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Consequential lightning-caused wildfires and the "let burn" narrative

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Abstract

Background Current guidance for implementation of United States federal wildland fire policy charges agencies with restoring and maintaining fire-adapted ecosystems while limiting the extent of wildfires that threaten life and property, weighed against the risks posed to firefighters. These ostensibly conflicting goals can make it difficult to clearly communicate specific response objectives of a given incident. Inherent ambiguity can expose land management agencies, like the United States Department of Agriculture Forest Service (USFS), to scrutiny when once remote, lightning-ignited wildfires burn across boundaries and result in damage. One such incident was the 2021 Tamarack Fire, ignited by lightning in a remote USFS wilderness area and ultimately burning 27,776 ha across multiple jurisdictions and destroying 25 structures. Intense sociopolitical interest developed around this incident, reigniting a "let burn" policy debate of the USFS despite this policy not formally existing. We provide a first approximation at quantifying the base rates of potentially consequently lightning-caused fires like the Tamarack Fire. We use multiple sources of fire-reporting data to characterize USFS fires from 2009 to 2020 by management-strategy to identify Tamarack Fire analogs. Within Incident Command System 209 (ICS-209) reports for fires originating on USFS lands, we identified 32 wildfires with similar key characteristics to the Tamarack Fire; nearly half ignited within wilderness areas.

Results Initial strategies were driven by resource objectives for only six of the 32 wildfires; firefighter hazard mitigation was the primary driver of all others. No fire exhibited every characteristic of the Tamarack Fire. Analog fires accounted for a small percent (3.4%) of large (> 121 ha) USFS lightning-caused ignitions. These fires were responsible for 61.6% of structures destroyed and 25.8% of total personnel commitments of large lightning-caused USFS fires.

Conclusions Lightning-ignited wildfires that could have resulted in sociopolitical controversy are rare, and those with strategies driven by resource objective are even rarer. More commonly, risks posed to firefighters from terrain, snags, or accessibility are factors driving strategy, even when fires ignite within wilderness areas. These results suggest that simple definitions of strategy such as those reported within the ICS-209 lack clarity and may increase sociopolitical pressure on the agency to continue aggressive fire exclusion strategies.

Keywords Wildfire response, Strategy, Cross-boundary, Wildfire transmission, Wilderness, ICS-209, ICS-209-PLUS database, "let burn"

Resumen

Antecedentes Los guías actuales para la implementación de políticas federales de manejo del fuego en los EEUU, responsabilizan a las agencias por las tareas de restauración y el mantenimiento de ecosistemas adaptados al fuego,

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mientras que limitan la extensión de los incendios que afectan la vida y la propiedad, sopesando esto con el riesgo al que exponen a los combatientes de incendios. Estas metas ostensiblemente conflictivas pueden hacer dificultoso el comunicar claramente respuestas objetivas en un incidente dado. Esta inherente ambigüedad puede exponer a las agencias de manejo de tierras, como el Servicio Forestal dependiente del Departamento de Agricultura (USFS), a un examen profundo, cuando incendios iniciados por rayos en áreas remotas sobrepasan los límites y resultan en daños. Uno de estos incidentes fue el incendio de Tamarak, que se inició por rayos en un área silvestre remota perteneciente al USFS, quemando 27.776 ha a través diferentes jurisdicciones y destruyendo 25 estructuras. Un interés sociopolítico muy intenso se desarrolló alrededor de este incidente, reavivando el debate sobre la política de "dejar quemar" del USFS, aunque esta política no exista formalmente. Proveemos acá una primera aproximación para cuantificar la línea de base sobre las consecuencias potenciales de incendios iniciados por rayos como el incendio de Tamarak. Usamos múltiples fuentes de reportes de incendios causados por rayos para caracterizar incendios del USFS desde 2009 al 2020 mediante estrategias para identificar análogos al incendio de Tamarak. Dentro del esquema de reportes del Comando de Incidentes 209 (ICS-209) sobre los incendios originados en tierras manejadas por el USFS, identificamos 32 incendios con características clave similares al incendio de Tamarak; casi la mitad se iniciaron dentro de áreas silvestres.

Resultados Las estrategias iniciales fueron conducidas hacia objetivos basados en los recursos para solo seis de los 32 incendios; la mitigación del riesgo de los combatientes fue el conductor primario en todos los otros. Ningún incendio exhibió cada una de las características del incendio de Tamarak. Los incendios caracterizados como análogos representaron solo un pequeño porcentaje (3,4%) de los grandes incendios (> 121 ha) del USFS causados por rayos. Estos incendios fueron responsables del 61% de las estructuras destruidas y comprometieron el 25,8% del personal responsable en los grandes incendios causados por rayos en tierras del USFS.

Conclusiones Los incendios por rayos, que podrían haber resultado en alguna controversia sociopolítica, son raros, y aquellos con estrategias orientadas hacia los recursos son aún más raras. Más comúnmente, el riesgo al que son expuestos los combatientes de incendios en el terreno, como árboles muertos en pie, o accesibilidad, son factores que conducen esa estrategia, aún cuando los incendios se inicien en áreas silvestres. Estos resultados sugieren que la simple definición de las estrategias tales como las reportadas dentro de la CS-209, le faltan claridad y pueden incrementar la presión sociopolítica sobre en la agencia (USFS) para continuar con una política agresiva de estrategia de exclusión del fuego.

Background

Set against a backdrop of climate change, increasing area burned, rising suppression costs, and an ever-expanding set of values at risk, the United States Department of Agriculture Forest Service (USFS) is charged with balancing the protection needs of these values against the inevitability and necessity of wildland fire in the western United States (Calkin et al. 2015, Abatzoglou et al. 2016, Schoennagel et al. 2017). Since its adoption in 2009, the Guidance for Implementation of Federal Wildland Fire Management Policy has allowed for naturally ignited, unplanned wildfires to be concurrently managed for objectives including protection of values at risk while also allowing fire to fulfill its natural role on the landscape (IFWFPR 2009). In this implementation guidance, there are no clearly defined terms to describe the collective suite of strategies and tactics that may be applied to any individual incident, potentially resulting in miscommunication and in some cases decreasing trust between federal agencies, cooperators, and the public (Fillmore et al. 2021).

In some circumstances, this ambiguity has led to scrutiny of federal agencies like the USFS by some in the media and political arenas. This scrutiny asserts that the USFS has a de facto "let burn" policy that fails to rapidly suppress new lightning-caused ignitions before they can cause damage, particularly following high-profile fires that spread across jurisdictional boundaries and threatened life and property (Dood 2013, Chabria 2021, McClintock 2021). High-profile events such as the 2018 Pole Creek and Bald Mountain fires in Utah have reinforced this narrative. Initially assessed to be remote and unlikely to threaten communities or infrastructure (USFS 2019) these fires did the opposite, resulting in peak evacuations of over 4000 people along the densely populated Wasatch Front Range (St. Denis et al. 2023, USDA 2019).

