

ARTICLES

THE DEVIL IS IN THE DEBRIS: HOW CONTEXTUAL DEFICIENCY IN FORENSIC FIRE DEBRIS ANALYSIS CONTRIBUTES TO WRONGFUL CONVICTIONS

Jessamyn Ward Chmura, M.S. and Daniel S. Medwed

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INTRODUCTION

Forensic science plays a pivotal and occasionally paradoxical role in the American criminal legal system. It helps solve crimes, yet also contributes to the conviction of innocent people. Although much of the scholarly literature related to the link between forensic science and wrongful convictions has focused on dubious forensic disciplines (so-called instances of “junk science”),¹ this Essay examines valid forensic evidence that is misused or misunderstood within the greater context of the case. Specifically, we focus on overturned arson cases involving forensic fire debris analysis, exploring how scientifically accurate conclusions—such as the presence of ignitable liquid residues in evidence—can still lead to wrongful convictions when misattributed.

In the process, we introduce the concept of “contextual deficiency.” Contextual deficiency occurs when the criminal legal process fails to properly integrate the results of scientifically valid forensic tests with case-specific contextual information. This can take place when there are innocuous reasons for the presence of the evidence (*e.g.*, inherent chemicals in floorboards) or an intervening process undermines the probative value of the evidence (*e.g.*, secondary transfer of DNA). Contextual deficiency can arise at almost any stage of the investigation and adjudication, from the forensic scientists to the prosecutors and jury. While all forensic evidence can be taken out of context, there are certain areas of testing that are more susceptible to contextual deficiency. Forensic fire debris analysis, often used in arson investigations, is one such discipline.

Most flawed arson convictions concern the methods employed during the origin and cause investigation. The methods used to discern the origin and cause of fires have evolved over time, transitioning from largely experienced-based assessments to more scientifically grounded approaches.² Historically, investigators relied on visual cues, patterns, and even anecdotal evidence, which sometimes led to inaccurate conclusions. Advances in fire science, coupled with the development of standardized protocols, have improved the accuracy of these investigations.³ This evolution has also led to a wave of exonerations of innocent people who were

¹ See, *e.g.*, SIMON A. COLE, JESSICA WEINSTOCK PAREDES, MAURICE POSSLEY & KEN OTTERBOURG, *Microscopic Hair Comparison Analysis and Convicting the Innocent*, in NATIONAL REGISTRY OF EXONERATIONS, 2023, <https://n2t.net/ark:/88112/x2d909> [<https://perma.cc/EAA4-9JGV>]; Jennifer D. Oliva & Valena E. Beety, *Regulating Bite Mark Evidence: Lesbian Vampires and Other Myths of Forensic Odontology*, 94 WASH. L. REV. 1769 (2019).

² See Valena E. Beety & Jennifer D. Oliva, *Evidence on Fire*, 97 N.C. L. REV. 508–10 (2019).

³ See *id.* at 496.

convicted based on the older methods of investigation.⁴ Alongside these advancements lies a previously underexplored component of many arson investigations: fire debris analysis, which involves the identification of ignitable liquid residues (ILR). In general, an ILR is a chemical substance that can start fires (ignite) easily under certain conditions.⁵

This study, which is the first known undertaking to examine the role of forensic fire debris analysis in wrongful convictions, identifies seventeen overturned convictions where the forensic fire debris analysis was in question during the post-conviction proceedings.⁶ The study began as a broader examination of these cases, but narrowed its scope after finding commonalities across cases that warranted greater scrutiny. The majority of the cases involved what we term “misattributions”—instances where the positive finding of an ignitable liquid residue was valid, but the conclusion drawn from it was contextually flawed.

Part I of the Essay reviews the nexus between forensic science and wrongful convictions. It also contains a case study of the wrongful conviction of Charles Jason Lively, an example of misattribution that we revisit throughout the paper. Part II offers a deep dive into the science behind forensic fire debris analysis before we reveal the findings of our study in Part III. Part IV then offers some tentative thoughts on the implications of our findings for criminal justice reform.

I. FORENSIC SCIENCE: A DOUBLE-EDGED SWORD IN CRIMINAL CASES

For more than a century, forensic techniques have shaped how we investigate and prosecute crime. But scientific validity alone does not guarantee justice. It is also essential that forensic findings are interpreted and applied in context. To fully grasp how this form of evidence may contribute to wrongful convictions, we must first examine the history of forensic science in American courtrooms: its rise, its strengths, and its shortcomings.

A. *Development of Forensic Science and Common Causes of Wrongful Convictions*

Forensic science has long figured as a cornerstone of the American criminal legal system. From early twentieth century techniques such as fingerprint analysis

⁴ See, e.g., *id.* at 507 (“[F]aulty fire science is to blame for a significant number of wrongful convictions across the United States.”).

⁵ See *infra* notes 81–86 and accompanying text (Section II.B on Ignitable Liquids).

⁶ While the robustness of our conclusions may be affected by the limited sample size, these findings nonetheless provide valuable insight into this emerging focus within innocence efforts across the country.

and blood typing to the dramatic growth of the field in recent decades, forensic scientific evidence has offered law enforcement agencies unprecedented assistance in identifying perpetrators of crime.⁷ What is more, juries tend to value—or, regrettably, overvalue—forensic evidence at trial because they are ill-equipped to scrutinize the underlying methodology and they may be wowed by the credentials of the expert witness entrusted with presenting the findings.⁸ One study from 1987 concluded that almost “one quarter of citizens who had served on juries which were presented with scientific evidence believed that had such evidence been absent, they would have changed their verdicts—from guilty to not guilty.”⁹ In the 1980s and 1990s, forensic methods expanded to include DNA profiling, which quickly became the gold standard due to its ability to individualize evidence and ascribe biological material to a specific person’s genetic profile.¹⁰ Yet the proliferation of forensic techniques has come with a cost. While they help solve crimes, they also sometimes generate miscarriages of justice.

Indeed, scholars have cited forensic evidence as one of the leading factors in the conviction of innocent criminal defendants (see Figure 1 below). Since 1989, *more than one thousand* exonerations of wrongfully convicted people have occurred in cases in which forensic science contributed to the original conviction.¹¹ When looking back on what went wrong in these cases, the forensic science failings mainly take two forms. First, in many cases, the forensic method utilized was scientifically unsound, commonly known as “junk science.” In the late twentieth century, courts routinely admitted testimony based on flawed, usually pattern-based techniques such

⁷ See, e.g., DANIEL S. MEDWED, PROSECUTION COMPLEX: AMERICA’S RACE TO CONVICT AND ITS IMPACT ON THE INNOCENT 92–102 (2012).

⁸ *Id.* at 92–93.

⁹ Joseph L. Peterson, John P. Ryan, Pauline J. Houlden & Steven Mihajlovic, *The Uses and Effects of Forensic Science in the Adjudication of Felony Cases*, 32 J. FORENSIC SCI. 1730, 1748 (1987).

¹⁰ See Michael Lynch, *God’s Signature: DNA Profiling, the New Gold Standard in Forensic Science*, 27 ENDEAVOUR 93, 93, 96 (2003).

¹¹ See % Exonerations by Contributing Factor, NAT’L REGISTRY OF EXONERATIONS, <https://exonerationregistry.org/exonerations-contributing-factor> [<https://perma.cc/U49S-K2JG>] (last visited Jan. 15, 2026) (listing more than 3700 exonerations since 1989 with 29% of them involving some type of false or misleading forensic evidence).

as microscopic hair¹² and bitemark analysis¹³ in which forensic analysts compared an exemplar taken from the prime suspect against evidence retrieved from the crime scene. Many courts and scholars later found this comparison method to be lacking in the rigorous performance evaluations necessary to establish limits, identify areas of variability, and recognize sources of potential bias.¹⁴

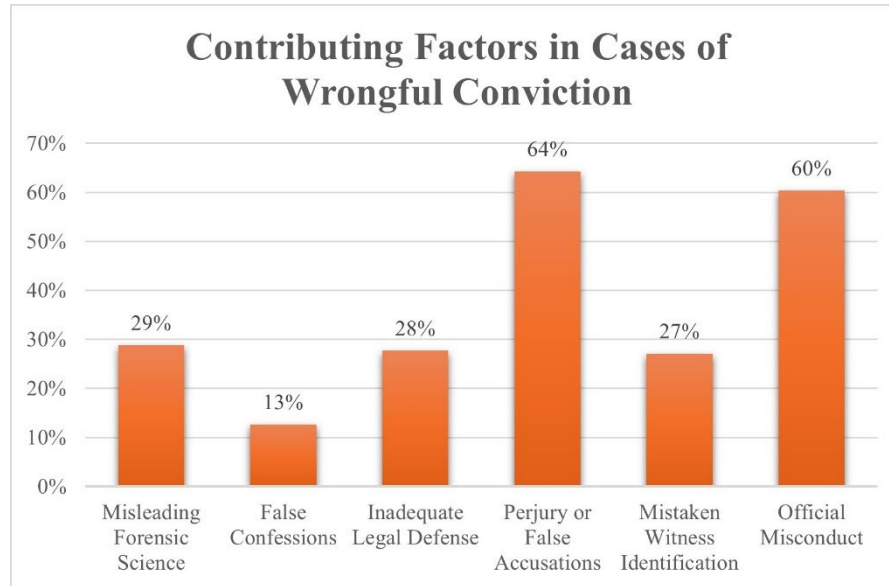


Figure 1: Contributing factors in wrongful convictions. Data from the National Registry for Exonerations as of April 2, 2025.

