Franz and Edgeley *Fire Ecology* (2025) 21:37
https://doi.org/10.1186/s42408-025-00379-y

Fire Ecology

TECHNICAL NOTE

Open Access

Bucking the suppression status quo: incentives to shift the wildfire management paradigm around natural ignitions

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Abstract

Background Wildfire policy has evolved rapidly over the past three decades, necessitating repeated shifts in management and communication strategies for US land management agencies. One growing focus considers the use of "other than full suppression" (OTFS) strategies, where managers use natural ignitions to achieve management objectives when conditions allow. While policy and guidance give managers operational flexibility, various sociopolitical, operational, and organizational factors contribute to risk aversion that inhibits OTFS use. This research investigates if wildfire management professionals in the Southwest US can reach consensus on incentives used to promote OTFS management.

Results Using a Delphi approach, whereby individual participants complete anonymous iterative surveys and provide feedback on group responses, wildfire management professionals in Arizona and New Mexico provided input on which incentives would have the greatest impact on use of OTFS strategies and how feasible implementation would be. Consistent public support from agency leadership, financial rewards for successful use of OTFS strategies, and allowing acres burned by OTFS wildfires to count toward regional treatment targets were among the most impactful in the eyes of participants.

Conclusions These results suggest that incentivizing OTFS management requires a combination of policy adjustment and agency alignment to better leverage wildfire for ecosystem restoration.

Keywords Managed fire, Wildfire management, Delphi, Policy, Incentives, Performance measures

Resumen

Antecedentes La política sobre incendios de vegetación ha evolucionado rápidamente en las últimas tres décadas, lo que necesitó de cambios repetidos en las estrategias de manejo y comunicación por parte de las agencias de manejo de tierras de los EEUU. Un grupo focal considera estrategias que "*vayan más allá de la supresión total*" ("*other than full suppression*" o OTFS en idioma inglés), mientras que los gestores de tierras aprovechan las igniciones naturales para alcanzar objetivos de manejo cuando las condiciones lo permiten. Mientras que la política y guías de manejo dan a los gestores una flexibilidad en sus operaciones, varios factores operacionales, sociopolíticos, y organizacionales contribuyen a una aversión al riesgo que inhibe el uso de las OTFS. Este trabajo investiga sobre si los gestores profesionales del manejo del fuego en el sudoeste de los EEUU pueden encontrar un consenso o incentivos usados para promover el manejo con OTFS.

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Resultados Usando la aproximación de Delphi, mediante la cual los individuos participantes completan cuestionarios anónimos iterativos y proveen de retroalimentación sobre respuestas de grupos, profesionales de manejo del fuego de Arizona y Nuevo México proveyeron de información sobre cuáles incentivos provocarían los mayores impactos en el uso de estrategias de OTFS y cuán factible sería su implementación. El apoyo público y consistente de los líderes de las agencias, las recompensas por el uso exitoso de las estrategias de OTFS, y la autorización para poder usar esas estrategias de OTFS (como el permitir que se quemen muchos acres para alcanzar metas de tratamientos regionales), fueron entre los incentivos más impactantes a los ojos de los participantes.

Conclusiones Estos resultados sugieren que la incentivación del manejo mediante OTFS requiere de una combinación de ajustes de las políticas y el alineamiento de las agencias para empoderar el alcance de los fuegos de vegetación para la restauración de los ecosistemas.

Introduction

The Wildfire Crisis Strategy outlined by the United States Forest Service acknowledges the need to accelerate the pace of landscape treatment to protect ecosystems, watersheds, and other values at risk (USDA Forest Service 2022a). Wildfire is a vital tool to achieve the scale required for landscape restoration (North et al. 2012), so utilizing natural ignitions to strategically advance restoration efforts offers one potential path forward that balances resource capacity with ecosystem health.

Despite some notable policy shifts in recent decades to more explicitly enable wildfire use for management objectives, decision-makers in the USA use it conservatively, often far away from human values like infrastructure or residential areas (Young et al. 2020; Iniguez et al. 2022), where both potential risks and potential societal benefits remain low. Furthermore, there is an ongoing challenge just to find a suitable term to identify it, as policy and people have referred to it as "prescribed natural fire," "wildland fire use," "managed fire," and others over the past few decades (Botti and Nichols 1978; USDA and USDI 2003; van Wagtendonk 2007; Davis et al. 2022). Here we refer to it as other than full suppression (OTFS) management or OTFS strategies. Research has documented diverse obstacles to using wildfire, including risk aversion (Calkin et al. 2011; Thompson et al. 2018; Fillmore et al. 2021), disconnects through layered policy (Steelman and McCaffrey 2011; Franz et al. 2023), organizational culture (Schultz et al. 2019), inadequate reporting and public communication (Pietruszka et al. 2023), and difficulty measuring performance (Donovan et al. 2008; Wilson et al. 2018). This research focuses on the latter of these factors, as fire professionals in the Southwest US have noted difficulty connecting beneficial wildfire to existing metrics (Franz et al. 2024). Balancing the inherent risks of wildfire management with suitable rewards for decision-makers are critical to buck the suppression status quo.