Counternarratives to this "let burn" scrutiny can point to comprehensive analyses suggesting the greatest wildfire risk often emanates from human-caused ignitions on private lands (Mietkiewicz et al. 2020; Downing et al. 2022; Hantson et al. 2022), as well as a host of pragmatic factors that justify alternate approaches to minimizing area burned as quickly as possible. In some cases, scarcity of fire personnel and equipment due to ongoing fire activity elsewhere may limit options (Belval et al. 2020, 2022), and in others, local management objectives may call for restoring rather than excluding fire (Young et al. 2019, Davis et al. 2022, Iniguez et al. 2022). Importantly, firefighter safety hazards often preclude aggressive suppression tactics, especially when weighed against threats posed to values at risk. Implementation guidance for wildland fire explicitly states, "Firefighter and public safety is the first priority in every fire management activity." (IFWFPR 2009, pg. 8). Firefighter safety hazards can include remote terrain with limited accessibility or egress (Campbell et al. 2019) and environmental hazards such as steep slopes or standing dead trees (North et al. 2015, 2021, Dunn et al. 2019).

Irrespective of the comparative validity of these narratives, high-profile lightning-caused fires often result in renewed political and societal pressure for federal agencies to double down on reactive and regressive policies focused largely on aggressive fire exclusion. This feedback loop reinforces itself, perpetuating the wildfire paradox in which aggressive fire exclusion exacerbates responder hazards and increases future fire risk (Calkin et al. 2015; Finney 2021).

The 2021 Tamarack Fire represents a microcosm of the operational, ecological, social, and political complexities of managing wildfire events. On 4 July 2021, the Tamarack Fire was ignited by lightning on a ridgeline within the Mokelumne Wilderness on the Bridgeport Ranger District of the Humboldt-Toiyabe National Forest in California, USA. The preceding weeks had seen locally heavy initial attack, with 40 new fires burning 549 ha within 50 km of the Tamarack with many still requiring extended resource commitments (WFDSS 2022). Seven other fires were ignited in the area on 4 July, and due to limited resource availability, were triaged and responded to in the order of the most immediate threats posed to values. The Tamarack Fire remained relatively small (< 1 ha) until the morning of 16 July. Due to forecasted high winds, low humidity, and high temperatures, an interagency hotshot crew was assigned to the incident the morning of 16 July, along with an air attack platform and a type one helicopter. By mid-morning, fire behavior had increased dramatically, and by the end of the day over 4452 ha had burned, and the fire was outside of the wilderness, threatening structures in the community of Markleeville, CA. By 22 August, the Tamarack Fire had burned 27,776 ha across multiple jurisdictions, destroyed 25 structures, and damaged seven. At its peak, over 1600 firefighters were assigned and managed by a type one incident management team. The Tamarack Fire does not stand out in terms of area burned or structures destroyed compared to fire outcomes in California from 2021, but it is unique for the intense media and political interest it garnered and the criticism of the initial decision to not aggressively suppress as a "let burn" approach (McClintock and LaMalfa 2022, Pimlott 2021).

The initial management decision to monitor the Tamarack Fire, filed in the Wildland Fire Decision Support System (WFDSS 2021), was driven primarily by a high level of firefighter hazards and the apparent lack of values at risk. However, the potential for the fire to result in benefits to natural resources was documented as part of the decision rationale as a by-product of the selected course of action. This was in response to USFS risk management direction, part of which asks, "What are the opportunities to manage fire to meet land management objectives?" as part of the risk assessment protocols (NWCG 2021, page 116). While only one of several other considerations in the decision, the answer to this question could lend credence to the emerging narrative that the agency's "let burn" policy was primarily responsible (Moon and Chan 2021; Graff 2021). While the Tamarack Fire was still burning, on 2 August 2021, the USFS issued guidance for the remainder of the 2021 fire season stating that "managing fires for resource benefit is a strategy we will not use," while also placing additional restrictions on prescribed fire implementation (USDA Forest Service 2021).

Perhaps partially catalyzed by the Tamarack Fire, a renewed public and political interest in wildland fire management emerged. In January 2022, the Bipartisan Wildfire Caucus sent a letter to the President of the US requesting a review of the 2000 National Fire Plan, additional wildfire response resources, and a limit on firing tactics (e.g., backfiring) without additional approval (Neguse et al. 2022). Concurrently, the U.S. National Association of Counties considered a proposed resolution that would have urged the USFS to initiate a nationwide analysis of wildland fire management under the National Environmental Policy Act, and to suppress all fires in the interim (Kirk 2021). By March 2022, congressional legislation was introduced with the purpose of "extinguishing wildfires detected on National Forest System lands not later than 24 h after such a wildfire is detected" (McClintock and LaMalfa 2022: 2). This proposed legislation failed to become law.

Here we attempt a first approximation at quantifying the base rates of potentially consequently lightning-caused fires, with aims to resolve some of the ambiguity and confusion regarding the drivers of incident strategies and the "let burn" characterization of USFS fire policy, and to inform social and political dialog that may influence fire management decision-making and agency direction moving forward. To do this, we review and interpret agency fire reporting data to understand the frequency of lightning-ignited wildfires that could have informed "let burn" narratives. Specifically, we use key characteristics of the 2021 Tamarack Fire to identify and classify fires originating between 2009 and 2020. Our study expands upon recent research exploring aspects of cross-boundary (CB) wildfires (e.g., Barros et al. 2021, Downing et al. 2022), with our focus on the extent to which lightning-caused fires have exhibited characteristics which could have similarly created scrutiny of USFS incident strategies. We compare these analog fires in terms of factors including origin in wilderness, structures threatened and destroyed, personnel used, reported strategies, and reported strategy drivers (i.e., resource objectives versus firefighter safety). We aim to determine whether events like the Tamarack Fire are truly emblematic of a broader "let burn" approach that can result in critique and socio-political pressure, or if they are perhaps better characterized as rare but salient events.

Methods

We leveraged multiple tabular and spatial data sources (Table 1) to identify lightning-caused fires resulting in CB transmission originating from USFS lands, and which also shared other key attributes of the 2021 Tamarack Fire (referred to hereafter as analog fires). The core data for this study were derived from the ICS-209-PLUS dataset, which is a science-grade compilation of ICS-209 reports (St. Denis et al. 2023) spanning from 1999 to 2020. To obtain official agency reports of fire cause, initial suppression strategy, and ownership at the point of origin (POO), we connected the ICS-209-PLUS dataset to records from the USFS final fire reporting system (FIRESTAT) for 1999 through 2019, and from the Interagency Fire Occurrence Reporting Modules (InFORM; NIFC 2020) for 2020. Reported POOs were further classified by jurisdiction by intersecting them with the WFDSS Surface Management Agency (SMA; WFDSS 2022) and Aggregated Wilderness System (UM 2022) datasets. We focused on POOs that ignited naturally on USFS-managed lands from 2009 to 2020, which occurred after the adoption of the 2009 Guidance for Implementation of Federal Wildland Fire Management Policy (IFWFPR 2009).

