for more learning resources, information and data?

Please contact: education@naturalresourceswales.gov.uk or go to <https://naturalresources.wales/learning>

Alternative format; large print or another language, please contact: enquiries@naturalresourceswales.gov.uk 0300 065 3000