On paper, law requires federal land management agencies to develop performance indicators and measurable goals, for the purpose of improving transparency and accountability (Public Law 103–62; Kravchuk and Schack 1996). In practice, fulfilling that requirement proves challenging. Policy goals are often oversimplified or ambiguous to maximize their applicability across a variety of landscapes and therefore increase their political salience (Rainey and Jung 2015; Wilson et al. 2018; Pahlka 2023). In land management, a common metric is "acres treated," the number of acres that have received treatments to reduce hazardous fuel buildup and reduce wildfire risk (USDA Forest Service 2022b). Though a part of quantifying progress, acres treated measures short-term outputs without connecting such efforts to long-term desired outcomes (Donovan et al. 2008). Crafting meaningful metrics requires a balance between salient and consistent standards at higher levels of government with adaptable connections to local, place-based contexts (Schultz et al. 2016; Craig et al. 2017). The obstacles to fire use and lack of local connections to metrics introduce difficulties for decision-makers trying to balance duce wildfire risk and improve ecological resilience (Franz et al. 2024). Given the authority granted by current federal and interagency policy to local units and decision-makers regarding wildfire management (Franz et al. 2023), this study aims to elicit insights from those that implement policy on a daily basis and can speak to the impact incentives could have on expanded use of OTFS strategies.

Eliciting expert opinion can help characterize dynamic systems where empirical data is difficult to collect and analyze due to complexity or uncertainty (Kuhnert et al. 2010). Environmental studies have used expert elicitation to validate modeling (Krueger et al. 2012), manage wildlife (Oedekoven et al. 2015), address invasive species (Johnson et al. 2017), or understand uncertainty in adaptive management (Runge et al. 2011). However, with known issues in wildfire management like imbalanced gender dynamics (Reimer and Eriksen 2018) and cultural bias toward short-term risk management and aggressive suppression (Calkin et al. 2015; Thompson et al. 2018), eliciting expert opinion via traditional group discussion

could silence valuable perspectives. Martin et al. (2012) suggest a Delphi approach, which involves anonymously eliciting opinions and allowing individuals to amend their input after considering others' responses, can address these drawbacks. A Delphi approach accesses the positive impacts of group meetings like multi-perspective exposure and idea synthesis, while mitigating negative impacts such as groupthink or dominating personalities (Hasson et al. 2000; Martin et al. 2012; Belton et al. 2019).

While some studies in forest management have used a Delphi approach (Filyushkina et al. 2018), few, if any, applied this methodology to wildfire policy. Schultz et al. (2022) conducted an in-person group workshop to recommend improvements to incentives and performance measures, but there remains a gap in controlling for some well-known biases in wildfire management. This prompted the following research questions:

1. What incentives do wildfire professionals in the Southwest US believe would reduce suppression bias and increase the use of OTFS strategies?
2. What trends of consensus or dissensus emerge for their suggested incentives?
3. Does the Delphi method serve as a viable method to elicit expert opinion in wildfire management policy?

Methods

We conducted a Delphi survey with 13 wildfire professionals in the US Southwest to investigate whether the group could reach a consensus regarding incentives that they considered most impactful for increasing the acceptance and use OTFS strategies in incident management. We referred to Delphi research recommendations outlined by Belton et al. (2019) and Franc et al. (2023) to inform our means of sampling, survey construction, feedback, and analysis as described below.

Expert sampling

Candidates had to meet the following criteria in order to be eligible to participate in this study: (1) held a position within a federal land management agency, state department of land management or forestry, or a local wildland firefighting department at the time of the study; (2) earned one or more of the following titles or qualifications: District Ranger, Forest Supervisor, Agency Administrator (AA), Incident Commander (IC), Fire Management Officer (FMO), Fire Staff, Fuels Specialist, Fire Ecologist, or Hotshot Superintendent; and (3) be primarily located in either Arizona or New Mexico. We chose this geographic focus because of the region's extended history successfully managing wildfire using OTFS strategies (Young et al. 2020; Iniguez et al. 2022). Furthermore, the titles and qualifications above are linked to the regional and local branches of land management agencies, which is an appropriate scale to investigate more tailored metrics and incentives to shift management paradigms (Franz et al. 2023).

We conducted purposive sampling using publicly available contact information from agency directories. Candidates received an email invitation to participate in the study as well as weekly follow-ups for 2 weeks to unresponsive candidates until the study began. While executing the survey, we sent correspondence between rounds supplying aggregate feedback and instructions for subsequent rounds. In total, we invited 118 qualified individuals to participate, of which 13 completed all rounds, which satisfies a generally accepted sample frame between 5 and 20 experts (Hasson et al. 2000; Belton et al. 2019; Franc et al. 2023).

Survey construction and feedback

We administered our Delphi survey using the Qualtrics online platform. We constructed three rounds (Fig. 1): one unstructured round (R_0) and two structured rounds (R_1 and R_2). Through a theoretical lens, one should run as many rounds as necessary to find response stability (Rowe and Wright 2001; Von Der Gracht 2012; Belton et al. 2019). In practice, a minimum of two rounds allows for some patterns of stability and consensus to emerge (Belton et al. 2019; Franc et al. 2023). In R_0, we asked participants to list incentives that they believed do help or could help facilitate the use of OTFS strategies in wildfire management. This allowed participants to determine issues instead of researchers, which helps focus responses and remove bias (Rowe and Wright 2001; Frewer et al. 2011). In R_1, we asked participants to assess these incentives on rank-ordered Likert scales (Belton et al. 2019).

