Forestry Commission

Wildfire investigation project report

April 2023

(Fire on Rushmore Heath, Ipswich in 2022. CREDIT: Sky Cam East/PA

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Executive summary

Wildfire[1] occurrences in the UK have been on the rise since the turn of the 21st century. In the last decade we have seen an increasing number of large wildfires which have caused widespread damage in either our woodlands and forests or in the rural urban interface. According to the Government's Climate Change Risk Assessment 3 (CCRA3), wildfire occurrences are going to continue to rise across the UK, and this is of particular concern to the Forestry Commission, as a landowner regulator, facilitator, and enabler [1].

The damage caused by a wildfire can be immeasurable. Wildfires can cause death or serious injury. Not only as a consequence of being a direct victim of the fire, but it has also been found that prolonged and regular exposure to particulate matter 2.5 (found in wildfire smoke) can cause cancers and ill health as declared by the World Health Organisation [2]. *"Infants, young children, women who are pregnant, and older adults are more susceptible to health impacts from smoke and ash, which are important air pollutants. Smoke and ash from wildfires can greatly impact those with pre-existing respiratory diseases or heart diseases. Firefighters and emergency response workers are also greatly impacted by injuries, burns and smoke inhalation."* Infrastructure, buildings, and machinery can also be damaged or destroyed by wildfires, wildlife, water quality and nature are threatened, carbon is released into the atmosphere which has a negative impact on climate change, and costs to local economy incurred, are all potential impacts of wildfires. Importantly, the ability of emergency responders to deal with other life-threatening emergencies is also compromised while attending a wildfire.

Wildfire mitigation is a complex issue and requires consideration in several areas. Key to mitigation is understanding the cause behind every wildfire. Analysis of global wildfire data as observed in the article, A Review of the Main Driving Factors of Forest Fire Ignition Over Europe, indicates that 97% of all wildfires are related to some form of human action (deliberate and accidental) [3]. Understanding the cause of wildfires is considered by many to be key in ensuring prescribed

[1] A wildfire, forest fire, bushfire, wildland fire or rural fire is **an unplanned, uncontrolled, and unpredictable fire in an area of combustible vegetation that often requires intervention to extinguish**.

prevention campaigns are effective. Countries such as Australia, the U.S.A. and Canada have been experiencing regular and widespread wildfires for the best part of a century. They have been using qualified wildfire investigators and subject matter experts for several decades, which has provided answers to the question of where wildfires ignite and their cause. These findings have provided valuable data to address deliberate and accidental ignitions. They have also led to recovery of damage and suppression costs through civil litigation. Critically, they have ensured accurate targeted social behaviour prevention campaigns.

The evidence for the forecasted rise in wildfires is compelling and recent exposure to more extreme wildfire events provides an indication of the changing risk of wildfire in the UK. With this in mind, communities need to be better informed of the need to learn to live with wildfires, understand their impacts and what they can do to help live with the issue. To mitigate the impact, they have on society and our landscape, we need to understand them to inform our prevention programs. Understanding wildfire causation through fire investigation is one way to do this. The greater understanding, we have of what is behind the cause of all wildfires in the UK, the more we can do to prevent the ignitions that start them.

This project examined what England can learn from international experts, how improved fire investigation knowledge can offer a solution to the increasing problem of wildfire, and what options are possible. The project had support from the Forestry Commission (FC), the National Fire Chiefs Council (NFCC), the Department for Environment, Food and Rural Affairs (DEFRA), Natural England, and other impacted stakeholders, who have been keen to work together to better understand the problem.

This report recommends that improving data gathering, undertaking further research, and developing a wildfire investigation capability is vital to progress our understanding of this area of prevention. Currently, there is very limited understanding of how to determine the cause of a wildfire within fire, police, and other agencies across the UK. Upskilling of key agency personnel is essential to address this need. It is the recommendation of this report that the FC engages with subject matter experts, international wildfire investigators, and the NFCC to provide advice and deliver training packages. The initial focus is on developing a UK based '*FI-110 Wildland Fire Observations and Origin Scene Protection for First Responders Course*' and a *'FI-210 Wildfire Investigators course'* which will improve the quality of data we collect following a wildfire and

improve our knowledge through learning and collaboration across the sector. Focus should also be given to further research of the human dimension of wildfire causes through the analysis of data collected from wildfire incidents.

Acknowledgements

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Introduction

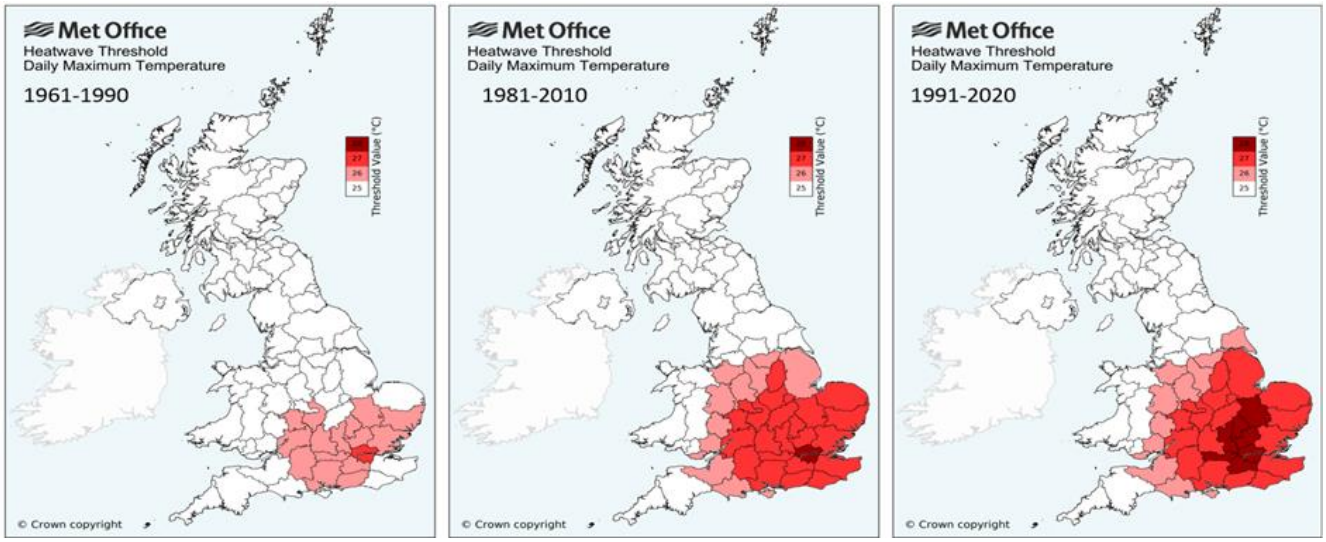
A proactive approach to better understand the causes of wildfires in the UK is recommended by the Forestry Commission (FC). Forestry in the UK is generally in private ownership (80%) and the FC has a role in supporting the protection and management of our forests on both Crown estate and private land. The FC recognises that wildfires are indiscriminate when it comes to land ownership and can start in all manner of rural spaces protected or owned by a variety of stakeholders. These fires will either start and spread from forested land into other areas, or conversely spread into forestry, therefore a landscape scale approach is required. The FC recognises that it is important to understand the causes of wildfires and to work with and share knowledge across all stakeholders to better understand the problem as it pertains to forest fires. This report has been produced as part of the short-term secondment of *Rhodri Jones into the Forestry Commission from Greater Manchester Fire and Rescue Service. This was a recommendation of **Rob Gazzard and funded by the FC as a step towards better understanding the UK wildfire causation problem which could act as a golden thread towards wildfire preparedness, prevention, response, and recovery within a national strategy, and to promote joint working across the sectors impacted by wildfires.