¹² As stated in the 2009 National Academy of Sciences report, “microscopic hair analysis may provide reliable evidence on some characteristics of the individual from which the specimen was taken, but it may not be able to reliably match the specimen with a specific individual.” COMM. ON IDENTIFYING THE NEEDS OF THE FORENSIC SCI. CMTY., NAT’L RSCH. COUNCIL OF THE NAT’L ACADEMIES, STRENGTHENING FORENSIC SCIENCE IN THE UNITED STATES: A PATH FORWARD 8 (2009) [hereinafter NAS REPORT]. See generally Daniel S. Medwed, *Introduction: Path Forward or Road to Nowhere? Implications of the 2009 National Academies of Science Report on the Forensic Sciences*, 2010 UTAH L. REV. 221 (2010).

¹³ See, e.g., KELLY SAUERWEIN, JOHN M. BUTLER, CHRISTINIA REED & KAREN K. RECZEK, BITEMARK ANALYSIS: A NIST SCIENTIFIC FOUNDATION REVIEW 4 (2023), <https://nvlpubs.nist.gov/nistpubs/ir/2023/NIST.IR.8352.pdf> [<https://perma.cc/QQS5-EP9B>] (“[T]he ability of bitemark analysis to accurately exclude or not exclude individuals as a source of the mark is not supported.”).

¹⁴ See NAS REPORT, *supra* note 12, at 8.

In addition to the intrinsic flaws with these techniques, forensic experts often overstated their findings, declaring “matches” with near certainty based on subjective observations.¹⁵

The second common kind of forensic science issue occurs when an analyst misuses or misattributes scientifically sound results. To be sure, context itself is not inherently harmful. The key lies in who possesses that context, when they use it, and how it is managed. A very experienced analyst may jump to conclusions based on past patterns and historic results; conversely, a less experienced analyst may lack the background to grasp the overall meaning of a particular set of findings.

But experience is not the sole barometer in measuring whether a forensic analyst accounts properly for context. Forensic analysts work within resource constraints and practical limitations. In many cases, contextual information helps drive efficient and appropriate forensic testing.¹⁶ For example, knowing the nature of a crime or an item’s origin can help determine what biological fluids to screen for, what comparison samples to include, or if a test is even necessary.¹⁷ The National Commission on Forensic Science has emphasized that some task-relevant contextual information is essential for analysts to make informed, scientific decisions.¹⁸ Without context, laboratories risk misallocating resources or failing to identify probative evidence.

Problems may arise, though, when analysts are exposed to task-irrelevant information—in a sense, too much context—and become vulnerable to cognitive bias.¹⁹ This type of exposure is especially dangerous in forensic disciplines involving subjective interpretation, such as pattern comparison. Confirmation bias, in particular, surfaces as a risk in these situations. That bias reflects the tendency of people to search for or favor information that confirms their pre-existing beliefs.²⁰

¹⁵ See *FBI Testimony on Microscopic Hair Analysis Contained Errors in at Least 90 Percent of Cases in Ongoing Review*, FED. BUREAU OF INVESTIGATION (Apr. 20, 2015), <https://www.fbi.gov/news/press-releases/fbi-testimony-on-microscopic-hair-analysis-contained-errors-in-at-least-90-percent-of-cases-in-ongoing-review> [<https://perma.cc/S8ZW-72UZ>].

¹⁶ NAT’L COMM’N ON FORENSIC SCI., ENSURING THAT FORENSIC ANALYSIS IS BASED ON TASK-RELEVANT INFORMATION 2, <https://www.justice.gov/ncfs/file/641291/dl?inline> [<https://perma.cc/6WFT-A54Y>] (last visited Jan. 15, 2026).

¹⁷ *Id.*

¹⁸ *Id.* at 1.

¹⁹ *Id.* at 3.

²⁰ See, e.g., Bryce Hoffman, *Confirmation Bias: What It Is and How to Overcome It*, FORBES (July 20, 2024, 1:34 PM), <https://www.forbes.com/sites/brycehoffman/2024/07/20/confirmation-bias-what-it-is->

For instance, one study concluded that fingerprint examiners were less likely to find a link between a print from a crime scene and a suspect when they were told the suspect had a solid alibi.²¹

One of the most well-known instances of confirmation bias is the case of Brandon Mayfield, a United States citizen who was erroneously identified as the source of a fingerprint found on a bag connected to train bombings in Madrid, Spain in 2004.²² Three separate FBI latent print analysts had positively identified Mayfield as the source, which many attributed to cognitive bias errors, including knowing the high-profile nature of the crime (thus feeling more pressure to solve it) and knowing the other analysts' conclusions prior to their own examinations.²³

Conversely, too little context can also be hazardous. Consider the example of blood typing or "serology," which was a well-established, valid technique long before DNA profiling.²⁴ It allowed forensic analysts to determine whether the source of biological material had a certain type of blood.²⁵ That, in turn, empowered law enforcement to winnow the pool of suspects.²⁶ But blood-typing was often used without proper integration with case-specific, relevant information that could drastically change the jury's interpretation of a result.²⁷

Take the wrongful rape conviction of Gary Dotson from Illinois.²⁸ At trial, the state's analyst testified that the perpetrator had Type B blood, stating that only 11%

and-how-to-overcome-it/ [https://perma.cc/7D68-F5BR]. Confirmation bias is associated with related biases, like tunnel vision and expectation bias, that spur people to overvalue information that supports their hypothesis and discount evidence that undermines it. *See* Beety & Oliva, *supra* note 2, at 511–13.

²¹ *See* NAT'L COMM'N ON FORENSIC SCI., *supra* note 16, at 3–4.

²² *See* U.S. DEP'T OF JUSTICE, OFF. OF THE INSPECTOR GEN., A REVIEW OF THE FBI'S HANDLING OF THE BRANDON MAYFIELD CASE (2006), <https://oig.justice.gov/sites/default/files/legacy/special/s0601/final.pdf> [https://perma.cc/U7YC-Z5JU].

²³ The Office of the Inspector General's report on the Mayfield case, however, did not find "compelling evidence" suggesting any problems with bias in the fingerprint verification procedure, and no evidence to suggest that the pressure of working on a high-profile case contributed to the error. *Id.* at 10–11.

²⁴ *See, e.g.,* Sandip Ghosh, *ABO Typing in Forensic Analysis: To Be or Not to Be in the Epoch of Genotyping*, 9 INT'L J. FORENSIC SCI. & PATHOLOGY 487, 487–88 (2022).

²⁵ *Id.* at 488.

²⁶ *Id.*

²⁷ *Id.* at 491.

²⁸ *See* Brandon L. Garrett & Peter J. Neufeld, *Invalid Forensic Testimony and Wrongful Convictions*, 95 VA. L. REV. 1, 4–5 (2009).

of people (the percent of Caucasians with that blood type) could be the culprit.²⁹ However, the fact that the victim herself had Type B blood—and that her biological material was inevitably mixed in the sample, rendering the evidence essentially meaningless—went unacknowledged by both the forensic analysts and prosecution throughout the trial.³⁰ The problem was not the science of blood typing, but rather the contextual deficiency in how that evidence was characterized in the legal process. DNA profiling exposed that error years later when it excluded Dotson as the source of the biological specimen and he became the first DNA exoneree in the United States.³¹

Ultimately, preventing contextual issues in cases with forensic science evidence hinges on distinguishing between *task-relevant context*, which analysts need to conduct efficient and scientifically appropriate testing, and *fact-relevant context*, which factfinders need to adequately frame forensic results. In other words, forensic laboratories must shield their analysts from biasing information while still enabling informed scientific decisions. Meanwhile, courts and juries must hear forensic testimony that communicates both the objective conclusions and their subjective limitations. Some forensic disciplines are more prone to one type of error over another. And other disciplines, most notably arson, have shown to be susceptible to all these errors.³²

B. *Wrongful Arson Convictions*

As of April 2025, at least ninety people wrongly convicted of arson have had their convictions overturned,³³ usually based on a determination that the fire was not set intentionally and therefore did not constitute arson to begin with.³⁴ The vast

²⁹ *Id.*

³⁰ *Id.* at 4.

³¹ *Id.* Some commentators classify the David Vasquez case from Virginia as the first DNA exoneration. See Marvin Zalman, *An Integrated Justice Model of Wrongful Convictions*, 74 ALB. L. REV. 1465, 1485 (2011).

³² See, e.g., Neil R. Morling & Marika Henneberg, *Contextual Information and Cognitive Bias in the Forensic Investigation of Fatal Fires: Do These Incidents Present an Increased Risk of Flawed Decision-Making?*, INT'L J.L., CRIME & JUST., Sept. 2020, at 1, 2.

³³ See *Arson*, THE NAT'L REGISTRY OF EXONERATIONS, https://exonerationregistry.org/cases?search_api_fulltext=arson&f%5B0%5D=n_pre_1989%3A0 [<https://perma.cc/EZ25-J2XJ>] (last visited Jan. 15, 2026) (listing 97 exoneration).