Fig. 1 Flow diagram outlining the steps of the Delphi survey used for this study

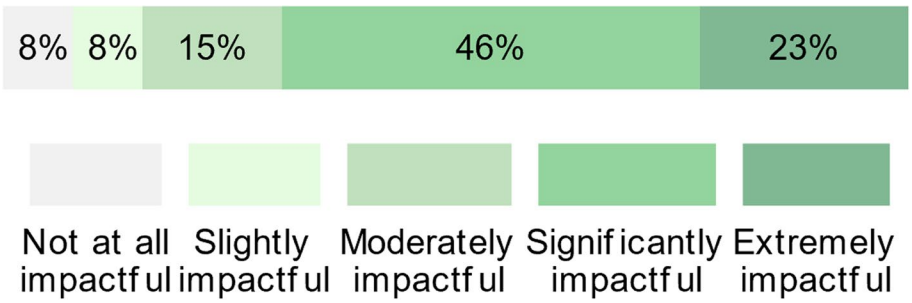

Fig. 2 Example of the visual distribution of responses provided to participants between rounds. This stacked bar chart shows the responses for a single incentive

Participants were first asked to assess each incentive's expected impact on use of OTFS strategies, ranging from "not impactful at all" (1) to "extremely impactful" (5). We invited respondents to offer rationale behind their answers via open-ended text entry, providing the opportunity to examine a holistic set of pros and cons for each incentive (Franklin and Hart 2006). The research team aggregated qualitative responses, combined them with basic summary statistics (mean, median response) for each incentive (Fig. 2), and provided this feedback for each participant to review. After 6 days, we executed R_2, inviting participants to take the same survey again after reviewing feedback from the previous round.

Analysis

Many studies on Delphi approaches recommend defining consensus a priori (i.e., before executing the study and analyzing its data), with an emphasis on not only the level of agreement for answers in a given round, but the stability of those answers across multiple rounds (Dajani et al. 1979). However, these studies do not agree on the definition consensus (Diamond et al. 2014; Belton et al. 2019). Policy-focused Delphi studies, for example, consider both consensus and dissensus, as the latter can deepen explorations of a topic and enable more robust policy formulation (Turoff 1970; Franklin and Hart 2006; Nowack et al. 2011; Von Der Gracht 2012). To measure the threshold between the two, Franc et al. (2023) argue that parametric methods have little practical difference than more complex non-parametric methods. Given our goals and the purview of policy-focused Delphi studies, we chose a similar approach, defining consensus using sample standard deviation and a test for homogenous variance.

For incentive i, we calculated its sample standard deviation for each round (s_1 and s_2) and used Levene's test[1] to assess if variance was statistically homogenous. We defined agreement for an incentive as having either $s_1 \leq 1$ or $s_2 \leq 1$. We defined stability for an incentive as having a p value from Levene's test (p_{lev}) that indicated homogenous variance ($p_{lev} > 0.1$ using a 90% confidence interval). Therefore, we considered consensus to be the spectrum of agreement and stability for an incentive, with four logical categories: Stable Agreement, Unstable Agreement, Unstable Disagreement, and Stable Disagreement (Table 1). Additionally, we descriptively coded qualitative response rationale to align feedback with incentives and their categories. This both informed participants in the feedback provided between R_1 and R_2 and contextualized our analysis of larger themes alongside the quantitative data (Saldaña 2013).

[1] We ran a Shapiro–Wilk test on the data to determine if we could assume our sample came from a normally distributed population. Results indicated our data were not normal; thus, we selected Levene's test as it is less prone to error when data appears non-normal (Levene 1960).

Results

Respondent qualifications

Five respondents listed their title as District Ranger, two as FMO, and one each as Fuels Manager, Fuels Specialist, Forest Fire Staff, Regional Fire Staff, Forest Supervisor, and Hotshot Superintendent. Eight participants listed IC qualifications and seven listed AA qualifications (two participants held some level of both).

R_0: elicited incentives

Participants offered 25 unique incentives (Table 2), which we grouped into six descriptive categories: organizational (O1–7), sociopolitical (S1–2), ecological (E1), performance (P1–3), financial (F1–9), and liability (L1–3). Organizational incentives consisted of both

Table 1 Spectrum of consensus and defining criteria

Consensus	*Criteria*
Stable Agreement	$p_{lev} > 0.1 \cap (s_1 \leq 1 \cup s_2 \leq 1)$
Unstable Agreement	$p_{lev} \leq 0.1 \cap (s_1 \leq 1 \cup s_2 \leq 1)$
Unstable Disagreement	$p_{lev} \leq 0.1 \cap (s_1 > 1 \cap s_2 > 1)$
Stable Disagreement	$p_{lev} > 0.1 \cap (s_1 > 1 \cap s_2 > 1)$

Table 2 Incentives elicited from participants in the initial unstructured round (R_0), categorized by incentive type. We gave each incentive a unique identifier for reference (e.g., O1–O7 for organizational incentives, P1–P3 for performance incentives)