This report describes the UK wildfire problem and the important role of a variety of stakeholders in the prevention of large-scale wildfires. It briefly summarises some of the likely and unlikely causes of wildfires and examines data collected from the Fire and Rescue Service (FRS) Incident Recording System (IRS), a public perception of wildfires survey, and from fire investigators from

England and Wales. It provides an insight into the knowledge of international wildfire investigators and how investigations have supported prevention campaigns in Australia and the USA, and from stakeholders who see the benefits of understanding our wildfire problem through fire investigation. The report then provides recommendations to address the issues raised, including how to enhance wildfire investigation knowledge here in the UK.

What is the current situation?

Over the last 12 years, we have seen the annual UK wildfire season start earlier and finish later over what has been experienced in the past. Evidence from the Climate Change Risk Assessment 3, and its supporting research documents, highlights an increase in summer wildfire danger across England as well as an increase by three to four times the number of danger days by the 2080s [1]. The current number of danger days is approximately 30-40.



(Increase in heatwave threshold. SOURCE: Met Office)

In the report 'Developing a Risk Assessment Approach for Forest Fire at the Rural-Urban Interface: Potential of the Wildfire Threat Analysis Framework', it was observed that the financial, environmental, and societal cost wildfires in England is already high. Fire suppression costs for one large moorland fire in the Peak District was £1m. Annual costs to UK fire services are estimated at up to £55 million per annum and are set to increase [4]. According to a 'Wildfire risk to carbon stores (Peatland) report' in the future, the impact of wildfire incidents on peat could exceed £1Bn per annum [5].

The impact of a wildfire in the Rural Urban Interface (RUI) can cause significant disruption to property and infrastructure, damage the natural environment, threaten lives, and devastate and disrupt local communities. They can also challenge UK Fire and Rescue Service's (UKFRS) resilience, as highlighted by the declaration of 14 major incidents on the 19 July 2022, on a day of an extreme fire danger rating, like that experienced in more prone countries such as Spain and Southern France. In particular here in the UK, the Wennington fire in London destroyed 19 houses in an afternoon which saw an unprecedented impact of wildfire on our communities [6]. Wildfires can have a significant impact, through damage caused to Natural Capital Assets (NCA), which are critical to mitigating and adapting to climate change and biodiversity loss. Given the increasing risk, the FC and DEFRA are keen to better understand the cause of wildfire to address this growing problem more effectively.

(Aftermath of the Wennington fire in July 2022, CREDIT: SWNS)

The FRS have a duty under the Fire and Rescue Service Act 2004, to provide; *'accurate information, prevention materials to encourage the community to take responsibility to prevent fires and death or injury by fire'* [7]. Seasonally, FRSs provide wildfire prevention advice to the public. In some cases, this information is not based on accurate data around the causes of wildfires. One of the primary sources of this data is from the IRS which captures rudimentary data as to the causes of a wildfire following a basic fire investigation. In nearly all cases in the UK, a wildfire investigation is undertaken

by a Tier 1 investigator[2] and a probable cause is recorded, with very little scrutiny applied to the Tier 1 investigators determination. Because it is a probable cause, the margin of certainty need only be 51%, and therefore the data should only be seen as quantitative rather than qualitative. The data does provide an indication as to potential human factors that contribute to wildfire causation, however it is non-specific and does not provide quality root cause analysis of the problem.

The Policing and Crime Act 2017 states that where it is in the interests of their efficiency or effectiveness, stakeholders should collaborate [8]. Therefore, the issue of wildfires caused deliberately is a matter for both police forces, fire services and land managers, who should work together to mitigate the problem when criminality with high consequences is suspected. Furthermore, the police have a duty to investigate unexpected deaths in the community on behalf of his Majesty's Coroner. With regards to fire related deaths, the FRS are often commissioned by the police to undertake the origin and cause investigation and provide a report. Therefore, they need the skills and relevant knowledge to collect and analyse data to make a determination as to the cause of the fire with a reasonable margin of certainty. The Forensic Science Regulators (FSR) statutory Code of conduct also specifies the need to demonstrate competence when undertaking a forensic activity such as fire investigation within the Criminal Justice System (CJS) [9]. Given there is absence of wildfire investigation knowledge in the UK, forensic fire scene investigators are most probably working beyond the limits of their competency for any wildfire investigations that require a reportable outcome for the CJS or His Majesty's Coroner. This will need to be taken into consideration for FRS's committed to achieving ISO/IEC 17020:2012 accreditation as per the FSRs statutory code of conduct.

In the 2022 wildfire season it was reported that six members of the public and 28 firefighters sustained injuries due to a wildfire. To date there have been no recorded fire deaths that are directly linked to a wildfire in the UK, however this could very likely change as the incidents of wildfires continues to grow each year.

[2]Tier 1 Is a basic fire and arson investigation, where the cause is/can be easily established by Fire Officers/Pump Commanders initially attending the incident.

The Heather and Grass etc. Burning (England) Regulations 2007 allows for the burning of specific vegetation on rural land for the purposes of land management between the 1st of October, and the 15th of April in upper moorlands, and between the 1st of November to the 31st of March in other areas [10]. However, there is currently no legislation that requires a landowner to report a fire on their land. It has also been observed anecdotally that landowners will burn outside of these of the dates, especially if the weather has adversely affected their ability to burn during the permitted time for land management purposes.

The Regulatory Reform (Fire Safety) Order 2005 does not place any legal expectation pertaining to land and fire safety, therefore there is very little regulation on how land should be managed in a wildfire context, that could then be enforced by the FRS or another authority [11]. Subject matter experts in the fire safety sector have discussed whether amendments should be made to Approved Document B with regards to the management of land near to regulated or domestic premises, to reduce the risk of harm to the occupants from a potential wildfire [12]. These discussions are ongoing and only informal at this time.

Whilst undertaking research for this report, there was very little information available regarding civil litigation and cost recovery from a party found to be responsible for the ignition of a wildfire which had a significant financial impact. Further research is required to establish what civil litigation action has been taken, whether landowners insure or are self-insured and who, if anyone, has undertaken a third-party investigation as part of a civil litigation claim, and what is the cost to the insurance sector. However, in the UK Climate Risk Independent Assessment (CCRA3) report it was observed that [13].

"One major insurance firm (NFU Mutual) has reported that farm fire costs during the dry Summer 2018 for the UK were nearly £32m, an increase of 137% on 2017 with the overall costs of claims for farm fires over the harvest period up by 21% at £5.5m (Ecosulis and Farmlytics, 2019). Anecdotal reports from 2020 have suggested that harvesting during heatwave conditions has incurred a significantly elevated risk on stony ground due to generation of sparks, although quantitative data showing the relationship to actual wildfire events is yet to be produced. Further work is therefore required to show if there is a longer-term trend towards increasing wildfire events on agricultural land."