We identified analog fires by querying this compiled dataset for the characteristics of the 2021 Tamarack Fire seen in Table 1; Fig. 1. Although the Tamarack fire was ignited within wilderness, we did not limit our selection of fires to only those that ignited in wilderness. Rather, we attributed each wildfire POO as being within wilderness or not. This allowed us to explore potential differences between the two populations. Other querying criteria stemming from the Tamarack fire characteristics were either treated as rigid filters (i.e., cause, complex association, and CB transmission) or as minimum acceptable values (i.e., maximum daily growth and growth duration). Rather than focusing on fires with a minimum fire size equal to the Tamarack, we chose to focus on fires greater than or equal to 121 hectares, a common threshold of US Fire Reporting metrics defined as a large fire in reporting systems. The largest fire size class in the US reporting system are those greater than or equal to 2023 hectares (NIFC 2020), which we used to inform our maximum daily growth. It is not uncommon for wildfires larger than 2023 ha to experience a single day growth of 2023 ha.

There were 940 large, lightning-caused USFS POO incidents with at least one ICS-209 report between 2009 and 2020. We applied further classification to this subset, which we call our denominator of interest, because they were potential candidates for alternative fire management strategies. We classified fires by growth duration and maximum fire spread rate (ha) to determine frequency of fires by threshold (Table 2). In total there were 66 fires with a maximum fire spread rate of at least 2023 ha. Of these we identified 41 fires with a growth duration greater than 14 days (Table 2, > 2 weeks). We then reviewed each of the individual ICS-209 reports for

Table 1 Key reported characteristics of the 2021 Tamarack Fire, condition sets and datasets used to identify similar incidents, and counts of these similar incidents by query level

Variable	Tamarack characteristics	Analog filter criteria	Datasets	Incidents
Point of origin (POO)	USFS	USFS	WFDSS SMA	3848
Cause	Lightning	Lightning	ICS-209 PLUS	2322
Final size (ha)	27,776	>= 121 ha	ICS-209 PLUS	1117
Single incident or complex	Single incident	Single incident	Fire Program Analysis Fire Occurrence Database	940
Maximum daily Growth (ha)	10,944 ha 7/19/2021, at least 6 days exceeding 2023 ha	>= 2023 ha	ICS-209 PLUS	65
Growth duration (days)	14	>= 14 days	ICS-209 PLUS	40
Cross-boundary (CB) transmission	Yes	Yes	Monitoring Trends in Burn Severity & Wildland Fire Interagency Geospatial Service (Aggregated by Gannon and O'Connor 2022) and WFDSS SMA	32

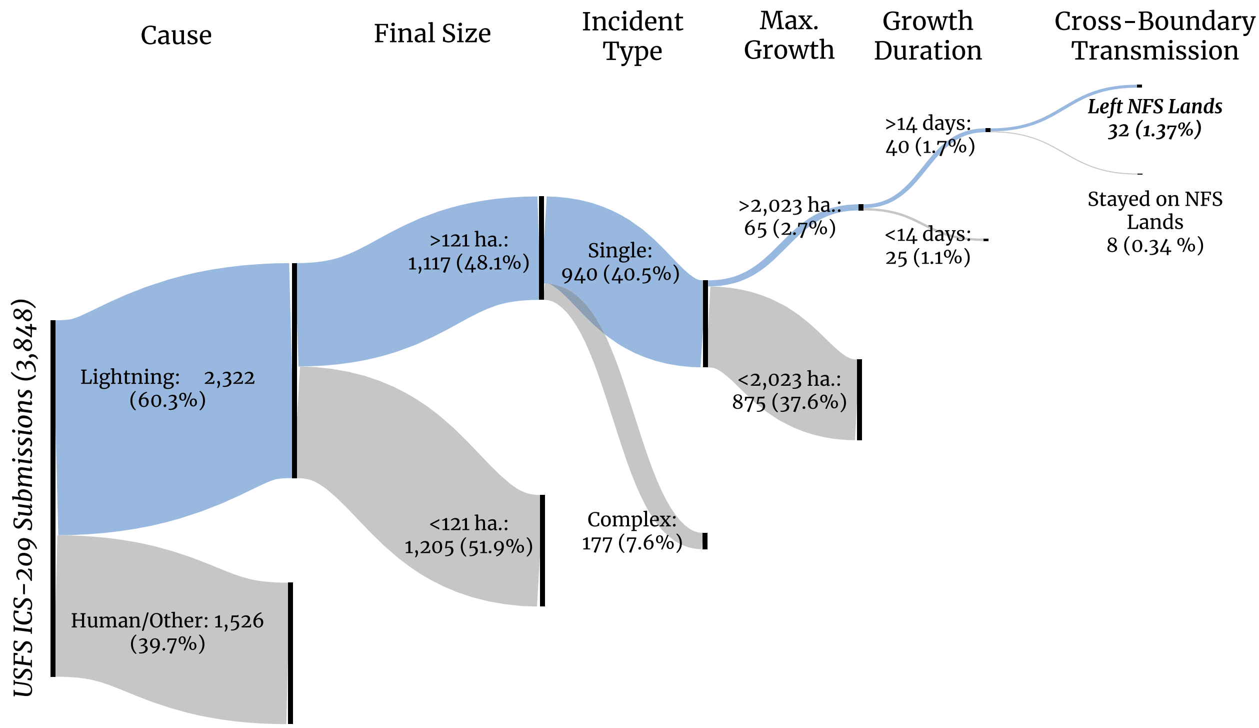

Fig. 1 Sankey diagram of USFS POO fires with an ICS-209 submission and our initial filters applied. Cross-boundary transmission was only determined for the 40 fires that met all preceding criteria. While wilderness characteristics were attributed to incident POOs, they were not excluded from further analysis on this basis and as such are not represented in this figure. Percentages displayed from "Final Size" moving to the right are based on a denominator of the total number of lightning-caused ignitions, 2322

Table 2 Count of large (> 121 ha) lightning-caused USFS POO wildfires (excluding complexes) by maximum single-day fire spread rate (ha) and overall growth duration (weeks) from 2009 to 2020. The subset adopted for further analysis (i.e., fires with single-day growth > 2023 ha and > 14-day duration) is shaded in gray (fires $n = 40$, after excluding 2020-WYMRF-Middle Fork)). These 40 fires CB characteristics were determined, resulting in 8 fires that did not exit USFS lands, leaving 32 analog fires

Hectares / Growth Duration (Weeks)	<405	405	809	1214	1619	2023	4047	6070	8094	12141+	Totals
0-1	196	41	14	9	3	7	2	2		1	275
1-2	108	23	8	10	3	10			2	1	165
2-3	81	22	8	10	4	5	1		3		134
3-4	57	9	9	3		6		1		1	86
4+	203	22	15	8	8	12	6	3	1	2	280
Totals	645	117	54	40	18	40	9	6	6	5	*940*

the 41 fires of interest by day and found that the maximum daily growth of one incident (2020 WY-MRF Middle Fork) was a reporting artifact and did not meet our fire-growth threshold. It was therefore excluded from further analysis leaving 40 incidents of interest (Fig. 1 and 40 wildfires with a growth duration > 14 days). Of these 40 fires, 32 were CB and therefore satisfied all of the requirements of "analog fires".