Organizational	
O1	Verbal/written support from agency for OTFS strategies prior to an incident
O2	Adding OTFS-specific qualifications to workforce development and training (i.e., taskbooks)
O3	Adding OTFS-specific positions to organizational capacity and hierarchy
O4	Positive recognition by agency leadership (at regional and national levels) of a unit's successful use of OTFS strategies
O5	Remove regional approval requirement to manage wildfire OTFS
O6	Increased capacity to manage wildfire OTFS (i.e., larger workforce)
O7	Increased availability of capacity to manage wildfire OTFS (i.e., fewer restrictions at PL 4 or 5[a] to manage OTFS locally)
Sociopolitical	
S1	Verbal/written support from local elected officials for OTFS strategies prior to an incident
S2	Media coverage and education for the public
Ecological	
E1	Ecological benefits linked to wildfire managed OTFS (i.e., nutrient cycling, fuel loads, or other measures of landscape health)
Performance	
P1	Claiming acres treated with wildfire managed OTFS toward the regional fuels target
P2	Claiming acres treated with any wildfire toward the regional fuels target
P3	Resilience-based targets, beyond those based on measurements of acres
Financial	
F1	Funding to increase public understanding of wildfire
F2	Funding to increase smoke monitoring by experts where OTFS is common
F3	Funding to increase fire effects monitoring capacity
F4	Monetary awards or bonuses for successful use of OTFS strategies
F5	Time off awards for successful use of OTFS strategies
F6	Monetary awards or bonuses for utilization of local partner capacity to support OTFS operations
F7	Increases in overall financial compensation (i.e., base pay, overtime)
F8	Increases in region/unit funding to cover the cost of OTFS resources
F9	Availability of national suppression funds for incidents managed OTFS
Liability	
L1	Liability coverage for burn bosses and line officers
L2	Sufficient NEPA coverage with resources identified (i.e., heritage sites, habitat)
L3	Claiming acres treated with wildfire managed OTFS even if no NEPA coverage exists

[a] The National Multi-Agency Coordinating Group (NMAC) oversees allocation of equipment and resources, establishing priorities for active incidents. It sets the national Preparedness Level (PL), a scale from 1 to 5 (5 being the highest) that indicates the quantity and severity of wildfire incidents across the country, and the percentage of resources committed to active incidents

material changes to wildfire management agencies, such as increasing general or OTFS-specific capacity (O2, O3, O6), and immaterial gestures, like support from agency leadership (O1, O4). Financial incentives included specific funds for OTFS management like bonuses for successful use, to more general allocations like a broad increase in wildland firefighter compensation. Liability incentives included pre-fire issues, like adequate NEPA planning, post-fire issues, and liability coverage for decision-makers in the event a fire managed with OTFS strategies escaped control. Performance incentives focused on the opportunity to count acres burned using OTFS strategies toward existing "acres treated" targets set for Forest Service Regions. Sociopolitical and ecological incentives were the least populated and focused on public support for OTFS and ecosystem benefits respectively.

R_1 and R_2: consensus and dissensus trends

Results were tabulated based on our spectrum of consensus (Table 1). We measured 12 incentives as having Stable Agreement after two rounds, 12 as Stable Disagreement, and one as Unstable Agreement. No incentives were measured as Unstable Disagreement. Among those measured as Stable Agreement, six incentives had agreement in both rounds (Fig. 3a). Furthermore, that subset represented five of the six incentive categories used in Table 1: organizational (O4), performance (P1), sociopolitical (S1, S2), liability (L3), and financial (F6).