Our current and future forests and woodlands are also important assets for the Woodland Carbon Code (WCC) validated projects. WCC projects are specifically developed to sequester carbon through the planting and maintenance of woodland, that carbon which is sold into the marketplace to allow for companies to offset their residual carbon footprint. A typical hectare of broadleaved or coniferous woodland will sequester in excess of approximately 450 tonnes of Carbon-dioxide Equivalent (tCO_2e) over a 100-year period. Through the Woodland Carbon Guarantee (WCaG) the current cost that government pay for sequestered tCO_2e under has been approximately £22.50 per tonne. The private market for carbon seems to be offers a range of prices anywhere from £20 to £45 tCO_2e sequestered. It is expected the price for a tCO_2e will rise to over £150 in the years up to 2050. There is already insurance available for WCC validated projects and it is understood that the market for this insurance type will expand as the number of projects registered increases. The risk of wildfire will need to be considered when calculating insurance premiums. It is foreseeable that insurance companies might want to investigate any losses of carbon stored due to a wildfire in the future.

Given wildfire investigation is a specialist skill which is currently carried out by personnel in the UK with limited or no wildfire investigation training and knowledge, the accuracy of investigation findings is open to scrutiny. This would be especially true for the criminal, coronial and civil courts who may hear those findings. Often wildfire cause determinations are based on pre-conceived ideas and the effects of cognitive bias as to what causes a wildfire. This in part is due to a lack of training and knowledge, and many of these "ideas" are not supported by evidence. For example, cigarettes are often cited as a main cause of wildfires, in the absence of linked evidence and in contradiction to research around cigarette ignition potential in wildfires. Yet in the UK prevention campaigns are often centred around "*don't drop your cigarette, they cause wildfires".* Messages such as this aren't without merit in mitigating wildfires through prevention campaigns or more importantly as a way of reducing littering, but they are at risk of misdirecting attention away from the true causes of wildfires. This is just an example of why wildfire investigation and a better understanding of the causes is needed to help focus attention and messaging towards the actual causes of wildfires in the UK.

What are the causes of wildfires?

The causation of wildfires can be broadly categorised into two areas: the physical causes of wildfires and the motivating factors behind those causes. A fire investigator's primary role is to determine the origin and cause of a fire. This can be done through understanding the causes of wildfires: as in what are the circumstances that occur to have a competent ignition source come into contact with vegetation fuels for a successful ignition?

The important thing to note with a wildfire, unlike a building or vehicle fire, is that when we consider the fuels ignited, we are talking about various vegetation types, arrangement, fuel loads and condition. These types of fires are classified by many in the wildfire sector as vegetation fires. Therefore, the fuels involved are living and dead vegetation, unlike manmade synthetic materials found in buildings. This means their propensity to ignite from various sources may differ to materials found inside buildings. Importantly, the conditions wildfires ignite, and spread are subject to a very different environment (in particular weather, fuel, and topography) from that of an enclosed structure.

The chemistry of such vegetative material is mainly hydrogen, carbon, and oxygen, which, when heated provide efficient fuel to propagate and sustain a fire. However, as they are living materials exposed to the elements, they are more likely to absorb water, so unlike synthetic materials their environment can have more of an impact on their ability to thermally decompose and ignite. For example, it is commonly accepted that the risk of wildfire fuel ignition will increase during dry spells or extreme weather conditions (hot and cold). The composition and arrangement of wildfire fuels also influences the likelihood of ignition. The density and size of the fuel will determine its heat output and ability to create and sustain a flame, which would then continue to spread until it runs out of fuel or is extinguished. Therefore, depending on the composition of the fuel and the type of ignition source the likelihood of a fire increases and decreases, and it is important that the fire investigator understands this.

NFPA 921 Guide for Fire and Explosion Investigations (NFPA 921) [14] which is an internationally recognised manual for fire investigators identifies several potential ignition sources. However,

given this is a US-based manual it must be taken to account that the causes discussed will be relative to weather and vegetation factors of the USA, which differ to UK conditions.
Causes cited in NFPA 921 include campfires, cigarettes, incendiary devices, spontaneous heating, electricity, and sunlight, to name a few.

As an example of addressing the current challenges faced by fire investigation, we should consider the myth of the cigarettes causing a large number of wildfires. Research undertaken by wildfire scientists has determined that the cigarette as a cause is extremely unlikely and has been debunked by most eminent wildfire investigators as a main cause. NFPA 921 does state *'smouldering smoking materials require receptive fuel for ignition. Fuel factors such as type, size, moisture content, temperature and arrangement affect the potential for ignition.'* So, consideration of a cigarette as the most probable cause cannot be made by the presence of cigarette remains alone and requires a detailed scene examination and thorough analysis.

Establishing environmental factors and the location in relation to the fire's point of origin is key to considering cigarettes as a cause. Scientific research has observed that relative humidity (RH) must be below 22%, and temperatures must be above 30 degrees Celsius, with the presence of wind, a susceptible fuel, and the embedding of the coal end in the first fuel, for any opportunity for a cigarette ignition. RH in the UK rarely, if ever, drops below 22%. This is not to say that cigarettes are not a potential cause of wildfires in the UK, the number reported however is very likely overrepresented.

Sunlight refraction and reflection via bottles or broken glass, is also considered to be an extremely unlikely cause of wildfires. NFPA921 also states *'Fires started by these items are very rare occurrences.'*

Evidence and research support that the cigarette and sunlight are highly improbable causes of wildfires, yet in the UK prevention campaigns are often centred on them as the main causes. Therefore, this suggests that present prevention campaigns are at risk of being misfocussed due to an absence of considered investigation into the causes of wildfires.

The disposable or instant barbecue is often cited by UKFRSs' and the media, as one of the main cause of wildfires. Whilst it is possible that they can cause fires through the ignition of susceptible

fuels, the methodology and likelihood of this occurring requires further research before we can draw a reasonable conclusion as to how often and likely they are to cause wildfires. These devices will only produce a naked flame for a short amount of time when first lit by a person. Once the flame is no longer present, the method of ignition for the first fuel (vegetation) will be through conduction[3] and very low-level radiation[4]. Disposable barbecues constitute a metal tray that house pre-treated charcoal, a taper, and a grid for cooking. The metal tray will heat up, but its radiated heat output will be minimal. The barbecue coals will become super-heated and remain hot until depleted. Based on rudimentary proof of concept tests undertaken by Rhodri Jones, to achieve successful ignition they must be used with recklessness and negligence, and on vegetation with a low moisture content. However, used safely following manufacturing guidelines in areas not susceptible to wildfires they are most probably safer ways to cook than open fires or makeshift barbecues where lighter fluid is sometimes used as an ignition source.

DEFRA are soon to publish a *'Sky lanterns, single-use barbecues and helium balloons risks and mitigations report'.* The report observes that causation data regarding single-use barbecue fires, should be approached with a degree of caution. It recognises that at present there is a lack of consistency in identifying and recording the ignition source of wildfires. There is also the issue of contextual bias and the anchoring effect; the discovery of a burnt-our barbecue within a burn area is not evidence of the source of the ignition, without first establishing the point of origin of the fire. DEFRA also acknowledge the UK does not routinely investigate the cause of wildfire ignitions and lacks capacity of fire investigators sufficiently qualified in this specialist skill. The report is due to be published in the forthcoming months.

Currently there is a disposable barbecue bill passing through Parliament which is looking to either outright ban the devices or prohibit their use in specific areas [15]. From the review of evidence so far, concerns have been raised that there is very little data to support that they are the main cause of wildfires, and that outright banning them could lead to unintended consequences such as

[3] Conduction - heat travelling through connected objects.