³⁴ See Beety & Oliva, *supra* note 2.

majority of these wrongful convictions were based on faulty origin and cause investigations.³⁵

Here is how the investigation typically unfolds in a suspected arson. Fire investigators start by analyzing the scene, observing damage patterns and areas of greater burning to ascertain both the origin and the cause of the fire, before any evidence is collected or tested in a lab.³⁶ Origin and cause investigators are normally fire department personnel with training in fire investigations.³⁷ They are not specialists in forensic science (or even science at all) and their education and experience vary greatly. State and local fire investigators may have a high school diploma and on-the-job training,³⁸ whereas fire investigators at the federal level may complete two-year programs that require the investigation of at least 100 fire scenes and five graduate-level courses.³⁹

The currently accepted methodology for fire investigation is *NFPA 921*, which was first published by the National Fire Protection Association in 1992.⁴⁰ Some members of the fire investigation community initially balked at these new regulations, as origin and cause analysis was viewed as more of an art than a science.⁴¹ In the case of *Michigan Millers Mutual Insurance Co. v. Benfield*,⁴² the International Association of Arson Investigators (IAAI) even filed an amicus curiae brief, arguing that the standard set in *Daubert v. Merrell Dow Pharmaceuticals*,

³⁵ Although historically referred to as “cause and origin” investigation, the fire investigation community now prefers “origin and cause.” This updated terminology more accurately reflects the investigative process, emphasizing that the origin—where the fire first ignited—must be established prior to determining its cause.

³⁶ See John J. Lentini, *The Evolution of Fire: Investigation and Its Impact on Arson Cases*, WRONGFUL CONVICTIONS BLOG (2012), <https://wrongfulconvictionsblog.org/wp-content/uploads/2013/01/arson-investigation-evolution.pdf> [<https://perma.cc/ET87-WGJS>].

³⁷ *Id.*

³⁸ *Id.*

³⁹ *Certified Fire Investigators*, ATF: BUREAU OF ALCOHOL, TOBACCO, FIREARMS & EXPLOSIVES, <https://www.atf.gov/careers/certified-fire-investigators> [<https://perma.cc/M4A6-VABS>] (last updated Nov. 29, 2024).

⁴⁰ NAT’L FIRE PROT. ASS’N, *NEPA 921: GUIDE FOR FIRE AND EXPLOSION INVESTIGATION* (2024), <https://www.nfpa.org/codes-and-standards/nfpa-921-standard-development/921> [<https://perma.cc/3BN9-LD7B>].

⁴¹ See Parisa Deghani-Taft & Paul Bieber, *Folklore and Forensics: The Challenges of Arson Investigation and Innocence Claims*, 119 W. VA. L. REV. 549, 555 (2016).

⁴² 140 F.3d 915 (11th Cir. 1998).

*Inc.*⁴³ for the admissibility of scientific expert testimony should not be applied to fire investigation expert testimony “because fire investigation is ‘less scientific.’”⁴⁴ The court declined to adopt the IAAI’s position in that case,⁴⁵ serving as a harbinger of things to come.

As the understanding of the mechanics and science behind fire (and the damage it causes) evolved over the years, so has the understanding that a scientific approach to fire investigation is necessary. IAAI officially endorsed *NFPA 921* in 2000,⁴⁶ the same year that the United States Department of Justice released a report entitled “Fire and Arson Scene Evidence: A Guide for Public Safety Personnel.”⁴⁷ That report described NFPA 921 as the “benchmark for the training and expertise of everyone who purports to be an expert in the origin and cause determination of fires.”⁴⁸

A 2005 study by the Bureau of Alcohol, Tobacco, Firearms and Explosives (ATF) marked another vital step on the path to making arson investigation more of a science than an art. That study offered profound insights into fire investigations by delving into the effects of a phenomenon known as “flashover.”⁴⁹ Flashover happens when a fire in a confined space becomes so heated that all exposed combustible surfaces ignite, even those not directly in contact with existing flames.⁵⁰ After flashover, the fire can only grow where there is significant ventilation,⁵¹ as fire needs oxygen to burn. This process significantly alters the fire’s movement through a scene, which makes understanding ventilation crucial for tracing a fire’s movement back to the origin.⁵² In the study, two separate bedrooms were set ablaze and allowed

⁴³ 509 U.S. 579 (1993).

⁴⁴ Deghani-Taft & Bieber *supra* note 41, at 553–54 (quoting Brief for International Ass’n of Arson Investigators as Amici Curiae, *Mich. Millers Mut. Ins. Corp. v. Benfield*, 140 F.3d 915 (11th Cir. 1998)).

⁴⁵ *Michigan Millers Mutual Insurance Co.*, 140 F.3d at 920 (“We do not hesitate in finding that [the fire expert]’s testimony was science-based, rather than experience-based, and as such is subject to *Daubert*’s inquiry regarding the reliability of such testimony.”).

⁴⁶ See Lentini, *supra* note 36.

⁴⁷ U.S. DEP’T OF JUST.: OFF. OF JUST. PROGRAMS & NAT’L INST. OF JUST., FIRE AND ARSON SCENE EVIDENCE: A GUIDE FOR PUBLIC SAFETY PERSONNEL (2000), <https://www.ojp.gov/pdffiles1/nij/181584.pdf> [<https://perma.cc/USU7-YKY9>].

⁴⁸ *Id.* at 6.

⁴⁹ See Lentini, *supra* note 36.

⁵⁰ John L. Lentini, *Confronting Inaccuracy in Fire Cause Determinations*, in FORENSIC SCIENCE REFORM: PROTECTING THE INNOCENT 66, 81 (Wendy J. Koen & C. Michael Bowers eds., 2017).

⁵¹ Lentini, *supra* note 36.

⁵² *Id.*

to burn for about two minutes post-flashover. Then, fifty-three investigators from an IAAI-sponsored seminar examined the rooms and attempted to determine the fire's quadrant of origin. Remarkably, only three investigators identified the correct origin in the first room, and three different investigators identified the correct quadrant in the second room.⁵³

The ATF study even impacted how ignitable liquids fit into fire investigators' understanding of what they observe at the scene. The study proved that puddle-shaped areas of charring—originally believed to be indicative of the use of an ignitable liquid—could be the result of flashover.⁵⁴ The upshot from that study is that context matters in fire investigations, as one can see in a sobering case from West Virginia.

C. Charles Jason Lively—A Case of Contextual Deficiency

On the morning of March 15, 2005, a fire swept through a two-story home in Iaeger, West Virginia, a tiny town encompassing less than one square mile.⁵⁵ Although firefighters contained the blaze within ten minutes of arrival, the damage was devastating. One person died, a much beloved, wheelchair-bound doctor named Ebb “Doc” Whitley.⁵⁶

A man named Charles Jason Lively soon emerged as the chief suspect.⁵⁷ Lively had a criminal record, principally for assault, and circumstantial evidence linked him to Whitley. Lively's mother, a nurse who had worked with Whitley, had allegedly argued with the doctor on the evening before the fire. A witness also claimed Lively had tried to sell Whitley's computer at a pawn shop shortly after the fire. Lastly, two witnesses insisted they had observed Lively and his friend, Tommy Owens, at Whitley's house on the morning of the fire. Lively acknowledged his presence at the

⁵³ *Id.*

⁵⁴ *Id.*

⁵⁵ See generally Rachel Chason, *A Flawed Investigation Left Jason Lively Behind Bars for 14 Years for a Fire He Didn't Set. He's Not Alone*, WASH. POST (Oct. 22, 2020), https://www.washingtonpost.com/local/legal-issues/jason-lively-fire-innocent-west-virginia/2020/10/21/44772dba-f2b4-11ea-bc45-e5d48ab44b9f_story.html [<https://perma.cc/Q7TC-BQ2V>]; Maurice Possley, *Charles Jason Lively*, THE NAT'L REGISTRY OF EXONERATIONS, <https://exonerationregistry.org/cases/12898> [<https://perma.cc/8V5Q-BV6T>] (last visited Jan. 15, 2026); *State v. Lively*, 697 S.E.2d 117 (W. Va. 2010).

⁵⁶ Chason, *supra* note 55; Possley, *supra* note 55.

⁵⁷ *Id.*

scene and his possession of the computer but maintained that he had arrived only after Whitley had died and rushed in.⁵⁸

The loose threads holding together a case against Lively grew tighter after deputy state fire marshal Robert Bailey reported his findings. Equipped with minimal education and ten months on the job as a fire investigator, Bailey scoured the house for clues and took twelve samples for testing.⁵⁹ He concluded that the fire had been deliberately set, with two points of origin. One, he asserted, occurred downstairs and started with an open flame to the sofa. The other took place upstairs, its cause stemming from the use of an accelerant containing toluene, a chemical that surfaced in one of the twelve samples collected by Bailey.⁶⁰

At Lively's trial in November 2006, prosecutors focused on the arson evidence: the fire's two supposed points of origin and a positive finding of an ignitable liquid residue (toluene) in debris. These separate yet intertwined forensic findings helped convince a jury of Lively's guilt, despite testimony from a defense witness suggesting the fire may have been attributable to an electrical malfunction.⁶¹ In contrast, Lively's co-defendant Owens was acquitted in a separate trial, after only twenty-eight minutes of jury deliberation.⁶² This was cold comfort to Lively, who received a sentence of life in prison. He would spend more than a decade behind bars before a subsequent investigation proved his innocence.⁶³

Lively's path to exoneration began with an unlikely source: Sid Bell, the prosecutor who convicted him. Bell had followed the case of Cameron Todd Willingham—a father in Texas who was executed for allegedly setting a fire that killed his three daughters.⁶⁴ In a 2009 report, re-analysis of the evidence in the *Willingham* case determined the fire was most likely accidental, raising grave concerns about the reliability of arson investigation and the evidence used to convict the defendant.⁶⁵

⁵⁸ Chason, *supra* note 55.