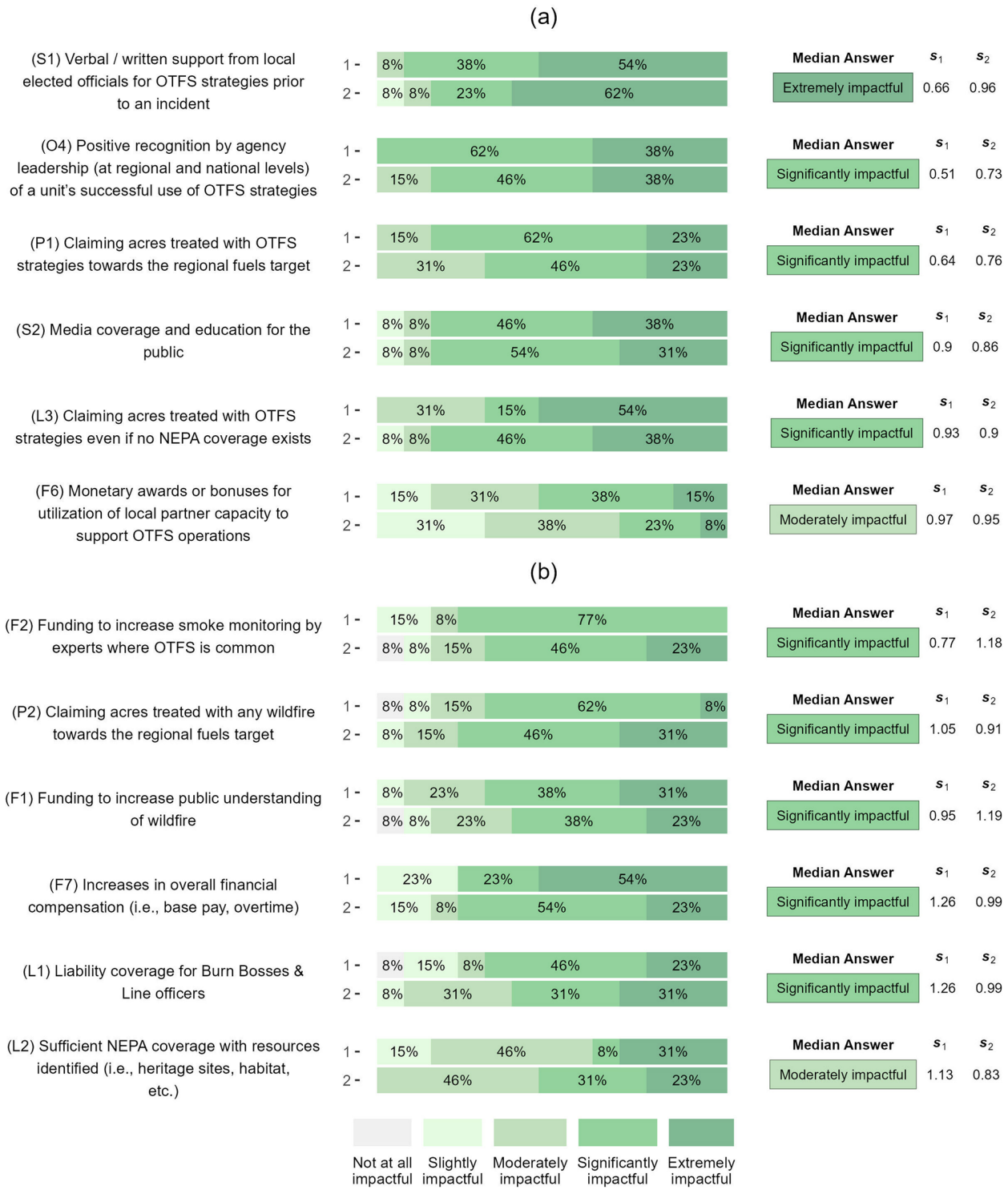

Fig. 3 Incentives that saw Stable Agreement after two Delphi rounds. This figure lists incentives, a response distribution on our 5-point Likert scale for the given incentive in each round, the median answer for the incentive, and the standard deviation from both rounds (s_1, s_2). We divided this group into two sections: **a** incentives where $s_1 \leq 1 \cap s_2 \leq 1$ and **b** incentives where $s_1 \leq 1 \cup s_2 \leq 1$. Median answer is the estimated level of impact of the last structured round (R_2) on a 5-point Likert scale (1—not impactful at all, 2—slightly impactful, 3—moderately impactful, 4—significantly impactful, 5—extremely impactful). See Table 1 for the definition of Stable Agreement

The remaining six incentives that saw Stable Agreement (Fig. 3b) had agreement in only one round, but measured statistically homogenous variance ($p_{lev} > 0.1$) thereby meeting the criteria shown in Table 1. They comprised a narrower categorical distribution than those in Fig. 3a, with three from financial (F1, F2, F7), two from liability (L1, L2), and one from performance (P2).

One incentive saw Unstable Agreement: verbal or written support from their agency for OTFS strategies prior to an incident (O1, Fig. 4). Though it met our agreement criteria, it was the only incentive without statistically homogenous variances between the two rounds ($p_{lev} \leq 0.1$), likely due to the number of respondents that converged on the answer "significantly impactful" from R_1 to R_2. Without a third structured Delphi round, we were unable to determine if this agreement is stable.

Of the 12 incentives measured as having Stable Disagreement (Fig. 5), most came from two categories: organizational and financial. Organizational incentives regarding OTFS-specific qualifications (O2) or positions (O3) had variance beyond our agreement threshold in both rounds and had among the lowest median responses for any incentive (3—moderately impactful). Multiple incentives with Stable Disagreement did not meet our agreement criteria despite seeing a significant majority (i.e., more than 66%) of responses list them as either significantly impactful or extremely impactful (F3, O7).

Between R_1 and R_2: qualitative feedback from participants

Six respondents contributed rationale for their answers in R_1 that was then summarized and provided to participants to review before completing R_2. Regarding organizational incentives, multiple participants argued that additional OTFS-specific qualifications or positions would add unnecessary complexity to the existing qualifications system, while one participant felt that incident commanders and teams lacked a defined learning track, limiting opportunities to gain and document experience with OTFS management. Additionally, feedback was divided on the effect of regional or national restrictions, like regional approval requirements or increased PL. Some argued that they limit options and imply a lack of support from leadership, while another said they rarely create significant delays or negative impacts. Participant feedback on sociopolitical incentives consistently stated that local public officials were critical to increasing support and understanding in their communities toward utilizing natural ignitions for management objectives. Feedback for the remaining categories either lacked consistency or received too few qualitative responses to determine themes.