[4] Radiation – heat transfer from a body of high temperature to a body with a lower temperature when bodies are not in direct contact or when they are separated in space.

alternative forms of outdoor cooking. There is also the potential for job losses on the part of those involved in manufacture, distribution, and sale of the disposable barbecues, with no discernible reduction of wildfire occurrences. The complete banning of the device also creates an equality issue for those who cannot afford to buy re-usable barbecues but wish to enjoy the "Great British BBQ" at home in their yards or gardens. Further understanding the issue and likelihood of the disposable barbecue fire is a relevant one though, as it will help to inform the best application of Public Space Protection Orders (PSPO)[5], prohibiting their use in areas susceptible to wildfire ignition and therefore reducing the risk. Wildfire researchers at the University of Exeter are currently considering undertaking research as to potential for disposable barbecues to ignite vegetation fires.

The motivating factors behind the ignitions are also important to understand from a wildfire prevention perspective. ***Dr Peter Moore has spent years researching and understanding why human behaviour contributes to 90% of all wildfire ignitions. He has observed that *"fire and wildfire problem is not well understood"*. People are the cause of the majority of fires globally. In the FAO Global Fire Assessment 2006, several regions estimated the proportion of fires that were human caused and for the Mediterranean it was 95% of fires [16]. The human behaviours associated with wildfire ignition are a combination of poor practice, limited access to alternative approaches to fire, accidents, weak understanding of fire risk, machinery, arson, negligence, and carelessness. However, although wildfires are most often initiated by human actions, their intensity and their effects are mainly driven by fuel condition and availability, vegetation structure and meteorological and topographic conditions.

It has been suggested by wildfire causation experts and researchers that anti-social behaviour is one of the main motivating factors behind wildfire ignition in the UK. Whilst this observation is generally presumptive based on the anecdotal experiences of UKFRSs. Data gathered from the UKFRS IRS (which is discussed later in this report) observes that approximately 40% of all wildfires are as a result of a deliberate act, with the 17% that are unknown potentially adding to that figure.

[5] Public Spaces Protection Orders (PSPO) are **intended to deal with persistent anti-social behaviour in a local area that is detrimental to the community's quality of life**.

This is somewhat backed up in the Forest Research report Wildfires in Wales [17]. In which it was observed that, *"The South Wales Fire and Rescue Service (SWFRS) suggest that 95% are the result of deliberate actions. This quantity of fires equates to 17 wildfires per km2 over the nine years 2000-2008 in South Wales, compared with 2 wildfires per km2 in the UK as a whole. South Wales has, on average, 8% of all grass, heath, and forestry fires in the UK."*

Following a literature review and through conducting interviews of youths, the report also observed that the motivations for arson include factors such as, relieving boredom, land clearing, socio-economic factors or as an act of rebellion. Whilst this report specifically relates to the Wales wildfire problem, it is highly likely that an anti-social behaviour wildfire problem exists in other areas of the UK with a similar geography and socio-economic background. Anti-social behaviour as it pertains to wildfire is clearly something that requires mitigation, understanding of the motivating factors behind deliberate fire setting, and targeting those areas that are at greatest risk of anti-social behaviour is one way to do this.

Wildfire as an act of Terrorism[6] or Pyro-Terrorism[7] is also a possible motivating factor, whilst this would be unlikely in the UK, it has been considered by Robert A Braid of the U.S government in the article Pyro-Terrorism -- The Threat of Arson Induced Forest Fires as a Future Terrorist Weapon of Mass Destruction. In which he postulates *'a future terrorist could easily ignite multiple massive wildfires that would severely damage our regional economies, impact our military forces, and terrorize the American population. An opportunistic terrorist could create a conflagration potentially equal to a multi-megaton nuclear weapon.'* [18]

Ed Nordskog in his textbook Arson investigations in the wildlands, also makes the following observation *'The one criminal in the world who possess the power of a nuclear weapon at his fingertips is the wildland arsonist.'* [19]

[6] The unlawful use of violence and intimidation, especially against civilians, in the pursuit of political aims.

[7] Pyro-terrorism is defined as **the use of incendiary attacks to intimidate or coerce a government or civilian population**.

(Cwmcarn Forest Drive fire, CREDIT: Wales online)

How can wildfire investigations help address this increasing risk to communities?

Understanding the causes of wildfires through cause analysis is considered by many wildfire sector experts as a key measure to dealing with the problem. Root Cause Analysis (RCA) is defined as *"the process of discovering the root causes of problems in order to identify appropriate solutions. RCA assumes that it is much more effective to systematically prevent and solve underlying issues rather than just treating ad hoc symptoms and putting out fires."* As discussed earlier, prescribed prevention campaigns are sometimes focussed on wildfire causation that is extremely improbable and therefore unlikely to prevent wildfires from occurring.

In the book Feeling the Heat - International Perspectives on the Prevention of Wildfire which considers the problem of human related wildfire causation; taking an interdisciplinary approach to comprehensively understand the topic, two quotes stand out [20]. *"It is next to impossible to design specific fire prevention campaigns if one cannot identify the causes in a systematic way."* And *"Until our ability to determine the causes of forest fires improves our efforts at prevention will essentially remain a shot in the dark."*

Richard Woods**** provided an insight into his experience as a leading wildfire investigator for this report. Richard has been investigating wildfires since 1994 in Australia, he states he has seen a significant change in unplanned wildfire ignitions through his Australian and international engagements. The reduction in the number of wildfires across many jurisdictions through the accurate examination of wildfire scenes has resulted from the accurate determination of wildfire cause. Accurately identifying the cause of wildfires is also seen as providing significant benefits to fire agencies in focused education campaigns centred on the accurate cause determination, leading to the successful prosecution of deliberate firelighters, resulting in a significant deterrent effect across communities and the recovery of damages costs through negligent acts causing property loss. In his experience, this situation currently faced in the UK is not dissimilar to that he experienced early in his wildfire investigation career in Australia. Without the skills to accurately identify wildfire cause and more importantly those responsible, there was no deterrent to those who wish to deliberately light fires or for others to prevent fires being started through negligence. Consequently, fire agencies geared up for suppression as the main priority in the hope that law enforcement could address the investigation of cause. However, they too were unskilled in addressing wildfire causation - essentially allowing ignition prevention to go unaddressed from a strategic point of view. Importantly Richard highlighted the need for wildfire investigators to come from various agencies and organisations, such as forestry, fire, and national parks, to bring a wide range of experience and professional skills, to bare upon incidents. Drawing upon the resources across several agencies was therefore both desirable but also practically necessary, especially when engaging with communities, land use types and other relevant factors. Involvement of land management agency personnel is also of value as they are often familiar with their estates, the areas where activities tend to occur such as public access areas frequented, familiarity with common users, political issues around the management of their estates and appreciation of high-risk areas for wildfire. They are also valuable in supporting investigations off their estate when fire/law enforcement investigators are not available.

Adopting a formal wildfire investigation capability has changed community attitudes and resulted in a reduction in the number of ignitions and specifically increased the number of successful prosecutions of arsonists. Importantly, it has resulted in an increase in the safety to the community and specifically to firefighters reducing their exposure to unplanned wildfire events. It has also reduced the costs to the emergency services in lessening the number of events attended. The trained cadre of police (Scenes of Crime Officers), detectives, arson squad officers, fire service

investigators and land management agency investigators, provide a depth of resource to investigate fires, across all areas, not just within their 'home' jurisdiction. Models in Australia and North America have these teams working across State and County lines if needed, particularly when local resources are committed to managing the emergency response to incidents.