⁵⁹ Chason, *supra* note 55; Possley, *supra* note 55.

⁶⁰ *Id.*

⁶¹ Chason, *supra* note 55; Possley, *supra* note 55; *see also* State v. Lively, 697 S.E.2d 117 (W. Va. 2010).

⁶² Chason, *supra* note 55.

⁶³ *Id.*

⁶⁴ *Id.*

⁶⁵ For an overview of the Willingham case, see David Grann, *Trial by Fire*, NEW YORKER (Aug. 31, 2009), <https://www.newyorker.com/magazine/2009/09/07/trial-by-fire> [<https://perma.cc/33VX-WQCL>].

Bell reached out to Craig Beyler, a fire scene investigations expert who had been hired by the State of Texas to examine the Willingham fire, and asked him to look at the *Lively* case.⁶⁶ Beyler subsequently produced a report condemning the government's arson investigation. Among other things, Beyler's report chided the West Virginia arson investigator for allocating blame to toluene without determining what liquid it may have come from:

They did no work to determine what the product was and what products may have been present in the room before the fire. In short, they could not identify the accelerant and could not establish that the liquid was a foreign material brought to the room for the purpose of starting a fire.⁶⁷

Beyler also disputed the conclusion that they were two separate fires.⁶⁸ He reasoned instead that the fire was likely the accidental result of an electrical problem below the subfloor.⁶⁹ When Bell received the "clearly exculpatory" report from Beyler in 2012, stating there was no evidence to support the finding of arson, he handed the report over to *Lively*'s habeas counsel.⁷⁰ A federal judge, however, denied habeas relief.⁷¹

In 2017, *Lively* obtained new legal representation, including attorneys affiliated with the West Virginia Innocence Project. After the new defense team met with state officials in 2018, prosecutors agreed to consult an independent chemist to review the case.⁷² That expert, Glen Jackson, echoed Beyler's findings that the fire likely started below the subfloor of the upstairs bedroom, a finding at odds with the use of toluene as an ignitable liquid.⁷³ Jackson issued a follow-up report after testing additional samples from *Whitley*'s home that revealed no detectable ignitable

⁶⁶ Possley, *supra* note 55.

⁶⁷ *Id.*

⁶⁸ *Id.*

⁶⁹ Chason, *supra* note 55.

⁷⁰ Possley, *supra* note 55.

⁷¹ *Id.*

⁷² Chason, *supra* note 55; Possley, *supra* note 55.

⁷³ Possley, *supra* note 55.

liquids. Rather, Jackson concluded that the toluene probably evolved from the burning process itself.⁷⁴

Armed with the Beyler and Jackson reports, as well as an affidavit from the prosecuting attorney Bell, the defense filed a motion for a new trial in August 2020. That motion went unopposed by the state, leading to the reversal of the arson and murder convictions the following month and Lively's release from custody.⁷⁵ In 2024, the West Virginia state legislature approved a damage award of \$1.56 million to Lively.⁷⁶

Although his exoneration would eventually come through new forensic testing, Charles Jason Lively languished in prison for fourteen years for a heinous arson-murder he did not commit. In addition, the flaws in the arson testimony at his 2006 trial and the delay in overturning his case even after the initial re-analysis of the fire evidence a few years later underscore a more pervasive problem: the criminal legal system's struggle to properly weigh forensic evidence, especially as science evolves. Lively's case is not an outlier. It reflects a larger tension at the heart of forensic science in the courtroom.

II. THE SCIENCE OF FORENSIC FIRE DEBRIS ANALYSIS

A. Overview

Fire debris analysis, unlike origin and cause investigation, is conducted within a laboratory setting.⁷⁷ For fire investigators, this analysis is helpful as it can reveal the presence of foreign ignitable liquids, pinpoint the origin of a fire, and potentially establish its cause, especially if an otherwise innocuous ignition source is implicated through the addition of such a liquid.⁷⁸ Fire investigators do not ordinarily perform this analysis. Instead, forensic scientists perform this testing; they typically work in public or private forensic laboratories and have expertise in forensic chemistry.⁷⁹ As of mid-2025, the American National Standards Institute National Accreditation

⁷⁴ Chason, *supra* note 55.

⁷⁵ Possley, *supra* note 55.

⁷⁶ *Id.*

⁷⁷ See *Fire Debris*, NAT'L CTR. FOR FORENSIC SCI., <https://ncfs.ucf.edu/research/chemical-evidence/fire-debris/> [<https://perma.cc/7BAE-DYGH>] (describing the general process for collecting and testing fire debris evidence).

⁷⁸ *Id.*

⁷⁹ *Id.*

Board (ANAB), the leading accrediting body of U.S. crime laboratories, had accredited 104 laboratories in fire debris analysis.⁸⁰

B. Ignitable Liquids

Ignitable liquids are substances that can easily ignite when exposed to an ignition source.⁸¹ While these chemicals are often colloquially referred to as “accelerants,” the terms are not synonymous and should not be used interchangeably.⁸² An ignitable liquid is classified based on its physical and chemical properties that render it capable of ignition.⁸³ Conversely, an accelerant is specifically employed to deliberately initiate and promote the rapid spread of a fire.⁸⁴ Thus, the presence of ignitable liquids at a fire scene does *not* necessarily imply an intent to use them as accelerants.⁸⁵

For example, acetone, a common ignitable liquid found in nail polish remover, is present in nail salons under normal circumstances. It is always considered an ignitable liquid. It only qualifies as an accelerant, however, if it is intentionally used to set the salon on fire. This insight is fundamental in forensic fire debris analysis: the presence of an ignitable liquid at a fire scene does not necessarily indicate its use as an accelerant.

Table 1: Classifications of ignitable liquids as described in ASTM E1618⁸⁶

Class	Examples
Gasoline	(Gasoline is its own class)
Petroleum distillates	Some camping fuels, charcoal starter fluids, paint thinners

⁸⁰ ANSINAT'L ACCREDITATION BD., <https://search.anab.org/> [<https://perma.cc/9SSE-JNYF>] (last visited Jan. 15, 2026). To view a list of the accredited laboratories, select “Fire Debris and Explosives” under the “Forensic Testing” dropdown menu, then click “Search Now.”

⁸¹ See generally ERIC STAUFFER, JULIA A. DOLAN & RETA NEWMAN, FIRE DEBRIS ANALYSIS (2008).

⁸² *Id.* at 26.

⁸³ *Id.*

⁸⁴ *Id.*

⁸⁵ No piece of physical evidence can objectively speak to the mental state of a perpetrator, which is why proper use of the term “ignitable liquids” is necessary in order to produce unbiased and objectively presentable forensic analysis.

⁸⁶ Subcommittee E30.13 on Ignitable Liquids, Explosives, and Gunshot Residue, *E1618-19: Standard Test Methods for Ignitable Liquid Residues in Extracts from Fire Debris Samples by Gas Chromatography-Mass Spectrometry*, in 14.02 PARTICLE AND SPRAY CHARACTERIZATION; FORENSIC SCIENCES; ACCREDITATION & CERTIFICATION; FORENSIC PSYCHOPHYSIOLOGY; NANOTECHNOLOGY; FORENSIC ENGINEERING (2025) [hereinafter *E1618-19 Test Methods*].

Isoparaffinic products	Aviation fuel
Aromatic products	Industrial cleaning solvents
Naphthenic paraffinic products	Some lamp oils
n-Alkanes products	Copier toners
De-aromatized distillates	Some camping fuels, odorless kerosene
Oxygenated solvents	Acetone, alcohols
Miscellaneous	Turpentine products

Ignitable liquids are categorized into distinct classifications, each with unique properties (see Table 1 above). Although this nomenclature may appear overly complex for legal professionals, understanding these classifications is crucial for accurately interpreting a laboratory report with a positive Ignitable Liquid Residue (ILR) result.

C. Forensic Fire Debris Analysis Workflow

Forensic fire debris analysis begins with the examination of physical evidence. Investigators usually retrieve these items from the scene of a fire, as well as from secondary locations, such as a person's clothing or vehicle. Although slight variations can be observed in different labs' standard operating procedures, the general workflow is shown in Figure 2.⁸⁷

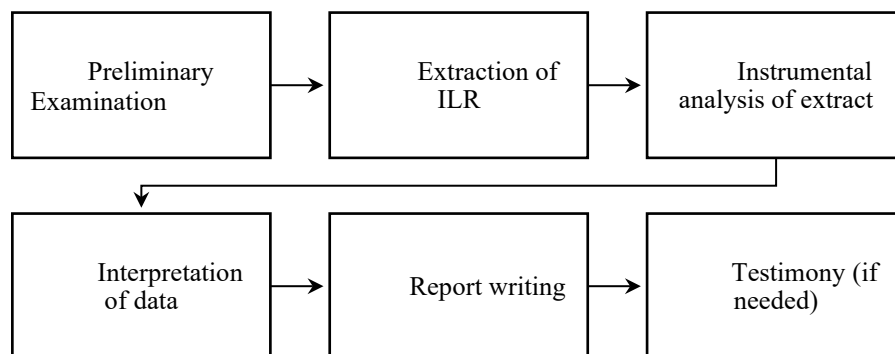


Figure 2: General steps in fire debris analysis.

Through various methods, ILR can be extracted from the evidentiary sample and concentrated into a small volume of chemical solvent.⁸⁸ This extract is then

⁸⁷ See STAUFFER ET AL., *supra* note 81, at 32.