To classify the 32 fires into subtypes, we sequenced daily ICS-209 suppression strategies over the duration of each incident (Table 3). Daily suppression strategy reporting is uniquely dependent on incident conditions,

Table 3 Descriptions and short names of fire subtypes according to the series of reported suppression methods for each fire

Description	Short name
Never reported full suppression during incident lifespan	Never full suppression
Initially reported full suppression, later as multiple suppression methods, or initially reported other than full suppression, later reported full suppression, but not full suppression on final report	Mixed suppression methods
Initially not full suppression, converted to full suppression later in during incident lifespan	Limited initial suppression
Reported full suppression on every submission	Always full suppression

resource availability, and other relevant factors that affect the desire and ability to suppress a fire. We leveraged this information to classify fires into four subtypes that characterize the use of "full suppression" methods over the duration of an incident. While the Tamarack Fire initially reported "monitor", it later changed entirely to "full suppression" coincident with its first major growth event. Later in the incident, suppression methods were reported as 82% "full suppression", and 18% "confine" in recognition of areas in which fire progression was halted by natural features. Within our fire subtype definition set, the Tamarack Fire would be classified as "mixed suppression methods."

Finally, we reviewed the first published WFDSS decision document for each of the analog fires to determine whether resource management objectives or firefighter safety concerns were driving factors in initial strategies. By reviewing the objectives and rationale contents of the first published decisions we were able to document manager reported strategic drivers into two categories: resource objective driven, or firefighter hazard driven. As an example, the 2017 Chetco Bar fire's first WFDSS decision rationale (a free-text block in which managers summarize their decision-making process) stated, "Initial attack efforts on 7/12 and 7/13 by Siskiyou rappelers (sic.) were unsuccessful. Conditions were not safe to engage the fire due to air access only, with no escape routes or safety zones. The decision was made by the IC (Incident Commander) to disengage due to concerns of firefighter safety and low probability of success…Anticipated weather changes may add to potential fire spread with uphill runs making access difficult for resources to engage in fire suppression safely." In the case of the 2018 Bald Mountain Fire, the initial WFDSS decision rationale stated, "Risk Decision: 1. What alternatives (objectives, strategies, and tactics) are being considered? Alternative 1 - Suppress Fire (Not Selected); Alternative 2 - Manage Fire for Resource Benefits (Selected)." In our analysis the Chetco Bar fire was documented as a firefighter hazard strategy driver while the Bald Mountain was documented as resource objective strategy driver.

Finally, we used fields within the ICS-209 PLUS system to analyze analog fires in terms of total personnel commitment, total structures threatened, total structures destroyed, peak evacuations, and total estimated costs.

Results

Out of 3484 USFS POO fires with at least one ICS-209 submission between 2009 and 2020, we identified 940 large, lightning-caused USFS POO single fires that form our denominator of interest. Within these, 32 fires (0.9%, Table 2) that had similar reported characteristics of the 2021 Tamarack Fire. Compared to the total set of all lightning-caused USFS fires (2322), these 32 fires represent just 1.3%. Of large, lightning-caused USFS POO single fires with at least one ICS-209 report ($n=940$), hereafter referred to as the denominator of interest, our analog fires represent 3.4% (Table 2). For clarity, the remainder of these results compare the 32 analog fires only to the denominator of interest.

Of these 32 analog wildfires, nine were never full suppression, seven were limited initial suppression, eight were mixed suppression methods, and eight were always full suppression (Fig. 2; Table 4). The initial strategy driver was resource objectives for six fires, four of which were never full suppression, while two were limited initial suppression. The remaining 26 analog fires had an initial strategy driver of firefighter safety considerations. This includes most of the never full suppression and limited initial suppression with five fires in each management type, and all fires managed with mixed suppression methods and always full suppression. For reference, the suppression series for the Tamarack Fire was categorized as the mixed suppression methods subtype and its initial strategy was driven by firefighter hazards as documented in WFDSS.

Fourteen of the 32 analog fires originated within wilderness areas (Table 4). These included three ignitions in always full suppression, mixed suppression methods, and never full suppression subtypes. In the limited initial suppression subtype, five of seven incidents ignited within wilderness. Of the 26 fires where Firefighter Safety drove initial strategies, ten ignited within wilderness. For wildfires with initial strategies driven by resource objectives, four of six ignited within wilderness.

Table 4 The 32 Tamarack-analog fires, reported metrics, fire subtype, percentage USFS ownership in final perimeter, and initial strategy drivers. Light gray shading indicates fires with wilderness POOs ($n=14$), dark gray shading indicates that resource objectives were identified in the initial WFDSS decision as the primary driver of incident strategy ($n=6$)

Incident Name	Final Size (ha)	Structures Destroyed	Max. Growth (ha)	Growth Duration (days)	Fire Subtype Short Name	% USFS Final Perimeter	Wilderness POO	Initial Strategy Driver
2012 Little Bear	17,940	254	4,817	17	Always Full Suppression	83.64%	Yes	Firefighter Hazards
2012 Seeley	19,445	1	5,827	52		79.96%	No	
2013 Silver	56,068	2	7,284	23		99.34%	No	
2017 Meyers	25,104	1	6,511	56		99.86%	Yes	
2018 Coal Hollow	12,813	0	3,256	33		79.52%	No	
2018 Cougar Creek	17,285	0	2,561	28		46.51%	No	
2020 Bighorn	48,553	2	3,830	24		90.17%	Yes	
2020 Bringham	9,365	2	2,267	17		99.97%	No	
2011 Pagami Creek	37,309	2	30,834	27	Limited Initial Suppression	90.78%	Yes	Firefighter Hazards
2015 Rough	61,360	4	4,760	56		92.92%	No	
2017 Chetco Bar	77,346	30	17,806	81		89.21%	Yes	
2017 Lolo Peak	21,813	10	3,646	58		83.22%	Yes	
2018 Bald Mountain	7,535	1	4,738	28		93.25%	Yes	Resource Objectives
2018 Klondike	70,924	0	3,500	75		97.68%	Yes	Firefighter Hazards
2018 Pole Creek	41,355	1	11,879	15		66.02%	No	Resource Objectives
2012 Halstead	73,632	1	7,682	55	Mixed Suppression Methods	99.89%	Yes	Firefighter Hazards
2013 Thunder City	5,407	2	2,373	33		99.67%	No	
2015 Wolverine	29,187	4	3,642	102		95.77%	Yes	
2016 Lava Mountain	5,929	0	5,515	52		78.39%	No	
2017 Alice Creek	11,838	4	2,382	52		62.72%	No	
2018 Rabbit Foot	14,570	0	2,930	16		99.85%	No	
2020 East Fork	36,422	11	11,846	59		92.17%	Yes	
2020 White River	7,059	1	2,141	17		50.20%	No	
2010 Twitchell Canyon	18,167	2	2,919	72	Never Full Suppression	98.44%	No	Resource Objectives
2015 Tepee Springs	38,732	5	11,963	20		74.93%	No	Firefighter Hazards
2015 West Fork Fish Creek	5,463	3	3,559	77		96.98%	No	
2017 Caribou	10,017	40	2,839	34		79.63%	No	
2017 Corral	8,235	0	2,187	22		99.98%	Yes	Resource Objectives
2017 Frye	19,604	2	3,267	26		94.64%	No	Firefighter Hazards
2017 Highline	34,244	0	4,722	43		99.57%	Yes	Resource Objectives
2017 Rice Ridge	64,825	1	19,639	51		99.64%	No	Firefighter Hazards
2017 Strawberry	7,292	0	2,579	20		89.98%	Yes	Resource Objectives