As adopted in Australia, Canada and the United States, the three-tiered training programs (FI-110, FI-210 and FI-310) have provided the skills necessary to comprehensively address the need to reduce the number of wildfire ignitions by upskilling the firefighter through to the investigator, allowing for the confident determination of the cause of wildfires across these countries [21].

Bruce Balderston***** suggests that wildfire risk can be significantly reduced in communities when professional fire investigation is linked to fire suppression and fire prevention program. By accurately determining a fire's origin and cause, fire agencies are provided with two essential tools. Where fires occur (origin) provides fire managers with information essential for the correct allocation of equipment and personnel to effectively respond to future fires. Accurate determination of cause is necessary to proceed with criminal or civil actions in cases of arson, negligent burning, or cost recovery fires. The most effective use of cause determination is the application of cumulative statistics to develop effective fire prevention plans to reduce the incidence of wildfires.

As the Fire Prevention Officer/Investigator for Alaska Forestry he determined that a significant number of fires were the result of people engaging in the burning of organic debris. The vast majority of these people were land clearing or removing debris from their properties to mitigate the threat of wildfire. The coinciding fire investigation reports indicated that these escaped fires were directly related to the landowners' inexperience with outdoor slash burning. Reasonably, if the need to burn was reduced so too would this cause of wildfire be reduced.

Dr Peter Moore suggests that governments and institutions tend to react to high-profile damaging wildfires instead of putting in place sustainable integrated fire management that enables and empower them to reduce risk, be prepared, act quickly and safely and recover. In nearly all countries there is inadequate accurate data, information, and knowledge about fires; where they start, who starts them and why they start them. This leads then to a very weak understanding and in most cases efforts and investment are mis-directed rather than into activities.

Dan Quin, Chief Fire Officer of Surrey Fire and Rescue Service, provided the following comment: *"Surrey Fire and Rescue Service works closely with partners in the land management sector to help understand how land is managed and demonstrate how land management can be effective in reducing the impact of wildfires. With the projected impact of climate change posing a greater threat in the future, it is important this work continues."*

"Moving forward it is the intention for the Surrey Fire and Rescue Service fire investigation team to begin investigating wildfires, gathering information following significant incidents to understand the cause more accurately. The result of this will be a better focus of prevention resources for the fire service as well as our land management partners."

From a FC perspective, understanding the causes of forest fires and the application of investigations will be key to mitigating the problem. The FC is responsible for a wide range of habitats, from forestry to open habitats, with significant benefits to social, economic, and environmental assets, valued at approximately £61.5bn in terms of Natural Capital [22]. They also attract one of the largest amounts of the public, with an estimated annual footfall of 363 million visits [23]. Given we know from research that 90+% of wildfires are caused by humans and that our forests attract people, it is important that the forestry community understands what causes wildfires in forests. Understanding wildfire causation will assist the FC and other stakeholders to prevent future ignitions and provide them with data that can be used in the future planning of new forest plantations.

Helen Townsend, Forestry Commission's Head of People, Landscape and Historic Environment, has stated *"that a more informed and better understanding of the human impacts of wildfire both as causes of ignition, through to impacts on how the use of woodlands and forests for leisure and recreation can be better managed, is essential information for woodland owners and managers. How we inform, and shape behaviour of those living by, or directly benefiting from enjoying local woodlands will be an integral part of addressing accidental and negligent fire ignition, and requires better data, further research, and targeted communication campaigns."*

Michael Ullman, Operations Manager for Forestry England, in South England Forest District, agrees that understanding the causes of wildfires will be extremely useful. As one of the country's largest landowners, we need to be able to "*secure and grow the social, economic, and natural capital value*

of the nation's forests as part of our strategic purpose. Wildfires can have devastating effects on our landholding and be a huge risk to people, habitats, and assets in a changing climate. Understanding their causes ensures that we can protect these elements and improve our communications where necessary."

Euro News recently reported that the European Union needs to boost investments in wildfire prevention as the forest fire season is becoming longer and more geographically spread [24]. *"According to the World Bank study that was done in conjunction with the European Commission, €1 invested in wildfire prevention saves €10 in damage,"* the European Commissioner for Crisis Management told reporters. He added that the damage inflicted by wildfires in 2022 is estimated to be *"at least €2 billion"*.

Mark Owen, Principal Advisor to the Natural England upland management team, said that he can see many benefits of improved understanding of wildfire causes, such as: *"Better understanding of the cause of wildfire will help us advise on wildfire management plans so that they focus on site specific causes of fire – how fires start and who by. If we know what behaviours and activity leads to wildfire we can target advice to the public better, for example through the Countryside Code. Better understanding of the causes particularly where these may be related to patterns of behaviour and /or socio-economic factors may also help to inform our engagement with local stakeholders around the development of community mitigation strategies and opens the possibility of possibility drawing in expertise from other disciplines."*

The CCRA3 also recognised that wildfire is an increasing threat, and a coordinated approach is essential to mitigate and adapt to its impacts on people, property, infrastructure, and the environment, including natural capital and our natural carbon stores; as well as to plan the most effective response to wildfire incidents.

His Majesty's Government published the Environmental Improvement Plan in January 2023 [25]. The report recommends that *"we need upskilling across society to tackle the increased risk from wildfires. We have worked with partners across government and beyond, including the National Fire Chiefs Council, to design and deliver an accredited vegetation fire training programme. That continues to upskill land managers by consolidating knowledge and skills to prevent future wildfires*

and improving prescribed fire operations." Developing wildfire investigation knowledge through training will support this recommendation.

What does the data tell us?

A number of data group sets were collected for this report: IRS data which was analysed to consider what fire report data can tell us about wildfires in the UK; data from a '*Let's talk about wildfires* 'survey conducted by Greater Manchester Fire and Rescue Service in 2020; and data collected from UKFRSs and other responders as to their experiences of investigating wildfires and whether they would like wildfire investigation training.

IRS data

In the FC wildfire statistics for England report [26] it was observed that England's FRSs attended over 360,000 wildfire incidents in England over twelve years from 2009-10 to 2020-21 inclusive: an average of over 30,000 incidents per annum. In total just over 79,000 hectares of land was burnt; an average of over 6,600 hectares per annum. The total duration of the incidents was just under 540,000 hours; an average of just under 45,000 hours per annum. Importantly small wildfires (under 1 hectare) attended by FRSs accounted for nearly 250,000 hours of duration. The importance of recording small wildfire incidents, for wildfire investigation and other needs, has been highlighted by Richard Woods, as they provided evidence of trends and patterns of fire ignitions.