⁸⁸ See, e.g., Subcommittee E30.13 on Ignitable Liquids, Explosives, and Gunshot Residue, *Standard Practice for Separation of Ignitable Liquid Residues from Fire Debris Samples by Solvent Extraction*, in 14.02 PARTICLE AND SPRAY CHARACTERIZATION; FORENSIC SCIENCES; ACCREDITATION & CERTIFICATION; FORENSIC PSYCHOPHYSIOLOGY; NANOTECHNOLOGY; FORENSIC ENGINEERING (2025).

analyzed by chemical instrumentation: analytical systems that can take various measurements of a sample to determine its elemental and chemical composition.⁸⁹ The data generated from these analyses are complex and demand meticulous interpretation by forensic chemists.⁹⁰ Once a competent analyst draws conclusions and another analyst reviews them, the results are compiled into a formal report and often subsequently presented at trial.

D. ASTM E1618

ASTM International, previously known as the American Society for Testing and Materials, is a globally recognized organization that develops and publishes voluntary consensus standards for a wide range of materials, products, systems, and services.⁹¹ ASTM Committees consist of a diverse group of subject matter experts in a particular field, including industry, academia, government, and other sectors.⁹² This diversity ensures that the committees develop balanced standards and consider the perspectives of various stakeholders.⁹³ ASTM Committee E30 on Forensic Sciences currently has over 300 members and is responsible for more than seventy standards, which play a dominant role in all aspects of forensic sciences, including test methods, classifications, and terminology.⁹⁴ Members regularly discuss, rework, and vote on standards to ensure that forensic science is constantly improving.⁹⁵

ASTM E1618, the *Standard Test Method for Ignitable Liquid Residues in Extracts from Fire Debris Samples by Gas Chromatography-Mass Spectrometry*, provides a systematic approach for forensic practitioners around the world to identify ILR in fire debris.⁹⁶ The use of a standard procedure bolsters the likelihood that the

⁸⁹ *Id.*

⁹⁰ *Id.*

⁹¹ See, e.g., *Detailed Overview*, ASTM INT'L, <https://www.astm.org/about/detailed-overview> [<https://perma.cc/DUC5-8EPC>] (last visited Jan. 15, 2026).

⁹² See *Technical Committees*, ASTM INT'L, <https://www.astm.org/membership-participation/technical-committees> [<https://perma.cc/MK5C-H858>] (last visited Jan. 15, 2026).

⁹³ See *Diversity, Equity, Inclusion, and Belonging: DEIB Commitment Statement*, ASTM INT'L, <https://www.astm.org/about/diversity-inclusion> [<https://perma.cc/TVN4-8YN6>] (last visited Jan. 15, 2026).

⁹⁴ *Committee E30 on Forensic Sciences*, ASTM INT'L, <https://www.astm.org/membership-participation/technical-committees/committee-e30> [<https://perma.cc/N6NQ-GDE2>] (last visited Jan. 15, 2026).

⁹⁵ *ASTM Membership*, ASTM INT'L, <https://www.astm.org/membership-participation/membership> [<https://perma.cc/HDK7-LY3Y>] (last visited Jan. 15, 2026).

⁹⁶ *E1618-19 Test Methods*, *supra* note 86.

methods used to analyze fire debris are reliable, reproducible, and scientifically valid. In addition to prescribing an accepted method of testing and interpretation, E1618 also defines how forensic reports should be worded in order to contextualize the results.⁹⁷ Crime labs may deviate from the standards based on their own procedures. Nevertheless, E1618 offers a blueprint for how fire debris is tested to determine the presence or absence of ILR.

E. Gas Chromatography-Mass Spectrometry

The most common instrumental analysis for the identification of ILR is gas chromatography-mass spectrometry (GC-MS).⁹⁸ GC-MS is the combination of two analytical instruments: the gas chromatograph, which separates individual chemicals in a mixture based on their physical and chemical properties, and the mass spectrometer, which breaks down chemicals into smaller, measurable fragments to create a distinct chemical fingerprint.⁹⁹ The combination of GC and MS in the application of fire debris analysis means that individual components in a mixture are first separated and then individually identified.

F. Interferents

In fire debris analysis, some chemicals in evidentiary samples can interfere with the interpretation of GC-MS data, thus hindering the identification of ILR.¹⁰⁰ These are known as “interferents.”¹⁰¹ The vast majority of samples that undergo fire debris analysis contain extraneous materials, such as fibers in clothing or wood from a door frame.¹⁰² These materials, or substrates, can endogenously contain or burn to produce chemicals that are similar to those found in ignitable liquids, which could lead to a false positive result.¹⁰³ Additionally, extraneous, benign substances may be present that produce interfering signals on the GC-MS, increasing the difficulty of true ILR identification.¹⁰⁴

⁹⁷ *Id.*

⁹⁸ See STAUFFER ET AL., *supra* note 81, at 208.

⁹⁹ *Id.*

¹⁰⁰ STAUFFER ET AL., *supra* note 81, at 358–59.

¹⁰¹ *Id.*

¹⁰² *Id.* at 347.

¹⁰³ *Id.* at 345.

¹⁰⁴ *Id.*

There are several categories of interferents, as described in Table 2. Each represents a potential increase in the complexity of interpreting GC-MS data in fire debris analysis.

Table 2: Interferents and their relation to a substrate.

Interferent Category	Definition	Example
Precursory products	Chemicals that originate from the raw material, manufacturing process, and contamination. ¹⁰⁵	Toluene, a petroleum distillate, is used in the manufacture of blue jeans. ¹⁰⁶
Pyrolysis and combustion products	Chemicals produced in a substrate by thermal degradation and oxidation due to the fire. ¹⁰⁷	Polyvinyl chloride (PVC), commonly used in pipes, produces aromatic compounds when thermally degraded. ¹⁰⁸
Fire suppression products	Chemicals used to combat fires. While these do not bring a possibility of false positives for ILR, their presence can diminish the amount of ILR recovered. ¹⁰⁹	Chemicals contained in fire extinguishers. ¹¹⁰

The existence of interferents necessitates the use of a substrate control or comparison sample. In fire debris analysis, a comparison sample is a sample of material collected from the fire scene that is believed to be free from any foreign ignitable liquids and have undergone some charring.¹¹¹ The purpose of a comparison sample is to help identify which compounds are naturally present in the materials, and which pyrolysis (burning) or combustion products may have been produced

¹⁰⁵ *Id.* at 362–63.

¹⁰⁶ AFPM Communications, *Toluene: The Secret Ingredient in Stretch Jeans*, AFPM (Mar. 15, 2020), <https://www.afpm.org/newsroom/blog/toluene-secret-ingredient-stretch-jeans> [<https://perma.cc/YZ9R-S227>].

¹⁰⁷ See STAUFFER ET AL., *supra* note 81, at 456, 463.

¹⁰⁸ *Id.* at 461.

¹⁰⁹ STAUFFER ET AL., *supra* note 81, at 468.

¹¹⁰ *Id.* at 466.

¹¹¹ See NAT'L CTR. FOR FORENSIC SCI., *supra* note 77.

during the fire.¹¹² For evidence not collected at the scene of the fire, *e.g.*, clothing from a suspected arsonist, a comparison sample would be that same article of clothing but brand new. A comparison sample is crucial to serve as a baseline or reference point for fire debris analysis.

G. Putting It All Together: Contextualization of Data from the Lively Case

When ignitable liquids are analyzed in their pure form, interpretation of the resulting data tends to be relatively straightforward.¹¹³ But fire debris analysts seldom examine “neat” ignitable liquids; typically, they test ILR contained in complex substrates. This means analysts must consider a vast array of both task- and fact-relevant information during their interpretation process.

One fire debris analysis expert describes the following steps for interpretation:

- A: Identify the sample and its substrates.
- B: Estimate the typical contribution from that substrate.
- C: Determine to which influences the substrate was subjected.
- D: Estimate the effect of these influences.
- E: Study the [GC data] from start to end, including peak identification.
- F: Study the [MS data] in the regions of interest, including peak identification.¹¹⁴

Unfortunately, these steps were not taken in the original fire debris analysis in Charles Jason Lively’s wrongful conviction. As noted above, in 2017 the West Virginia Innocence Project obtained the services of Glen Jackson, a professor of forensic and investigative science, to review the evidence in the *Lively* case.¹¹⁵ Although Dr. Jackson agreed with the State’s original finding of toluene in the debris on scene, he stated that “given that toluene is a common pyrolysis [burning] product of wood and flooring materials, one cannot be confident that the toluene . . . is present because an ignitable liquid was applied to the [floor].”¹¹⁶ He stated that “once a compound or class of compounds is identified in fire debris, an analyst must take

¹¹² See STAUFFER ET AL., *supra* note 81, at 175.

¹¹³ *Id.* at 441.

¹¹⁴ *Id.* at 475.

¹¹⁵ Unopposed Motion for Vacatur of Convictions and Motion for New Trial at Exhibit B, *State v. Lively*, 921 P.2d 1035 (Wash. 1996) (No. 05-F-157-S).

¹¹⁶ *Id.*

great care to determine whether the compounds arose from background contamination in the matrix, pyrolysis products during the fire, or from a foreign ignitable liquid.”¹¹⁷

Although it had been more than fourteen years since the fire, Dr. Jackson was able to apply this type of due diligence when he received additional samples from the scene to test.¹¹⁸ The additional testing demonstrated there were *many* known pyrolysis products, including toluene, in the data from burnt flooring in the house, but that no evidence suggested the presence of any foreign chemicals.¹¹⁹ Furthermore, a simple search of a fire debris substrate database showed toluene was a prominent pyrolysis product in some wood flooring.¹²⁰ Sadly, the wrongful conviction of Charles Jason Lively is not the only time errors in forensic fire debris analysis have produced a miscarriage of justice.