Discussion

This research aimed to understand: (1) what incentives wildfire professionals believe would impact the use of OTFS strategies, (2) what trends of consensus or dissensus emerged, and (3) if a Delphi approach proved suitable to facilitate such a discussion. Our findings inform and extend the literature in two ways. First, we demonstrated that professionals could reach consensus on a diverse array of incentives to begin developing more actionable public policy. These incentives corroborate both known and novel ideas across three key facets of wildfire management: cash, capacity, and commitment (McFayden et al. 2022). Second, we showed that a Delphi approach can serve as an empirically grounded vehicle for meaningful policy development. Though shifting the wildfire management paradigm in the USA involves complexities beyond what was captured in our data, we provide insight for improving wildfire policy incentives and identifying methodological approaches that facilitate those improvements.

Incentives

Cash

Participants proposed more financial incentives across scales than any other category, notably reaching consensus on known issues in wildfire management like increasing base compensation (F7) and public education of wildfire (F1). While some specific gaps in workforce

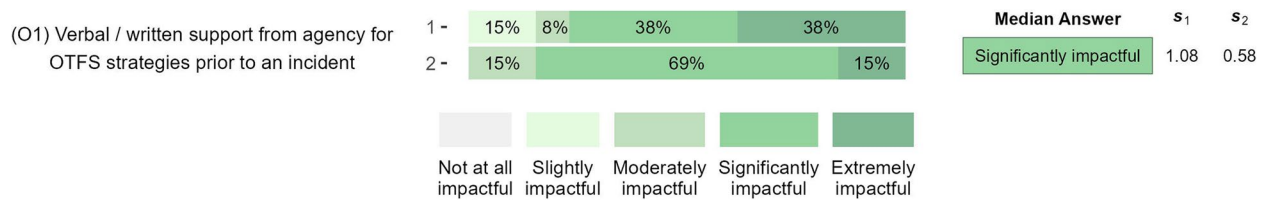

Fig. 4 Incentives that saw Unstable Agreement after two Delphi rounds. This figure lists incentives, a response distribution on our 5-point Likert scale for the given incentive in each round, the median answer for the incentive, and the standard deviation from both rounds (s_1, s_2). Median answer is the estimated level of impact of the last structured round (R_2) on a 5-point Likert scale (1—not impactful at all, 2—slightly impactful, 3—moderately impactful, 4—significantly impactful, 5—extremely impactful). See Table 1 for the definition of Unstable Agreement