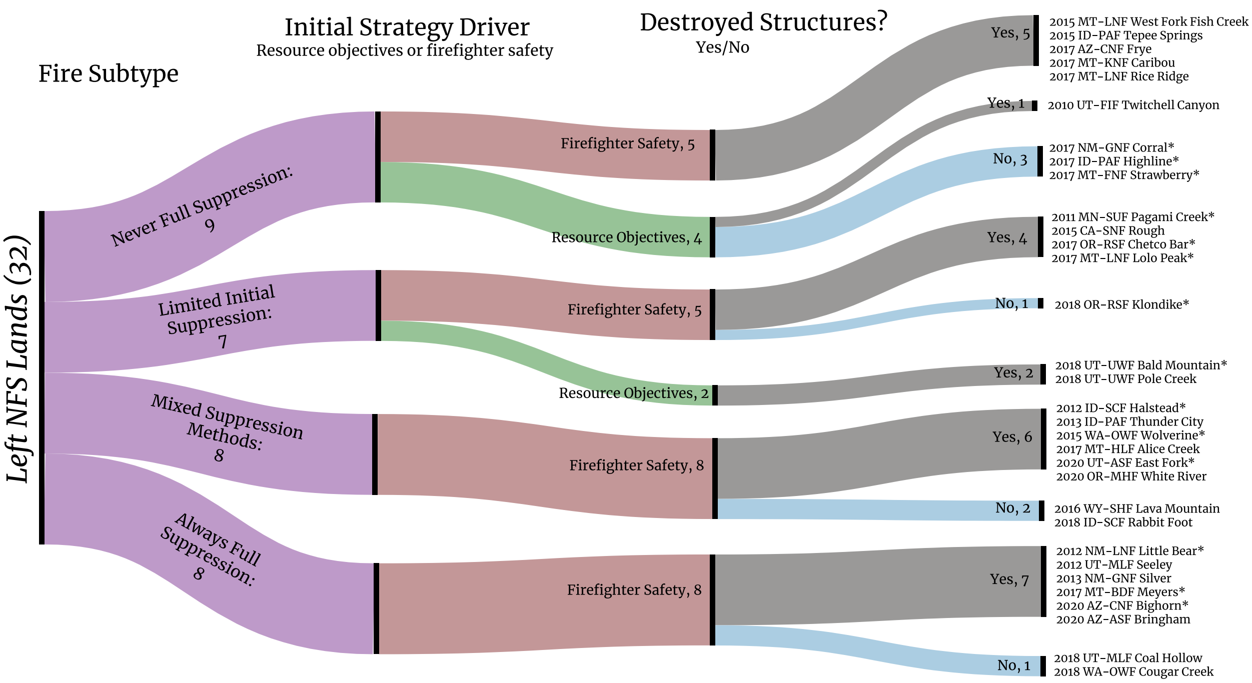

Fig. 2 Analog fires by subtype, initial strategy drivers, and whether they destroyed structures. Thirty-two analog fires were identified out of 2322 lightning-caused candidates from the ICS-209 PLUS (Fig. 1), which yielded 940 fires within the denominator of interest (large, lightning-caused USFS POO fires). Asterisks (*) indicate fires with wilderness points of origin. See list of abbreviations for full unit identifications (e.g., UT-MLF)

In terms of structures destroyed, the 32 analog fires accounted for 61.6% of all structure loss from the 940 denominator fires of interest (386 of 626 structures; Table 5). Twenty-five of the 32 analog wildfires resulted in structure loss, spanning all combinations of fire subtype and initial strategy drivers (Fig. 2; Table 4), with these 25 fires representing only 2.7% of the denominator of interest fires (25 of 940 fires). Of these 25 fires that destroyed structures, ten ignited within a wilderness area, representing an occurrence rate of 1.1% (10 of 940 fires).

Most of the structure loss on 32 analog fires was driven by the Little Bear Fire (254 of 386 structures; Tables 4 and 5), which originated in a wilderness, was always

Table 5 Count of structures destroyed by the 940 denominator fires of interest (excluding fire complexes) by maximum single-day fire spread rate (ha) and overall growth duration (weeks) from 2009 to 2020, with gray shading indicating the 32 analog fires. While structures destroyed by analog fires are identified by gray shading (*n* = 386), two fires within the gray shading were not CB yet destroyed two structures each, accounting for the discrepancy between the 390 structures destroyed within this table and the 386 destroyed by analog fires

Hectares / Growth Duration (Weeks)	<405	405	809	1214	1619	2023	4047	6070	8094	12141+	Totals
0-1	6	2	20	1	10	68	0	0		0	107
1-2	3	0	1	3	0	12			1	3	23
2-3	3	19	0	0	0	5	254		8		289
3-4	0	0	3	0		4		2		2	11
4+	3	54	19	2	3	65	6	2	11	31	196
Totals	15	75	43	6	13	154	260	4	20	36	626

full suppression, and whose initial strategy driver was firefighter hazard. Exclusive of this fire, analog fires accounted for 21.7% of structure loss from the set of 940 denominator fires of interest (136 of 626 structures). Fires whose strategy subtype was anything other than always full suppression accounted for 20.2% of structure loss from the denominator of interest fires (127 of 626 structures).

Of the six analog fires with an initial strategy driven by resource objectives, three destroyed structures, and collectively amounted to only four of the 386 structures destroyed by analog fires (1.03%) and only 0.6% of structures destroyed by the 940 denominator fires of interest (4 of 626 structures, Tables 4 and 5). Two of these fires were limited initial suppression (Pole Creek and Bald Mountain), and the third was never full suppression (Twitchell Canyon). Of these, only Bald Mountain ignited within wilderness. Of the three fires driven by resource objectives that did not destroy structures (Corral, Highline, and Strawberry), all were never full suppression, and all ignited within wilderness (Table 4).