III. STUDY OF WRONGFUL CONVICTIONS INVOLVING FORENSIC FIRE DEBRIS ANALYSIS

A. *Study Parameters*

After identifying a gap in the scholarly literature, we designed a targeted study of wrongful convictions generated in part through forensic fire debris analysis. The requirements for inclusion in this survey were: (1) overturned arson convictions relating to a fire believed by the prosecution to be intentionally set, (2) with a positive finding of ignitable liquid residues in fire debris evidence, (3) the validity of the fire debris analysis was in question during post-conviction litigation, and (4) the individual maintains their innocence.¹²¹

We then examined the cases to determine where the fire debris analysis went awry. Cases were labeled as “misattributions” when the positive ILR result was a true positive, indicating that the chemical identified was most likely present at the scene, albeit for a reason that did not inculpate the person convicted of arson. Cases

¹¹⁷ *Id.*

¹¹⁸ *Id.*

¹¹⁹ *Id.*

¹²⁰ *ILRC Database Information*, NAT’L CTR. FOR FORENSIC SCI., <https://ilrc.ucf.edu/ilrc-database-information/> [https://perma.cc/437A-KRMP] (last visited Jan. 15, 2026).

¹²¹ Forensic scientists will colloquially refer to all samples that undergo a certain type of testing as “[testing type] evidence.” Thus, “fire debris evidence” refers to any evidence collected for the purpose of undergoing fire debris analysis. It not only refers to actual debris from the fire, but also other items that may be tested for the presence of ILR, such as someone’s clothing, or a bottle of unknown liquid found in someone’s possession.

were designated as “misidentifications” when the positive ILR result was a false positive, suggesting the ignitable liquid identified was not actually present. Any case where it was unclear if the interpretation resulted in a misattribution or misidentification was labeled as “unknown.” Ultimately, this led to the identification of seventeen “fire debris exonerees”: ten misattributions, five misidentifications, and two cases with both (see Table 3 below).¹²²

Table 3: Exonerees included in this study.

Exoneree	State	Misattribution?	Misidentification?
Greg Brown ¹²³	Pennsylvania		X
Kristine Bunch ¹²⁴	Indiana	X	X
Sonia Cacy ¹²⁵	Texas		X
Daniel Carnevale ¹²⁶	Pennsylvania	X	
Francis Choy ¹²⁷	Massachusetts		X
Louis DiNicola ¹²⁸	Pennsylvania	X	

¹²² While we have organized the cases into broad categories, each one is ultimately a nuanced example of compounding evidence and overlapping errors, as discussed in more detail below. We note as well that several additional arson cases presented similar forensic and contextual features but did not map neatly into our study parameters, including the convictions of Michael Politte (Missouri) and Kenneth Richey (Ohio).

¹²³ *Greg's Story*, PA. INNOCENCE PROJECT, <https://painnocence.org/greg-brown> [<https://perma.cc/PWC3-FCXN>] (last visited Jan. 15, 2026); *see also* Commonwealth v. Brown, 2014 Pa. Dist. & Cnty. Dec. LEXIS 47 (Pa. Ct. Com. Pl. 2014). After Brown was granted a retrial, he entered a plea deal that allowed him to maintain his innocence and receive a sentence of time served.

¹²⁴ Rob Warden, *Kristine Bunch*, NAT'L REGISTRY OF EXONERATIONS, <https://exonerationregistry.org/cases/11255> [<https://perma.cc/955H-ED9T>] (last updated Jan. 4, 2021); *see also* Bunch v. State, 964 N.E.2d 274 (Ind. Ct. App. 2012).

¹²⁵ Maurice Possley, *Sonia Cacy*, NAT'L REGISTRY OF EXONERATIONS, <https://exonerationregistry.org/cases/12193> (Feb. 13, 2017); [<https://perma.cc/B68W-5SPH>]; *Ex parte* Cacy, 543 S.W.3d 802 (Tex. Crim. App. 2016).

¹²⁶ Maurice Possley, *Daniel Carnevale*, NAT'L REGISTRY OF EXONERATIONS, <https://exonerationregistry.org/cases/12797> [<https://perma.cc/2MWL-RPP5>] (last updated Feb. 28, 2022); *see also* Commonwealth v. Carnevale, 2012 Pa. Dist. & Cnty. Dec. LEXIS 36 (Pa. Ct. Com. Pl. 2012).

¹²⁷ Maurice Possley, *Frances Choy*, NAT'L REGISTRY OF EXONERATIONS, <https://exonerationregistry.org/cases/12896> [<https://perma.cc/GQ57-UY3P>] (last updated Dec. 2, 2024); *see also* Commonwealth v. Choy, No. 0383-CR-00300, 2020 Mass. Super. LEXIS 195 (Sept. 17, 2020).

¹²⁸ Maurice Possley, *Louis DiNicola*, NAT'L REGISTRY OF EXONERATIONS, <https://exonerationregistry.org/cases/11132> (July 15, 2012); *see also* Commonwealth v. DiNicola, 468 A.2d 1078 (Pa. 1983).

Exoneree	State	Misattribution?	Misidentification?
David Lee Gavitt ¹²⁹	Michigan		X
Adam Gray ¹³⁰	Illinois	X	
James Hebshie ¹³¹	Massachusetts (Federal)	X	
Jaqueline Latta ¹³²	Indiana	X	
Roger Latta ¹³³	Indiana	X	
Han Tak Lee ¹³⁴	Pennsylvania	X	
Charles Jason Lively ¹³⁵	West Virginia	X	
Garland "Butch" Martin ¹³⁶	Texas	X	
Davey Reedy ¹³⁷	Virginia		X

¹²⁹ Maurice Possley, *David Lee Gavitt*, NAT'L REGISTRY OF EXONERATIONS, <https://exonerationregistry.org/cases/11106> [<https://perma.cc/TY7S-59VE>] (last updated Aug. 6, 2019).

¹³⁰ Maurice Possley, *Adam Gray*, NAT'L REGISTRY OF EXONERATIONS, <https://exonerationregistry.org/cases/12234> [<https://perma.cc/N7S6-2K9J>] (last updated May 25, 2023).

¹³¹ Maurice Possley, *James Hebshie*, NAT'L REGISTRY OF EXONERATIONS, <https://exonerationregistry.org/cases/11056> [<https://perma.cc/MY3Q-5Q7F>] (last updated May 10, 2015); *see also* United States v. Hebshie, 754 F. Supp. 2d 89 (D. Mass. 2010).

¹³² Maurice Possley, *Jacqueline Latta*, NAT'L REGISTRY OF EXONERATIONS, <https://exonerationregistry.org/cases/12048> [<https://perma.cc/5TMD-MEK8>] (last updated Sept. 22, 2022).

¹³³ Maurice Possley, *Roger Latta*, NAT'L REGISTRY OF EXONERATIONS, <https://exonerationregistry.org/cases/12047> [<https://perma.cc/W555-5XFV>] (last updated Sept. 22, 2022).

¹³⁴ Maurice Possley, *Han Tak Lee*, NAT'L REGISTRY OF EXONERATIONS, <https://exonerationregistry.org/cases/11933> [<https://perma.cc/VE3X-9FMN>] (last updated Nov. 3, 2021); *see also* Han Tak Lee v. Tennis, No. 4:CV-08-1972, 2014 U.S. Dist. LEXIS 110766 (M.D. Pa. Aug. 7, 2014); *see also* *Locked Away for 24 Years, Han Tak Lee Still Feels Imprisoned*, N.Y. TIMES (Mar. 11, 2016), <https://www.nytimes.com/2016/03/11/nyregion/locked-away-for-24-years-han-tak-lee-still-feels-imprisoned.html>.

¹³⁵ Maurice Possley, *Charles Jason Lively*, NAT'L REGISTRY OF EXONERATIONS, <https://exonerationregistry.org/cases/12898> [<https://perma.cc/8V5Q-BV6T>] (last updated Mar. 11, 2024); Unopposed Motion for Vacatur of Convictions and Motion for New Trial, State v. Lively, 921 P.2d 1035 (Wash. 1996) (No. 05-F-157-S); *see also* Lively v. Ballard, 2015 W. Va. LEXIS 620.

¹³⁶ *Butch Martin*, INNOCENCE PROJECT OF TEXAS, <https://innocencetexas.org/cases/garland-butch-martin/>; *see also* *Ex parte Martin*, No. WR-93,211-01, ___ S.W.3d ___, 2024 WL ___ (Tex. Crim. App. May 22, 2024) (Yeary, J., dissenting).

¹³⁷ Maurice Possley, *Davey Reedy*, NAT'L REGISTRY OF EXONERATIONS (Dec. 31, 2015), <https://exonerationregistry.org/cases/11934> [<https://perma.cc/TL7Q-GRD4>]; *i* Reedy v. Wright, 60 Va. Cir. 18 (Va. Cir. Ct. 2002).