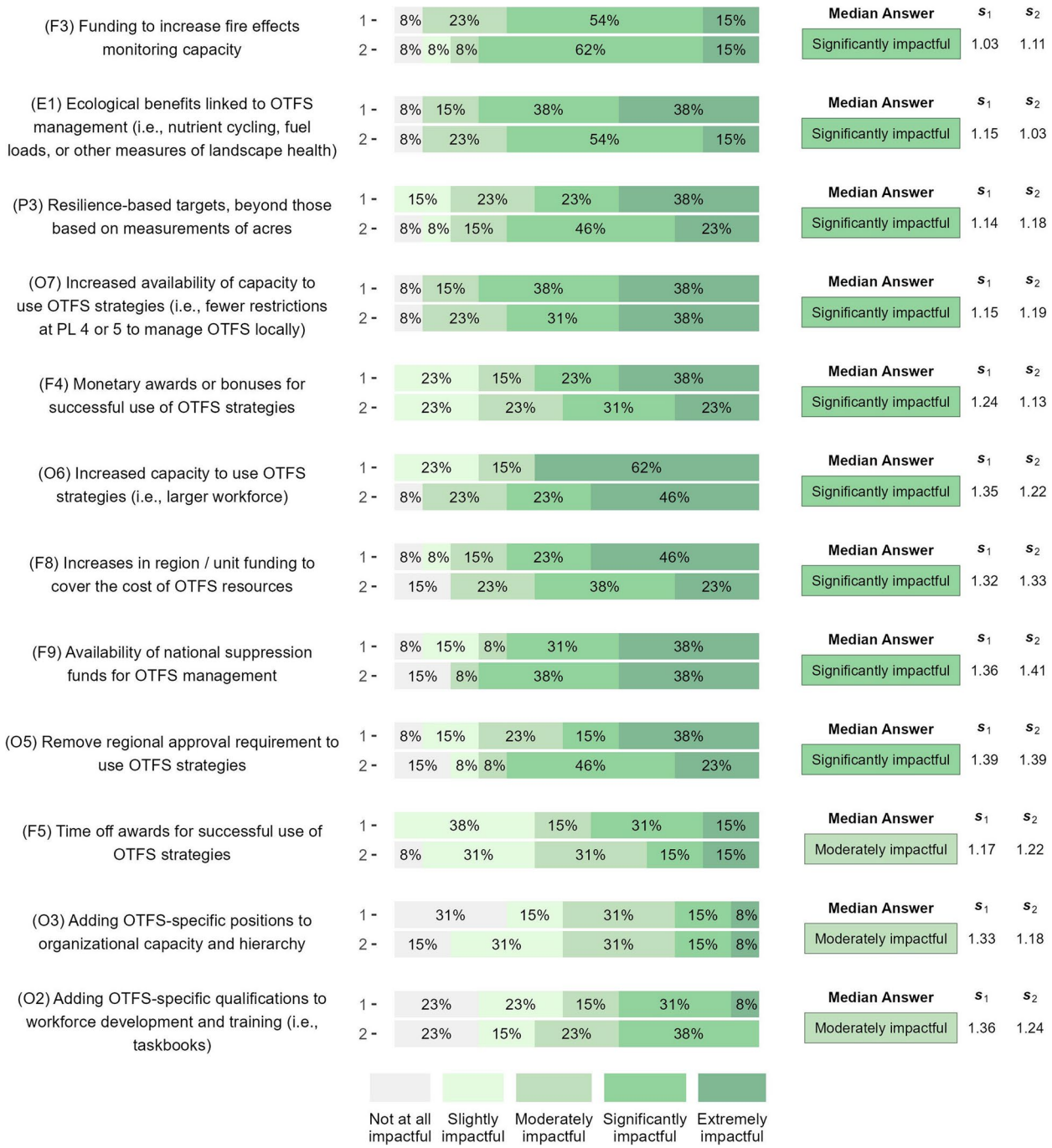

Fig. 5 Incentives that saw Stable Disagreement after two Delphi rounds. This figure lists incentives, a response distribution on our 5-point Likert scale for the given incentive in each round, the median answer for the incentive, and the standard deviation from both rounds (s_1, s_2). Median answer is the estimated level of impact of the last structured round (R_2) on a 5-point Likert scale (1—not impactful at all, 2—slightly impactful, 3—moderately impactful, 4—significantly impactful, 5—extremely impactful). See Table 1 for the definition of Stable Disagreement

compensation like hazard pay for activities on prescribed burns have been addressed in FS policy (FS and NFFE 2024), the Wildland Fire Mitigation and Management Commission (WFMMC) has called for significant increases to base pay, akin to other organizations tasked with matters of national security (WFMMC 2023). Public education and communication on wildfire management remains a challenge both in the USA and abroad, where inadequate reporting mechanisms and oversimplified media coverage have hampered attempts to push

against suppression bias for years (Anderson et al. 2018; Pietruszka et al. 2023).

Additionally, participants reached consensus on more novel issues, such as funding to improve smoke monitoring capacity (F2) and bonuses for utilizing external partner capacity (F6). Smoke monitoring and adaptation is a relatively unexplored domain in wildfire social science (Edgeley 2023) and will require significant investment to improve real-time forecasting and mitigate impacts to human health (WFMMC 2023). Utilizing external partner capacity emerged in Schultz et al. (2022) workshop, albeit for the purpose of validating treatments rather than executing them. It is encouraging that different methods (in-person or Delphi) in different geographies (CO or AZ and NM) produce similar themes.

Capacity

Beyond funding, participants proposed and reached consensus on incentives related to the capacity to act on said funding. Legal justification from up-to-date NEPA assessments are known bottlenecks to wildfire management capacity (Steelman and McCaffrey 2011), especially regarding OTFS strategies (Franz et al. 2024). Our participants not only found consensus on the need for NEPA coverage (L2), but they also considered the impact of removing the requirement for such coverage (L3), which may relate to the extensive time and effort necessary to update NEPA assessments (CEQ 2020). A more novel idea in legal capacity emerged as well: providing full liability coverage for decision-makers if a wildfire escaped control (L2). Sound strategies sometimes result in adverse outcomes, and wildfire decision-makers have expressed fear of the personal and professional risks associated with OTFS strategies (Fillmore et al. 2021, 2024).

In terms of personnel, agencies struggle to hire and retain staff at currently appropriated levels (Westphal et al. 2022; WFMMC 2023). However, our participants may be uncertain about the kinds of personnel needed to achieve landscape-level restoration via wildfire use in Region 3. Smoke monitoring (F2) met our consensus criteria, while fire effects monitoring (F3) did not. Additionally, we noted dissensus in qualitative and quantitative data for adding OTFS-specific qualifications (O2) or positions (O3). Given the consensus on liability coverage and performance measures, it is possible that participants prefer addressing the risks and rewards associated with OTFS management before hiring people and developing the skillsets necessary to do the work. Respondents do appear to acknowledge that there is high interactivity between the suggested incentives, revealing a potential order in which policy must change.

Commitment

Some of the most impactful incentives may not require a change of policy at all. Participants saw the strongest consensus on public and leaders both before (S1) and after (O4) incidents, giving further credence to the role leadership plays in shifting organizations away from suppression bias (Fillmore et al. 2021; Franz et al. 2024). Furthermore, leadership intent and direction help support not just the strategies and their underlying paradigm, but drive adoption of the decision support systems that help facilitate such strategies (Noble and Paveglio 2020; Greiner et al. 2021; Beeton et al. 2022; Buettner et al. 2023).