The 32 analog fires reported an outsized share of resource use when compared to the 940 denominator fires of interest (Fig. 2; Table 2). Despite the analog fires representing a small percent (3.4%, 32 of 940 fires) of these incidents, they reported 25.8% of total personnel commitments (388,648 of 1,500,754 structures, Tables 6 and 7).

Examining individual characteristics of the 32 analog wildfires among fire subtypes identified some temporal trends. Limited Initial Suppression showed a slower start in terms of fire growth, but final fire size was generally larger than other subtypes and had the greatest average number of fire growth days (49, Table 7). Limited Initial Suppression also had the highest projected final cost (Fig. 3; Table 7). Corresponding peaks in

Table 6 Count of total personnel assigned to the 940 denominator fires of interest (excluding fire complexes) by maximum single-day fire spread rate (ha) and overall growth duration (weeks) from 2009 to 2020, with gray shading indicating the 32 analog fires. Total personnel assignments by analog fires are within gray shading ($n=388{,}648$) — the additional 13,147 identified below are from non-CB fires eliminated from the analog set

Hectares / Growth Duration (Weeks)	<405	405	809	1214	1619	2023	4047	6070	8094	12141+	Totals
0-1	100681	31268	18676	15251	13756	22967	2637	1287		542	207064
1-2	99218	39188	11357	8691	3947	75516			11438	26111	275467
2-3	68388	42423	19424	86807	27276	25920	17007		17525		304769
3-4	41930	19495	25212	6758		21458		16135		22085	153072
4+	85140	45966	85277	39769	22293	112156	82350	38196	7870	41364	560382
Totals	395357	178341	159945	157276	67271	258017	101994	55618	36833	90101	1500754

Table 7 Summary reported values (total or average as noted) from ICS-209 PLUS by fire subtype

Subtype	Count	Total size (ha)	*Average* max. growth (ha)	*Average* duration (days)	Total structures threatened	Total structures destroyed	Total evacuations	Total personnel	Total estimated costs (US $)
Always Full Suppression	8	206,577	4544	31	19,592	262	865	90,314	188,387,648
Limited Initial Suppression	7	317,650	11,024	49	22,246	48	14,398	166,027	408,773,636
Mixed Suppression Methods	8	184,047	4814	48	5632	23	2356	78,621	171,276,421
Never Full Suppression	9	206,585	5964	41	4474	53	2636	53,686	139,251,864

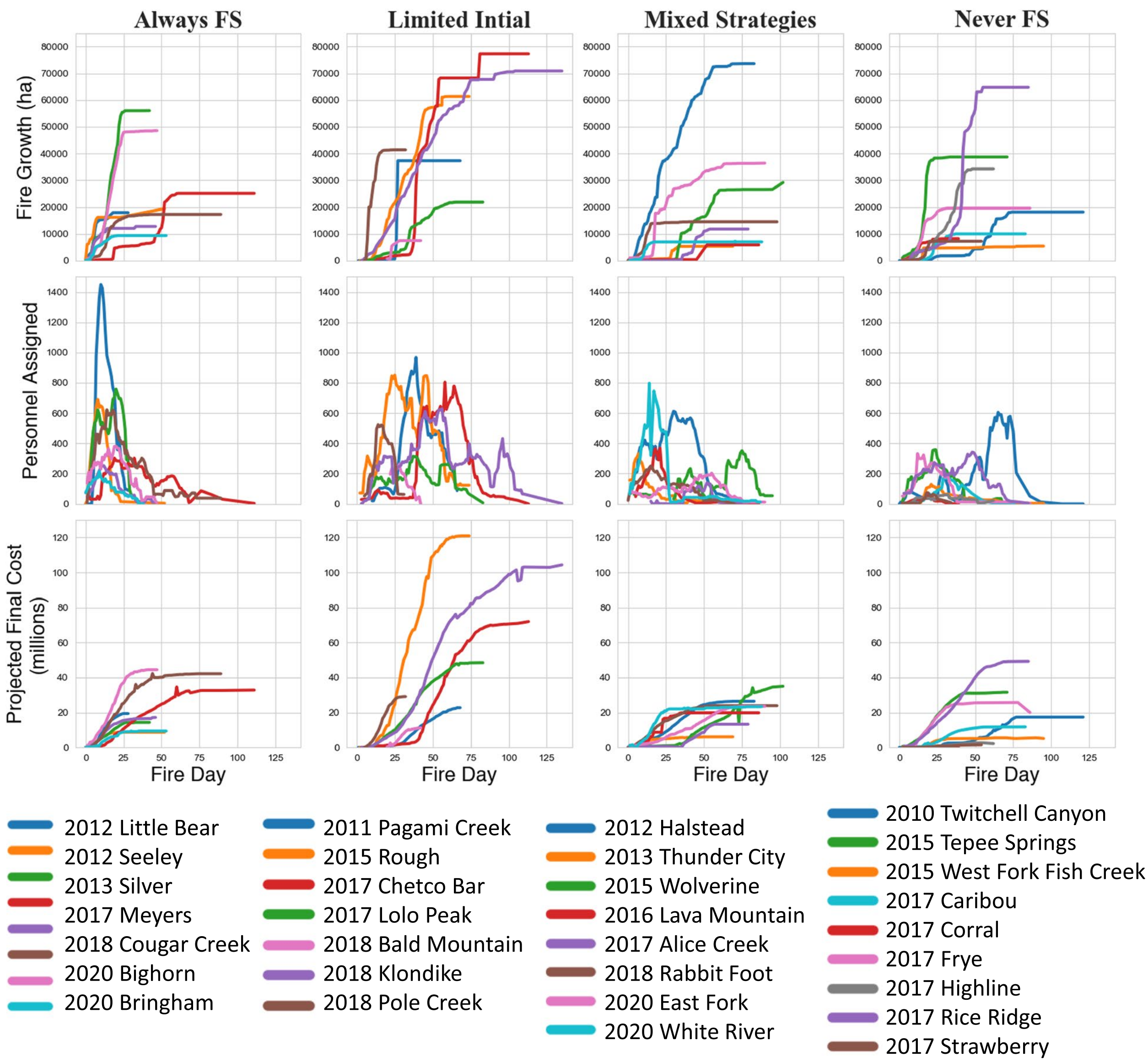

Fig. 3 Daily growth (ha), personnel assigned, and projected cost by fire subtype by fire day

personnel assigned were also higher for Limited Initial Suppression when compared to other subtypes (Fig. 4). Interestingly, the large spikes in structures threatened by Limited Initial Suppression fires did not appear to be indicative of total structures destroyed. Compared to other subtypes, Limited Initial Suppression fires' maximum values of final fire size, maximum growth event size, evacuations, structures threatened, and final costs were the highest. All analog fires destroyed very few structures relative to reported structures threatened (Fig. 4; Table 7).