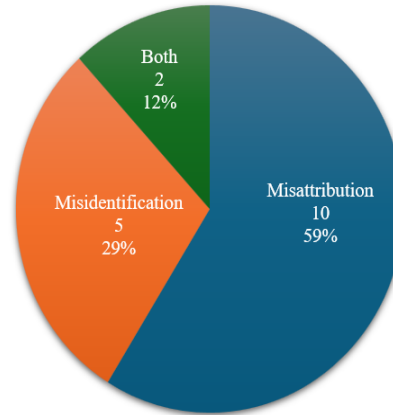
Exoneree		State	Misattribution?	Misidentification?
Randy Seal ¹³⁸		Florida	X	X
George Souliotes ¹³⁹		California	X	

¹³⁸ *Randy Seal*, INNOCENCE PROJECT OF FLA., <https://www.floridainnocence.org/randyseal> [<https://perma.cc/MPE7-6CE2>] (last visited Jan. 15, 2026); *see also* J.D. Schmid, *The Innocence Project of Florida Announces the Release of Randy Seal: Wrongful Conviction from Faulty Fire Forensics*, AM. ACAD. OF FORENSIC SCI. (Aug. 23, 2024), <https://www.aafs.org/article/innocence-project-florida-announces-release-randy-seal-wrongful-conviction-faulty-fire> [<https://perma.cc/YV8R-XVG2>].

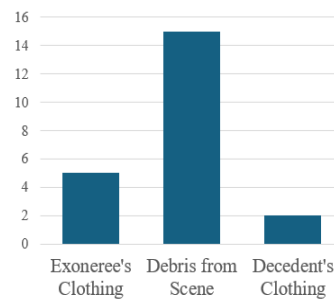
¹³⁹ *George Souliotes*, N. CAL. INNOCENCE PROJECT, <https://ncip.org/george-souliotes/> [<https://perma.cc/4QL6-RVWL>] (last visited Jan. 15, 2026); *see also* *Souliotes v. Grounds*, 2013 U.S. Dist. LEXIS 53170 (E.D. Cal. Apr. 12, 2013) (No. 1:06-cv-00667 AWI MJS HC); *Souliotes v. Evans*, 622 F.3d 1173 (9th Cir. 2010).

Statistics

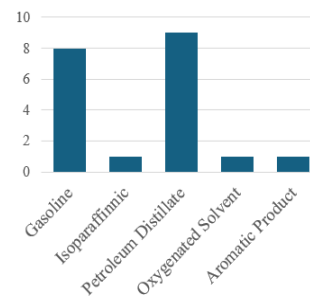
Number of Cases per Issue Type



ILR Location



ILR Identified



Notably, all seventeen cases involved flawed methodology in the origin and cause investigation as well as fire debris analysis. Even in the three cases where post-conviction investigation suggested the fire may have been set by a person (Cacy,¹⁴⁰ Choy,¹⁴¹ and Reedy¹⁴²), the origin and cause determinations were fundamentally unsound. This pattern underscores the synergistic effect between origin and cause investigation and fire debris analysis, where a positive finding on one side could potentially obscure errors on the other.

In several cases, errors in fire debris analysis became the foundation upon which the entire arson theory was built. In most cases, forensic errors were not

¹⁴⁰ See Possley, *supra* note 125.

¹⁴¹ See Possley, *supra* note 127.

¹⁴² See Possley, *supra* note 137.

isolated but rather started a domino effect that influenced the interpretation of evidence throughout the investigations and trials. For instance, in Kristine Bunch's case from Indiana, prosecutors asserted that the fire must have been incendiary because multiple floor samples tested positive for heavy petroleum distillates.¹⁴³ Investigators assumed that multiple debris samples testing positive for ILR indicated multiple points of origin, and thus, intentional fire setting.¹⁴⁴ Post-conviction records and expert reviews stated that the sample's classification was "undetermined." The samples were consistent with an innocuous source: a kerosene heater in the living room.¹⁴⁵ Similarly, in George Souliotes's case, analysts identified medium petroleum distillates at both the fire scene and on Souliotes's shoes, which served as the "smoking gun" linking the defendant to the scene.¹⁴⁶ In reality, medium petroleum distillates are ubiquitous in everyday materials such as flooring and adhesives used to affix soles to shoes.¹⁴⁷

All of these cases followed a similar post-conviction trajectory—years or even decades of litigation were needed to undo the damage. Most defendants had exhausted their direct appeals, as appellate courts initially upheld verdicts given the scientific evidence presented. Relief only came through extraordinary means: motions for new trials, federal habeas corpus relief, or even executive clemency. When motions for a new trial were granted, prosecutors often opted not to re-try the cases given the evidentiary issues. Some exonerees only secured guaranteed freedom through special pleas (Brown¹⁴⁸ and Seal¹⁴⁹) that allowed them to maintain their innocence while avoiding the risk of a new trial after decades behind bars.

We must note some of the limitations of our study. For one thing, we do not know the full universe of cases—including "rightful" convictions—in which accurate fire debris evidence contributed to the result. For another, these seventeen overturned arson convictions presumably only represent the "tip of the iceberg," those cases in which a prisoner garnered the services of an innocence project or post-conviction attorney, procured a second look at the fire debris evidence from a new expert in the field, and succeeded in convincing a judge and/or prosecutors that an

¹⁴³ See *Bunch v. State*, 964 N.E.2d 274, 280 (Ind. Ct. App. 2012).

¹⁴⁴ See *id.* at 299; see also Possley, *supra* note 135 (describing how this was also the reasoning in the Lively investigation).

¹⁴⁵ See *Bunch*, 964 N.E.2d at 283.

¹⁴⁶ See *Souliotes*, 622 F.3d at 1176.

¹⁴⁷ See *id.* at 1176–77.

¹⁴⁸ See PA. INNOCENCE PROJECT, *supra* note 123.

¹⁴⁹ See INNOCENCE PROJECT OF FLA., *supra* note 138.

injustice occurred.¹⁵⁰ We can only speculate about the unknown number of innocent people wrongfully convicted of arson based on faulty fire debris analysis who never benefited from such a fortuitous sequence of events. After all, data accumulated by the Federal Bureau of Investigation indicate that law enforcement agencies reported more than 33,000 arsons in 2019 alone.¹⁵¹

Despite these limitations, the results of our study show that fire debris analysts occasionally either misattribute or misidentify ILR in a manner that yields the conviction of an innocent criminal defendant. As noted above, jurors are ill-positioned to weigh the validity of forensic expert testimony and tend to defer to arson scientists.¹⁵² For that reason, among others, it is essential that (a) forensic fire debris specialists suitably account for context in their analyses and (b) that jurisdictions create procedures that allow prisoners to seek new trials or even exonerations when they were convicted based on specious fire debris evidence.

IV. CONFRONTING CONTEXTUAL DEFICIENCY: THOUGHTS ON REFORM

In contemplating how to grapple with contemporary fire debris analysis and its potential impact on innocent criminal defendants, it is useful to think about both “front-end” reforms that would enhance the quality of the forensic evidence introduced at trial as well as “back-end” reforms to facilitate the ways in which convicted arsonists challenge their cases.

A. Front-End Reforms

1. Standardization and Training

Forensic analysts should be encouraged, ideally even required, to adhere to the standards promulgated in ASTM’s E1618.¹⁵³ These standards not only promote best practices but also advance fairness at trial. By employing a uniform approach to this forensic discipline, prosecutors, defense lawyers, and judges would be better able to

¹⁵⁰ E.g., Daniel S. Medwed, *The Zeal Deal: Prosecutorial Resistance to Post-Conviction Claims of Innocence*, 84 B.U. L. REV. 125, 131 (2004) (noting that documented exonerations likely represent the “tip of the iceberg” of actual wrongful convictions).

¹⁵¹ *Crime in the United States, 2019: Arson*, FBI: UNIF. CRIME REPORTING PROGRAM (2019), <https://ucr.fbi.gov/crime-in-the-u.s/2019/crime-in-the-u.s.-2019/topic-pages/arson.pdf> [<https://perma.cc/8H35-QBK2>] (last visited Jan. 15, 2026).

¹⁵² See Peterson et al., *supra* note 9, at 1784 (noting that jurors tend to find expert witness testimony compelling and often results in higher conviction rates when present).

¹⁵³ See *E1618-19 Test Methods*, *supra* note 86.

evaluate the significance of the results and communicate that significance to the jury. This might ameliorate some of the risks of jurors' deference to expert witnesses.¹⁵⁴

The question, then, is how to spur crime labs to adopt these standards and avoid variations from lab to lab and jurisdiction to jurisdiction. One benefit of our federal system is that each state has flexibility in how it operates subject to certain constitutional constraints. One downside is that state-level autonomy might create differential treatment in arson cases across the nation. And the community of crime labs in the United States is famously diverse, ranging from public labs and forensic units to private labs and independent consultants.¹⁵⁵

Tethering fire debris analysis standards like E1618 to the crime lab accreditation process could help. As of 2024, roughly 88% of United States crime labs have received accreditation, typically through one of the two chief forensic oversight bodies.¹⁵⁶ Local law enforcement monitors the remaining 12% of labs.¹⁵⁷ The accreditation process should obligate labs to follow E1618 and train analysts in how to follow that guidance. That alone could reduce the chance of flawed test results, the presentation of dubious forensic evidence at trial, and ultimately the conviction of an innocent person. On the topic of training, programs should encompass lessons that address how contextual deficiencies may impact fire debris analysis.

Of course, it would be unfair to require more affirmative duties of forensic scientists without also giving them the proper education and resources to comply. That includes a greater understanding of legal concepts. Although graduate-level forensic science degrees usually require mock testimony classes as part of the core curriculum, not all demand coverage of basic criminal law.¹⁵⁸ Not only do budding forensic scientists need to understand the criminal legal system they wish to operate within, but active practitioners must continue to study the ever-changing

¹⁵⁴ See Peterson et al., *supra* note 9, at 1784 (noting that jurors tend to defer to expert witness testimony).