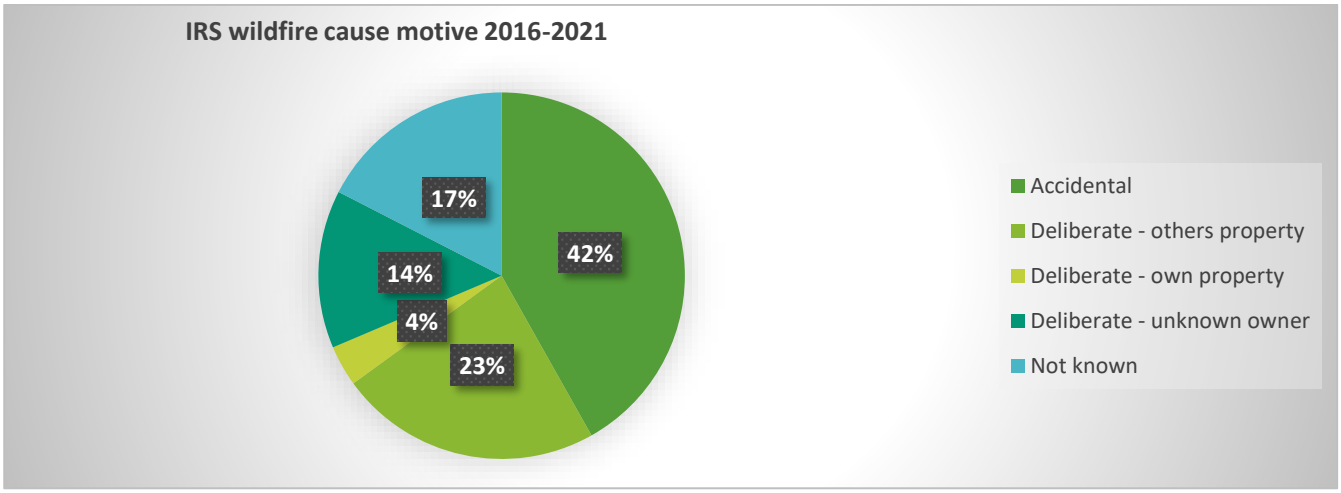
There were nearly 13,000 wildfires to the National Operational Guidance Programme (NOGP)[8] definition of 'wildfires', using the five criteria, in England in these twelve years. These NOGP wildfires burnt an area of over 77,000 hectares and had a duration of over 277,000 hours. The overwhelming

[8] A NOG wildfire needs to meet one or more of the following criteria. Involves a geographical area of at least one hectare (10,000 square metres). Has a sustained flame length of more than 1.5 metres. Requires a committed resource of at least four fire and rescue service appliances/resources. Requires resources to be committed for at least six hours. Presents a serious threat to life, environment, property, and infrastructure.

majority (86.6%) of NOGP wildfires were 'small' on the United Kingdom Vegetation Fire Standard (UKVFS)[9] size categorisation; however, there were some larger ones too and 18 NOGP wildfires were of a landscape scale over these twelve years.

Woodland and forest wildfires: The proportion of the total number of wildfires that occurred in woodland or forests 1 (14.2% over the twelve years) has generally increased a little from 12- 15% in the first three years to 15%-19% in the most recent three years. The greatest figure was 19% in the most recent year 2020-21. Throughout the twelve-year period, each year the overwhelming majority of wildfires in woodland have been in broadleaved woodland. However, the most severe and larger fires occur in pine tree and conifer forests, due to flammability of that species.

Data from the Home Office (HO) was made available for this report from the IRS wildfire motivating causes of NOGP definition wildfires in England, between 2016 and 2021. There has been a total of 5,575 wildfires in that time which meet the NOG definition.

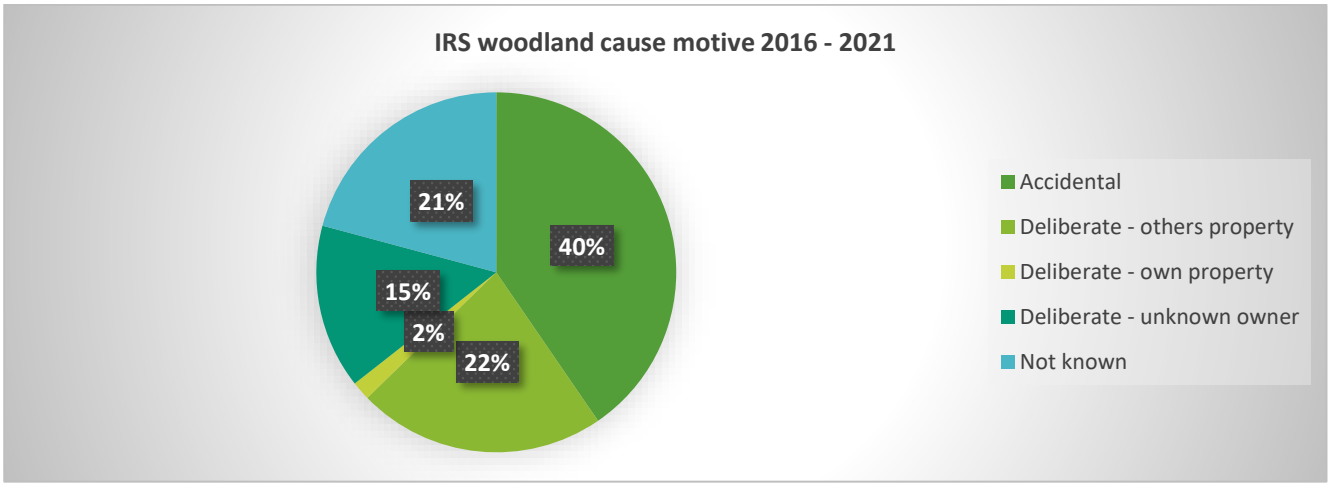


As previously discussed, we know that the accuracy of IRS data is predicated on the investigation being undertaken at a basic level and data gathered from England and Wales FRS' (see below – *FI FRS team data*) observes that investigations generally do not go further than a basic level.

However, we can at least observe from this data that on the balance of probability 42% of wildfires are caused accidentally and 41% are caused deliberately, with 17% of the causes being unknown.

[9] **United Kingdom Vegetation Fire Standard (UKVFS)** project is a multi-governmental agency and organisation approach to delivering vegetation fire (Outdoor fires) reporting.

What we cannot do from this data is better understand what those accidental[10] causes are. What must also be considered is that the term accidental is vague in the context of Tier 1 investigations. Accidental fires may include campfire and cooking related ignitions in areas that clearly prohibit those activities, and that the human interaction leading up to the fire was negligent or reckless, which will often be recorded as accidental by the administrator inputting the data. Which could be mean there was a pre-mediated decision where the person(s) involved knew their actions had potential consequences, and therefore not a true accident. What is also observed from this is that deliberate[11] fire setting occurrences are equal to the accidental fires. We can also see that 17% of causes are unknown which amounts to 948 wildfires during that period.



Wildfires that have occurred in that same period in our woodland areas, totalled 1572 incidents. The ratio of accidental to deliberate fires is also equal with 330 of those fires' causes being unknown.

Other researchers have analysed and made interpretations of historic IRS data, such as in the report Developing a Risk Assessment Approach for Forest Fire at the Rural-Urban Interface: Potential of the Wildfire Threat Analysis Framework by McMorrow J et. al.

Analysis of that IRS data showed that majority of fires in a case study area occur between 0-100 metres from built up areas, that the majority of fires occur 0-50 metres from roads, and 0-50 metres

[10] **Accidental fires** include those where the motive for the fire was presumed to be either accidental or not known (or unspecified).

[11] **Deliberate fires** include those where the motive for the fire was 'thought to be' or 'suspected to be' deliberate. This includes fires to an individual's own property, others' property, or property of an unknown owner. Despite deliberate fire records including arson, deliberate fires are not the same as arson. Arson is defined under the Criminal Damage Act of 1971 as 'an act of attempting to destroy or damage property, and/or in doing so, to endanger life'.

from foot access points [4]. Although the accuracy of this data in relation to the point of ignition cannot be guaranteed, an inference can be taken that these fires occur where there is a potential for a large footfall and human interaction, either because they are near to densely populated areas or they attract people for recreational purposes, which is consistent with the view that 90+% of wildfires are human related. However, what needs further analysis is whether the access points are near where people live or whether the site is accessible by permission or right.