Mixed suppression methods reported the lowest total number of structures threatened and the smallest final fire size (Figs. 3 and 4). This subtype demonstrated either one relatively small growth event when compared to other subtypes, or relatively consistent growth of a smaller magnitude (Fig. 3). Spikes in personnel assigned were generally early in the incident lifespan of mixed suppression methods relative to limited initial suppression and never full suppression. By comparison, always full suppression observed personnel spikes almost explicitly within early stages of an incident.

Never Full Suppression fires had the fewest total number of personnel assigned, while Limited Initial Suppression subtypes had the highest (Table 7). Limited Initial Suppression fires burned the largest areas, exhibited the

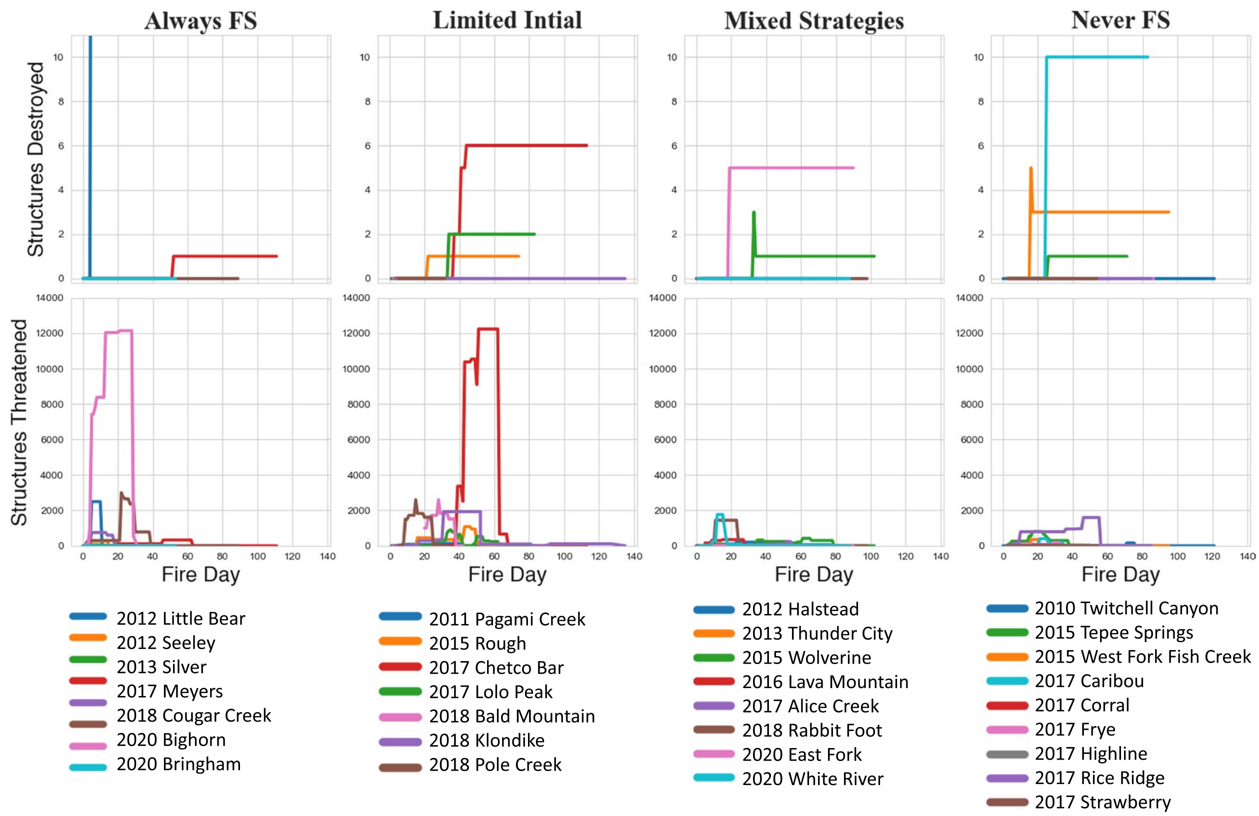

Fig. 4 Structures destroyed and structures threatened by fire subtype by fire day. The 2012 Little Bear Fire destroyed 254 structures; to preserve resolution for all other fires the *Y*-axis of structures destroyed was set to a maximum of 10

largest average single day growth events, evacuated the most total people, and had the highest estimated total cost. Always Full Suppression Fires destroyed the most structures yet grew the fewest number of days on average.

Discussion

If any fire can be described as the sum of its reported parts, then the Tamarack Fire is unique in how different reporting metrics compare to the broader population of USFS wildfires. No other fire demonstrated every characteristic of the Tamarack Fire, yet many shared important components. If a true "let-burn" fire was one that met every characteristic of the Tamarack Fire, *and* its initial strategy was driven by resource objectives (which the Tamarack was not), then only one fire could be construed to meet that mark. That fire, the 2018 Bald Mountain Fire on the Uinta-Wasatch Cache National Forest, was ignited by lightning within a wilderness area, had an initial strategy driven by resource objectives, and eventually destroyed one structure on private land. Bald Mountain's fire subtype was limited initial suppression, while the Tamarack's was mixed suppression methods. Differences in incident management team or local manager preferences may help explain this discrepancy in self-reported suppression methods. Indeed, every analog fire we identified had unique considerations which led to the observed outcomes.

While we found 32 fires sharing many of the same characteristics of Tamarack, and thereby possibly contributing to the "let-burn" narrative, only six had initial strategies driven by the pursuit of achieving resource objectives — that is, objectives weighted less towards protection and more towards allowing fire to play its natural role in an ecosystem. The remaining 26 wildfires had initial strategies that appeared driven instead by a desire to minimize putting firefighters in extreme and hazardous conditions. Because of this, initial action to minimize fire size was infeasible and longer-term strategies were necessary.

Of these 32 fires, eight were always full suppression, eight were mixed suppression methods, seven were limited initial suppression, and nine were never full suppression using the subtype definitions we developed. It is important to note that we did not attempt to quantify the prevalence of resource objective driven strategies across all USFS incidents — only those that met our criteria of characteristics displayed by the 2021 Tamarack

Fire. Incident POOs within wilderness areas were prevalent within the analogs, with 14 analog ignitions within wilderness, two within a half mile of wilderness, and the other sixteen occurring outside a half mile buffer. The intertwined relationship between resource objectives and firefighter exposure to hazards, especially given management objectives and the remote and rugged nature of wilderness areas may continue to present difficult decisions to fire managers and warrants continued research (Iniguez et al. 2022).

This is not to say that the analog fires identified here are the only impactful lightning-caused ignitions that have occurred on USFS lands over the period we assessed. For example, the 2020 Bridger Foothills Fire outside of Bozeman, Montana destroyed 68 structures but grew for only 5 days; the 2009 Mill Flat Fire just outside of New Harmony, Utah destroyed 11 structures over 39 days of growth, but its maximum fire spread rate was just under 1000 ha on its largest day. These two fires had different rationales for initial strategy selection and were locally impactful, yet our criteria set excluded them from inclusion in our analog fires.