¹⁵⁵ E.g., Lucas Zarwell, John Grassel & Maya Metni Pilkington, *Police Crime Lab Accreditation Initiative*, NAT'L INST. OF JUST. (Jan. 31, 2024), <https://nij.ojp.gov/topics/articles/police-crime-lab-accreditation-initiative> [<https://perma.cc/Q474-5URT>].

¹⁵⁶ *Id.*

¹⁵⁷ *Id.*

¹⁵⁸ See, e.g., *Core Curriculum for MS in Biomedical Forensic Sciences*, B.U. CHOBANIAN & AVEDISIAN SCH. OF MED., <https://www.bumc.bu.edu/gms/bmfs/curriculum/core-curriculum/> [<https://perma.cc/J5DL-4HYM>] (last visited Jan. 15, 2026) (highlighting an example of a forensic curriculum that includes mock testimony and basic criminal law); cf. *Curriculum for Forensic Science, M.S.*, UNIV. OF NEW HAVEN HENRY C. LEE COLL. OF CRIM. JUST. & FORENSIC SCI., https://catalog.newhaven.edu/preview_program.php?catoid=31&poid=8804&returnto=2076 [<https://perma.cc/NG9M-82KY>] (last visited Jan. 15, 2026) (providing an example of a forensic curriculum that only includes mock testimony).

jurisprudence defining their profession. This could be implemented by requiring continuing education for both forensic laboratory accreditation and individual certification. Furthermore, crime laboratories should employ an in-house attorney as part of their accreditation-required quality systems, a luxury currently only afforded to larger crime laboratories with greater funding.¹⁵⁹

Forensic analysts and crime labs are not solely responsible for the errors wrought by problematic forensic fire debris evidence. Attorneys—especially prosecutors who control discovery—must have a more in-depth understanding of forensic science disciplines. No attorney should be expected to understand every scientific nuance in a case. Even so, continuing education with an emphasis on forensic science would assist prosecutors in recognizing potentially exculpatory evidence. Judges, too, must also be well-versed in the forensic science they supposedly vet in their courtrooms. Without better interdisciplinary training across all courtroom actors, contextual deficiencies will continue to slip through the cracks, jeopardizing the fairness of criminal trials.

2. Constitutional Safeguards

The role of forensic evidence in criminal trials is not just shaped by the process through which it is generated and presented in court. Several constitutional doctrines also affect how jurors receive, and perceive, this information.

Pursuant to the seminal 1963 case of *Brady v. Maryland*,¹⁶⁰ prosecutors have a constitutional duty to disclose evidence to the defense that is “favorable” to the accused and “material” to guilt or punishment.¹⁶¹ Evidence is material if there is a “reasonable probability” that it would affect the outcome.¹⁶² Known flaws in the production of forensic evidence, including contextual deficiencies in fire debris analysis, may satisfy the *Brady* test, serving as information that is favorable to the defendant (by discounting the notion that the fire was set intentionally) and that has a reasonable probability of affecting the assessment of guilt. If defense attorneys were armed with discovery about gaps in the forensic evidence in advance of trial, they would be better prepared to cross-examine the state’s expert witness and present their own competing interpretation of the evidence.

What are the implications of *Brady* for forensic fire debris analysis? If fire debris test processes were standardized for forensic scientists and they were trained

¹⁵⁹ Zarwell et al., *supra* note 155.

¹⁶⁰ 373 U.S. 83 (1963).

¹⁶¹ *Id.* at 87.

¹⁶² *United States v. Bagley*, 473 U.S. 667, 668 (1985).

in best practices in the manner discussed above,¹⁶³ analysts would be required to collect and test comparison samples or compare against known substrate databases, such as what Dr. Jackson did in Charles Jason Lively's post-conviction testing.¹⁶⁴ Prosecutors would be constitutionally obligated to disclose the results of these comparison tests if they tend to exculpate the accused. While the original finding of toluene was scientifically valid in the *Lively* case, its presence could not be meaningfully interpreted without determining whether the toluene stemmed from a foreign ignitable liquid or was inherent to the burned flooring itself.¹⁶⁵ Failing to collect a comparison sample or to make a good faith effort in determining the inherent chemical profile of a substrate undermines the integrity of the entire analysis.

But what if the government neglects to preserve samples that could be used to achieve potentially exculpatory results? In *Arizona v. Youngblood*, the Supreme Court held that due process is not violated when the state fails to preserve potentially exculpatory evidence unless the defendant can prove that the government acted in bad faith.¹⁶⁶ *Youngblood* could pose a problem in the fire debris testing realm in situations where sloppy behavior, rather than intentional misbehavior, leads to the destruction of the comparison samples. This is all the more reason to standardize processes across the board, including a requirement that forensic scientists collect and preserve these results and an understanding that the failure to do so would create a presumption of bad faith.

B. Back-End Reforms

Even if processes were standardized, forensic analysts, lawyers and judges were adequately trained, and prosecutors were compelled to disclose information related to comparison and control tests in fire debris analyses, some innocent defendants would fall through the cracks and suffer wrongful convictions. Given that likelihood, perhaps inevitability, there must be robust post-conviction procedures that allow prisoners convicted of arson the opportunity to return to court and contest the underlying validity of the fire debris evidence in their cases.

In general, there are two types of post-conviction remedies available in these instances. First, every jurisdiction has some type of procedure that allows for those convicted of crimes to present "newly discovered evidence" to a judge and claim that

¹⁶³ See *supra* notes 96–112 and accompanying text.

¹⁶⁴ See Unopposed Motion for Vacatur of Convictions and Motion for New Trial at Exhibit B, *State v. Lively*, 921 P.2d 1035 (Wash. 1996) (No. 05-F-157-S).

¹⁶⁵ *Id.*

¹⁶⁶ *Arizona v. Youngblood*, 488 U.S. 51, 58 (1988).

evidence is substantial enough to warrant a new trial.¹⁶⁷ Without going too far into the weeds of these complicated procedures, which are grounded in a sixteenth-century British remedy known as the writ of error *coram nobis*,¹⁶⁸ it is important to note that “newly discovered” evidence does not refer to evidence that is merely newly available to the defense team. It means evidence that could not have been unearthed by the defense even with the exercise of due diligence prior to trial.¹⁶⁹ Accordingly, these procedures do not lend themselves readily to the fire debris setting in which contextual deficiencies make up the problem, rather than “newly discovered” evidence per se.

Here is an example. Suppose a forensic analyst failed to properly account for context at the time of fire debris testing and the fire investigator neglected to collect comparison samples. Further suppose the defense later, after conviction, pursues these comparison analyses on its own by testing the remaining evidence. That does not necessarily comprise “newly discovered evidence” under these post-conviction procedures because the defense could have sought to do that before trial.

The second type of post-conviction remedy is a challenge based on a state statute targeting flawed forensic science. Starting with Texas in 2013, a few states have passed legislation specifically geared toward permitting prisoners to overturn convictions predicated on dubious forensic science.¹⁷⁰ Yet these so-called “junk science” writs contain barriers similar to more traditional *coram nobis*-style remedies. The Texas law obliges applicants for relief to put forth “relevant scientific evidence” that “is currently available and was not available at the time of the convicted person’s trial” even through the exercise of reasonable diligence.¹⁷¹ In the fire debris analysis setting, would new, post-conviction results from comparison sample testing conducted by the defense count as evidence that was not available at the time of trial? We doubt it.

Arguably, statutes that depend upon “newly discovered evidence” to rectify flawed convictions are poor vehicles to remedy those compromised by deficient

¹⁶⁷ See Daniel S. Medwed, *Up the River Without a Procedure: Innocent Prisoners and Newly Discovered Non-DNA Evidence in State Courts*, 47 ARIZ. L. REV. 655, 659 (2005).

¹⁶⁸ See *id.* at 669.

¹⁶⁹ See, e.g., DANIEL S. MEDWED, BARRED: WHY THE INNOCENT CAN’T GET OUT OF PRISON 5 (2022).

¹⁷⁰ David Faigman & Jeff Kukucka, *The Law Must Respond When Science Changes*, SCI. AM. (Nov. 4, 2024), <https://www.scientificamerican.com/article/the-law-must-respond-when-science-changes/> [<https://perma.cc/LZ7Z-6QKH>]; Valena E. Beety, *Changed Science Writs and State Habeas Relief*, 57 HOUS. L. REV. 483, 524–26 (2020).

¹⁷¹ TEX. CODE OF CRIM. PROC. art. 11.073(b)(1)(A) (2015).

contextual integration of forensic results. We should amend those laws to include situations where forensic analysts misattribute or misidentify results because of an inability to take the entire context of the purported crime fully into account. As our study shows, this happens in the realm of forensic fire debris analysis and will continue to do so unless action is taken.

CONCLUSION

Our novel study of seventeen wrongful arson convictions involving forensic fire debris analysis demonstrates how contextual deficiencies can contribute to the conviction of the innocent. Standardizing testing procedures, and training analysts on how to follow uniform and unbiased methods, would go a long way toward reducing the risk of a miscarriage of justice. In addition, it is critical to revamp post-conviction procedures to enable those convicted at trial based on specious fire debris analysis to seek and obtain relief. Faulty forensic fire debris analysis has burned too many innocent defendants. We must do more than just heal those wounds one case at a time.