This project did seek to gather analysed IRS data to establish if there is any correlation between a wildfire point of origin and the socio-economic or recreational factors known to that area. Unfortunately, due to timescales that spatial analysis of this data was not achievable, however, this could be achieved as part of further research in the future.

Public perception survey

In 2020 Greater Manchester Fire and Rescue service conducted research by using a Let's talk about wildfire survey to understand more about the public's perception of wildfire in the UK. Public perception of wildfire is a very under-researched topic and very little is known about what the public thinks cause wildfires and their concerns about wildfire impact. This initial research aimed to establish an understanding of what the public think about wildfire. 2,149 people responded to the survey from across the UK, with the majority of responses coming from the Northwest of England.

One observation of the survey concluded participants generally felt that there should be consequences for people found to have started a wildfire and that consequences should depend on several factors such as who started the fire, their intent and how much damage was caused. They also felt that consequences should also involve an element of education to change behaviours.
Those living in areas recently affected by wildfires were more likely to think their fire FRS does enough to communicate with them about wildfires than others living in areas less affected by wildfires. However, there were some who do not feel like they are communicated with effectively. They commented on areas they think stakeholders should do (or continue to do) related to wildfire prevention:

1. *Campaigns about wildfire should contain an educational element to encourage behaviour change and should be targeted to both young people and people found to have started fires deliberately to deter fire setting behaviours.*

2. *Communicate with residents using a range of different communication channels such as social media, TV, and radio campaigns to ensure different parts of the community receive messages about how to prevent fires from occurring.*

3. *Continue seasonal campaigns focusing on wildfire risks, with posters and banners in the countryside reminding the public of potential risks and how to mitigate them.*

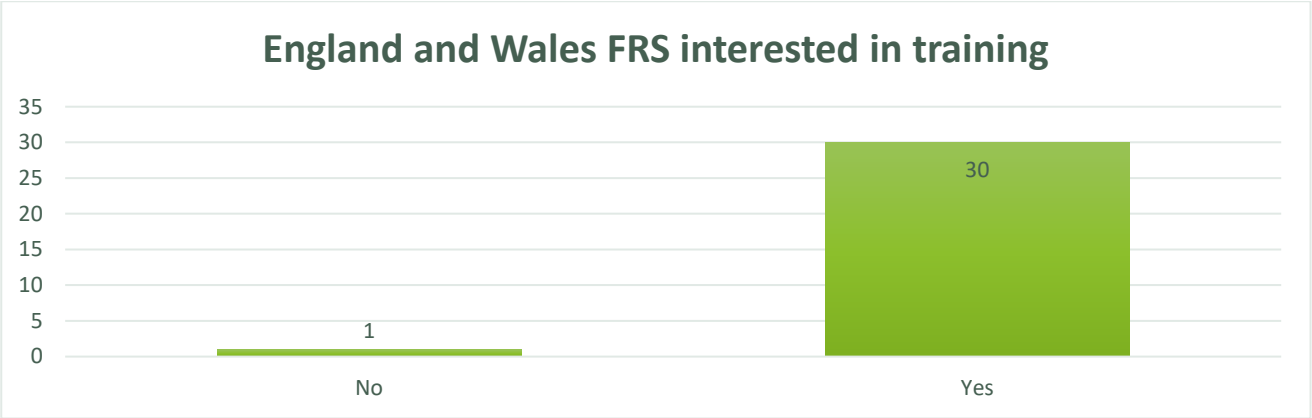
4. *Different organisations should work together to prevent wildfires to communicate key messages to a wider audience. For example, fire and rescue services could work with local community and conservation groups, charities, schools, and media outlets to ensure information about wildfires and associated risks are effectively communicated.*

FRS FI team data

In January 2023 a request for information was sent to all fire investigation teams in FRSs' across England and Wales to establish how many wildfires they have had in the last five years, whether any tier two[12] investigations had been carried out, if they had resulted in a reportable outcome, and whether they would be interested in a UK based wildfire investigation course should one exist.
Over 70% of FRSs in England and Wales responded by saying a very low amount of tier two investigations had been undertaken, with a lack of knowledge and service support as to why this happens.

However, the interest in further capacity building to better understand their wildfire problem was high, with nearly all the services who responded stating they would like further learning opportunities and skills development. If the findings from this survey were scaled up the potential delegates from the fire and rescue service could range between 50-150. With candidates from the FI-110 course showing an aptitude for Wildfire investigation, being potential candidates for a FI-210 course. There is also interest from local London borough authorities, wildlife trusts, the National Trust, other environment NGOs and researchers at Manchester University in understanding wildfire causation better.

[12] Tier two investigations are carried out by nominated Fire and Rescue Service Officers with specific advanced training and experience, when a more detailed or extensive investigation is required.



Conclusion from this data

Based on this data analysis, it was observed that the IRS causation data we have, does not help us understand the problem accurately. The public's view from the survey indicates that we should be doing more to inform people as to the causes and impacts of wildfires through a targeted approach. The data also observed that stakeholders impacted by wildfires do not necessarily have the range of skills required to accurately determine the causes to improve our understanding of the problem.

Conclusions and recommendations

The evidence that fire investigation can play a part in mitigating the wildfire problem we face is clear from the data, expert opinion and through the individuals engaged in preparing this report. What is also clear is that we don't truly understand what the causes of UK wildfires as we do not routinely investigate wildfires to better understand how and why they happen. And therefore, our knowledge in this area is limited. Observations taken from international experts has led to the conclusion that we cannot be effective in dealing with a problem without first understanding it, as suggested in the book *'Feeling the heat, international perspectives on the prevention of wildfire.'*

"It is next to impossible to design specific fire prevention campaigns if one cannot identify the causes in a systematic way."

And *"Until our ability to determine the causes of forest fires improves our efforts at prevention will essentially remain a shot in the dark."*

Understanding wildfire causation will help us to understand wildfire and in particular forest fire causation. Which is particularly important to the FC given the effects of climate change will increase the wildfire days in the UK. And because the FC are entrusted with protecting our forests which are important for many reasons.

Based on the observations entailed in this report it is recommended that key stakeholders such as the FC, NFCC, NPCC, Natural England, DEFRA, and the National Park Authorities, work together in key areas to improve our knowledge and understanding as to what causes UK wildfires. This can be done through further research into the causes and motivating factors of wildfires, the production of articles and seminars on the subject and the upskilling of personnel who play a part in investigating wildfires for either prevention or criminal and coronial purposes, to ensure the margin of certainty for wildfires causation is reasonably accurate.

Research

- A detailed desk exercise to determine the cause and motives of wildfire incidents, using existing reports and data. This will improve prescribed prevention campaigns both locally and nationally.
- Further surveying of the public perception of wildfires utilising the survey already undertaken by Greater Manchester Fire and Rescue service.
- Spatial analysis of data to determine what impact socioeconomics has on an area with an annual wildfire problem.
- Further research in collaboration with academics which considers proof of concept testing to validate and consider various ignition sources.
- Consideration into how stakeholders can work together to tackle anti-social behaviour through education programmes.
- Collaboration with the UK Wildfire Research Group to establish further areas of research into the societal elements associated with wildfire causation. With the anticipation this could create MSc or PhD opportunities for academics.