Policy change would prove most impactful in crafting incentives that reward people for successful use of OTFS. Acres treated targets will likely remain for their simplicity and political salience (Donovan et al. 2008; Wilson et al. 2018). Participants understandably valued claiming acres burned with OTFS wildfire toward those goals (P1) but also considered counting acres from any wildfire toward them, regardless of strategy (P2). The Forest Service policy update that prescribed fire activities qualify for hazard pay (FS and NFFE 2024) sets precedent that potential hazards are functionally the same in fire management, regardless of whether the fire was planned or unplanned. In the same vein, wildfire's potential benefit to reduce hazardous fuels or serve an ecological function is the same, regardless of whether teams managed the fire with full suppression or OTFS strategies and regardless of whether the ignition began from a lightning strike or abandoned campfire. Wildfire management organizations should consider developing a new "acres treated" metric specifically for OTFS management (Schultz et al. 2022), but also removing irrelevant barriers like management strategy or ignition source from existing incentives, and clarifying long-term strategies to address accusations of double counting acres where multiple treatments overlap.

Future research on OTFS incentives should investigate incentives in other geographic regions beyond the Southwest US. A notable limitation of this study is our sample size and its geographic distribution. While 13 individuals falls in a range considered suitable for Delphi studies (Belton et al. 2019), that quantity from only Arizona and New Mexico is not representative of other parts of the country. The feasibility of OTFS management varies due to unique ecological and sociopolitical landscapes (Davis et al. 2022; Iniguez et al. 2022), so more work is needed to understand if the trends seen in this study remain consistent elsewhere. Furthermore, our study likely has some selection bias. Given the tendencies in management, media, and society toward fire suppression, both in the USA and abroad (Anderson et al. 2018; Fillmore 2024;

Pietruszka et al. 2023), participation in our study was limited to only those willing to share their thoughts on a difficult subject. Future studies should prioritize not only expanding the sample population, but encouraging as much qualitative feedback for answers as possible. Points of dissensus in our study were among the most intriguing results, but not all respondents offered rationale for their answers (as seen with O2 and O3). Without it, the nature of that dissensus remains unclear. Combining Delphi or other prioritization and consensus techniques with in-person settings (Edgeley et al. 2020; Schultz et al. 2022) could maximize the breadth and depth of feedback, giving participants more exposure to alternatives and trade-offs, which should improve decision quality (Árvai and Gregory 2021).

Delphi approach

A Delphi approach showed promise in exploring wildfire policy options and alternatives. Given the alignment with proposed incentives to known gaps, challenges, and opportunities identified in existing research, this could warrant the use of simpler, parametric criteria for Delphi studies in an exploratory context (Franc et al. 2023). Despite the alignment we saw with existing literature, we noticed some potential false negatives such as increasing fire monitoring capacity (F3). Monitoring is a known gap in land management (Wurtzebach et al. 2019), and a supermajority of participants (i.e., 66% or more) considered it significantly impactful, but it did not meet our threshold based on standard deviation. Principles of supermajority exist in the legislative branches of government in the USA, like overriding a presidential veto or proposing a constitutional amendment (McGinnis and Rappaport 2008; CRS 2023), and many Delphi studies have used supermajority rules to define consensus (Von Der Gracht 2012; Belton et al. 2019). Consensus could also depend on question framing. Those with a unipolar scale (i.e., 1 to 5, like perceived impact in this study) may best align with a supermajority threshold, while questions with bipolar scale (i.e., −2 to 2, from strongly disagree to strongly agree with 0 as neither) may best align with a variance threshold. Future policy Delphi studies could present multiple such options and allow participants to define consensus and dissensus themselves. Defining consensus is crucial for Delphi studies, but it is also arbitrary. Future work should both thoughtfully consider which is most suitable and recognize the futility of finding a perfect threshold.

Conclusion

Implementing social mechanisms that can help fire and land management professionals extend the safe use of OTFS strategies is critical to accelerate forest restoration. In this study, we identified numerous incentives that fire professionals in Arizona and New Mexico felt could motivate their use. These findings suggest both formalized and informal pathways that could motivate the expansion of OTFS management, while simultaneously highlighting the importance of inclusive discussions about the policy implications across regions and at multiple levels within agencies. This study also invites the use of more novel methodological approaches to understand policy within the wildfire social sciences, underscoring the importance of diversifying data collection approaches to support understandings of nuance across scales and contexts. Ultimately, advancing the use of naturally ignited fires as a landscape management tool necessitates both verbal and political support at the national level to ensure successful implementation at the local level.

Acknowledgements

The authors would like to thank the Joint Fire Science Program for funding the study, all the participants for participating in the study, and to our friends and family for supporting them throughout the study.

Authors' contributions

SF designed, conducted, and analyzed the study and wrote the manuscript. CE assisted in design, planning, and analysis. All authors reviewed and approved the final manuscript.

Funding

Funding provided by the Graduate Research and Innovation (GRIN) fund from the Joint Fire Science Program (Award Number: L23AC0028300, Project ID: 23–1-01–2).

Data availability

Portions of the data that support the findings of this study are available from the corresponding author on reasonable request. However, the personally identifying information of the interview participants is protected under the provisions of human subject research in compliance with Northern Arizona University Institutional Review Board guidelines and is not available.

Declarations

Ethics approval and consent to participate

This study was classified Exempt and approved by the Northern Arizona University Institutional Review Board (IRBNet ID 2016443–1). Informed consent was obtained by all participants.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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Received: 27 January 2025 Accepted: 8 May 2025
Published online: 20 June 2025

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