While these analog incidents are exceedingly rare, they are responsible for the majority (61.6%) of structures destroyed from fires within the 940 denominator fires of interest. However, when compared to human-caused fires originating on USFS lands these same loss levels appear relatively modest (Caggiano et al. 2020). Viewed through the lens of a Wildland Urban Interface (WUI) disaster fire, only one of the fires we identified destroyed over 50 structures (2012 Little Bear Fire, 254 structures destroyed). The outsized total resource commitment burden of these analog fires (25.8% of all resources across 940 denominator fires of interest) can be viewed along with structures destroyed as the toll that these infrequent yet consequential events take on the wildland fire management system. Given that only six analog fires' initial strategies were driven by the pursuit of resource objectives, eliminating this option for fire managers would not in and of itself decrease these costs. Ultimately, our results do not appear to support the narrative of lightning-caused fires managed for resource objectives as a primary source of structure loss risk.

It is important to contextualize structure destruction by fire cause. Our research corroborates findings from other efforts showing that most structures are destroyed by human ignitions originating on private lands (Downing et al. 2022). We believe our analog criteria have reasonably accounted for fires that share much of the burden for the "let burn" narrative that has emerged around USFS fire management policy, including those that generated significant sociopolitical interest, for example the 2018 Pole Creek and Bald Mountain fires in Utah and the 2017 Chetco Bar fire in Oregon (USFS 2019, US Government Accountability Office 2020). We found that in most cases, analog fires had initial strategies driven by severe hazards to firefighters, and in only six cases had resource objectives as driving factors. This is an important distinction to make when messaging around the "why" a series of incident strategies was selected, because it may have a substantial impact on how the message is received.

Conclusions

Climate change, combined with increasing aridity (Abatzoglou and Parks 2016) and fire season duration (Westerling et al. 2006) will combine to increase the challenge and complexity to land management agencies with fire management responsibilities (Essen et al. 2022). It has been well established that meeting ecological and land management objectives requires an expansion of wildfire within fire-adapted systems, as well as to reduce the risk of future high severity wildfire events (He et al. 2015). The fire management community has increasingly demonstrated competence in making risk-informed decisions that balance landscape health and community protection objectives, but decision makers are incentivized to minimize short-term risks over maximizing long-term risk reduction (Calkin et al. 2021; Thompson et al. 2018, Young et al. 2022). Indeed, in four of the past 11 years the USFS issued direction that could be perceived to reinforce a fire-exclusion paradigm (USFS 2012, USFS 2020a, b, USFS 2021, USFS 2022). How land and fire management organizations prepare for and manage for low-probability, high-consequence events is critical to informing their risk tolerance. Defining consistent and durable risk tolerances of land management agencies is necessary to shift society's relationship with fire and support local manager decision making.

Alternative methods to define and communicate incident strategy is an area for future research exploration. As we have demonstrated, reported ICS-209 strategies can have very different motivations (firefighter safety vs. resource objectives). Extreme fire conditions and or resource scarcity during periods of heavy fire activity may preclude the use of perimeter control actions, necessitating operational nuance to limit threat to the degree possible given on-site conditions. The reality of strategy on these complex incidents will be a combination of actions to limit losses to highly valued resources and assets while balancing exposing firefighters to hazards. Yet this strategy may be communicated internally and externally as simply "full suppression." Restricting terminology around strategy to a narrowly defined set of four options may present difficulties when aiming to accurately describe the unique and complex set of spatiotemporal, ecological, and sociopolitical factors that inform strategic decisions on incidents. A limited palette of strategic reporting categories may be partially responsible for the falsely premised “let burn” narrative.

Our results suggest that a “let burn” strategy is not a predominant USFS management approach. However, because these rare events often result in damage and disruption to communities, additional investigation could help inform how to better prepare for and mitigate these events and how to communicate the complexity of the decision process. Adaptive learning and management to support improved wildfire strategies can help achieve resilient landscapes, fire adapted communities, and a safe and effective response.

Abbreviations

BLM	Bureau of Land Management
C	Confine
CB	Cross-boundary
FIRESTAT	USFS Fire Statistics System
FPA FOD	Fire Program Analysis Fire Occurrence Database
FS	Full suppression
ICS-209	Incident Command System 209
IFWFP	Interagency Federal Wildland Fire Policy
InFORM	Interagency Federal Wildland Fire Policy
InFORM	Interagency Fire Occurrence Reporting Modules
M	Monitor
MMS	Managed with Multiple Strategies
MTBS	Monitoring Trends in Burn Severity
POO	Point of origin
PZP	Point/zone protection
USFS	United States Department of Agriculture Forest Service
WFDSS	Wildland Fire Decision Support System
WFIGS	Wildland Fire Interagency Geospatial Service
WUI	Wildland Urban Interface
AZ-ASF	Arizona, Apache-Sitgreaves National Forest
AZ-CNF	Arizona, Coronado National Forest
CA-SNF	California, Sierra National Forest
ID-PAF	Idaho, Payette National Forest
ID-SCF	Idaho, Salmon-Challis National Forest
MN-SUF	Minnesota, Superior National Forest
MT-BDF	Montana, Beaverhead-Deerlodge National Forest
MT-FNF	Montana, Flathead National Forest
MT-HLF	Montana, Helena-Lewis and Clark National Forest
MT-KNF	Montana, Kootenai National Forest
MT-LNF	Montana, Lolo National Forest
NM-GNF	New Mexico, Gila National Forest
NM-LNF	New Mexico, Lincoln National Forest
OR-MHF	Oregon, Mount Hood National Forest
OR-RSF	Oregon, Rogue River-Siskiyou National Forest
UT-ASF	Utah, Ashley National Forest
UT-FIF	Utah, Fishlake National Forest
UT-MLF	Utah, Manti-LaSal National Forest
UT-UWF	Utah, Uinta-Wasatch-Cache National Forest
WA-OWF	Washington, Okanogan-Wenatchee National Forest
WY-SHF	Wyoming, Shoshone National Forest

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Authors' contributions
BMP conceived the study design and co-led the writing of the manuscript with JDY. LASD and KCS provided updates to the ICS-209-PLUS database as well as QA/QC of linked datasets for analysis and contributed to writing the manuscript. BMP, JDY, and LASD performed data analysis. MPT and DEC helped focus the study design and contributed to writing the manuscript.

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Availability of data and materials
The data and source code used to create the ICS-209-PLUS dataset are publicly available and open source. (St. Denis et al., 2023). Datasets developed and used in this manuscript are available from the authors upon reasonable request.

Declarations

Ethics approval and consent to participate
Not applicable.

Consent for publication
Not applicable.

Competing interests
The authors declare they have no competing interests.

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