Articles, seminars, educational events

- The production of articles for various publications such as the UK Association of Fire Investigators (U.K.A.F.I) magazine or the Institute of Fire Engineers (I.F.E).
- The development of stakeholder relationships through the organisation of wildfire causation seminars.
- Workshops with land managers and local authorities to discuss the use of PSPOs and where they should be based on risk.
- Educational events that inform the public as to the causes of wildfires and the role society plays in wildfire mitigation.

Training and upskilling of relevant personnel

- Developing a UK-based wildfire investigation capability through the upskilling of personnel currently working within key stakeholders such as NFCC, UKFRS, FC, Natural England the NPCC, DEFRA and devolved government organisations under an agreed cooperative framework arrangement and Concept of Operations (CONOPS).

- Drafting procedural documentation based on the above to confirm arrangements for the investigation of wildfires on a cooperative basis through the UK. With consideration to which wildfires should be investigated, by whom, when and at what level (Tier 1 or 2). Not all FRSs will have capacity to undertake wildfire investigation at a Tier 2 level, and the need to investigate will be underpinned by the impact of the fire, this should be reflected in procedural documentation.

- Developing a phased approach encompassing the adoption of the two-tiered training program as outlined below, which would also include a strategy for Continual Professional Development (C.P.D) for delegates. To do this, the Forestry Commission should engage with international subject matter experts and the NFCC to provide advice and deliver training packages and National Occupational Standard using the NWGC FI-110 and FI-210 syllabi.

  i) First Response Crews - being a one-day training package based on the 'FI-110 Wildland Fire Observations and Origin Scene Protection for First Responders

Course. This course provides the skills necessary for first attack crews to preserve the scene and to identify cause, which will assist agencies gather intelligence as to what is causing fires in their area, allowing to them to focus prevention strategies. It also prepares attendees to refer the scene for formal investigation. It could be modified if necessary to upskill target groups who work in the sector (such as fire service crew leaders, entry-level fire scene investigators, wildfire tac-advisors, foresters, and land managers).

ii) Wildfire Investigators – being a *five-day* training package delivered through theory and field-based training in the 'FI-210 Wildland Fire Origin and Cause Determination Training Course'. This course is targeted at more experienced officers from fire services, law enforcement, civil litigation investigators and fire science academics, who will investigate more critical events requiring formal investigation that may result in a prosecution, damage to property or serious injury/death. This course will need to consider ISO/IEC 17020:2012 accreditation for forensic practitioners who provide reports to the Criminal Justice System (CJS).

The adoption of these recommendations will require the development of a more comprehensive strategic plan to identify timelines, costings and intended outcomes to be agreed to by all parties mentioned above. Richard Woods has provided an estimate cost for the service of himself and two colleagues. His services would initially train up to 100 FI-110 delegates and 35 FI-210 delegates at a suitable location in the UK over a two-week period. However, the precise details for such an engagement are yet to be finalised. Nevertheless, this two-tiered approach would ensure the necessary skills for frontline responders to identify fire cause; and for specialist investigators to conduct formal investigations. Given the need for 'live fire' events to make up the course components, With the land burning period permitted under The Heather and Grass etc. Burning (England) Regulations 2007, is considered the best time to run courses.

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Appendix A Report Contributors

*Rhodri Jones MSc is an experienced fire officer having served for over 15 years with Greater Manchester Fire and Rescue Service (GMFRS). Since October 2018 he has been a dedicated Fire Scene Investigator (FSI), he has supported the investigation of over 100 criminal and accidental fires, including 12 fatal fires. He has also investigated several wildfires. He was the technical lead for ISO17020 accreditation for 16 months. In June 2020 he organised and chaired a National Fire Chiefs Council (NFFC) wildfire investigation webinar, and in 2022 he presented on the subject of wildfire investigation to the United Kingdom Association of Fire Investigation (UKAFI) summer conference. Rhodri achieved a Masters in Fire investigation with distinction from the University of Central Lancashire in 2022. He is an associate member of UKAFI and the Chartered Society for Forensic Sciences.

** Rob Gazzard is the Forestry Commission's Advisor on Contingency Planning and Wildfire in the Policy Advice Team and is seconded to Defra for domestic and international wildfire advise. Since 1999 he has attended over 10 large wildfire incidents in the South of England, undertook training and operational response globally, including North America (Oregon and California) and Europe (Spain and Portugal), as well as a sabbatical to Australia. Was one of only two UK members in the EU Civil Protection Mechanism as Technical Advisor and Operations Commander. Team Leader of the UK's first official international wildfire deployment using a bilateral agreement to Greece in 2018 and first British Overseas Territory deployment in 2023. A founding member of the England and Wales Wildfire Forum, joint coordinator of the UK Wildfire Research Group, an Advisor to Central Government and official SAGE member. Programme Leader for the UK first accredited Vegetation Fire training modules.

***Dr Peter Moore has over 40 years of operational, management and policy experience in natural resources with an emphasis in fire management, system development, policy formation and implementation, national MRV systems, forest and land management across Africa, Australia, Europe, North America, and South America. Peter has been engaged on a wide range of national and international natural resources related activities working for national governments, FAO, the World Bank and in the private sector.

****Richard Woods is an Adjunct Associate Lecturer in Wildfire Investigation with Charles Sturt University in Australia and is the Director of an International Wildfire Investigation Consultancy based in Canberra. He has completed a Graduate Diploma in Fire Investigation; Graduate Certificate in Applied Management at the Australian Institute of Police Management and a Diploma of Government (Investigation) during his career and was awarded the Australian Fire Service Medal for his commitment to the field of Wildfire Investigation.

He has delivered Wildfire Investigation training both within Australia and internationally including South Korea, USA (Hawaii), China, Canada, India, and The Netherlands and has been a keynote speaker at a number of national and international conferences in the field of Wildfire Investigation. In 2012 he advised European Union Country members on Wildfire Investigation, Wildfire Arson prevention and training to the United Kingdom, The Netherlands, Italy, Spain, Germany, and the Czech Republic.

He has also been deemed an expert witness in Wildfire Investigation by the Alberta Provincial Court in Canada, giving evidence in relation to the successful prosecution of an arsonist in that Province.
He is the current Chair of the International Association of Arson Investigators, Wildland Fire Investigation Committee and Australian representative on the North American based National Wildfire Co-ordinating Group, Wildland Fire Investigation Team and is a former President of the NSW Chapter (47) of the International Association of Arson Investigators).
He is about to publish a book on wildfire arson prevention for international use.

*****Bruce Balderston has been a member of IAAI and NAFI since 2012. He has held wildland fire positions in fire dispatch, as a Fire Management Assistant with the National Park Service, Fire Prevention Officer/Investigator with the Alaska Forestry-Fire and Aviation Division and, Senior Fire Investigator with the Washington Department of Natural Resources.
During his fire career, Mr. Balderston has investigated over 400 wildfires as the chief investigator while assisting and, or consulting on more than 300 investigations. As the Lead Instructor he has taught FI-110, FI-210 and developed specialized training in the areas of wildfire investigation and incident safety.

As CEO of Arson Track LLC, Bruce has developed **Arson Track**, a computer database in the cloud that assists in the tracking and ultimate identification of wildland fire arsonists.