FINAL REPORT

Title: Bucking the suppression status quo - Incentives to shift the wildfire management paradigm around natural ignitions

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List of Abbreviations

AA : Agency Administrator
FS : United States Forest Service
IC : Incident Commander
NEPA : National Environmental Policy Act of 1969
NMAC : National Multi-Agency Coordinating Group
OTFS : other than full suppression
PL : Preparedness Level
WFMMC : Wildland Fire Mitigation and Management Commission

Keywords

Managed wildfire, fire management, policy Delphi, wildfire policy, Southwest US

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Abstract

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 can reach consensus on incentives used to promote OTFS management. Using the Delphi method, whereby individual participants complete anonymous iterative surveys and provide feedback on group responses, we asked wildfire management professionals in Arizona and New Mexico 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 affected by OTFS wildfires to count towards regional treatment targets were among the most impactful in the eyes of participants. These results suggest that incentivizing OTFS management requires a combination of policy adjustment and agency alignment to better leverage wildfire to restore ecosystems and reduce hazardous fuels.

Objectives

The objectives of this study are to investigate what incentives fire management experts would increase use of other than full suppression (OTFS) strategies, what level of agreement or disagreement these experts find about those incentives, and whether Delphi techniques are suitable to elicit these opinions. We met all three of these objectives over the duration of the study.

Background

To build resilience in ecosystems plagued by a history of fire exclusion in the Southwest US, managers need a combination of treatment techniques in their proverbial toolbox, including wildfire, prescribed fire, and mechanical means (Stoddard et al. 2020; Huffman et al. 2020). The Wildfire Crisis Strategy set by the US Forest Service acknowledges that we must significantly accelerate the pace of landscape treatment to protect invaluable ecosystems, watersheds, and other human values (USDA Forest Service 2022a). While forests in the Southwest US often need mechanical treatments first to facilitate safe reintroduction of fire, treatment effects significantly improve with a mixture of mechanical treatments, prescribed fire, and wildfire (Roccaforte et al. 2024). Furthermore, wildfire is a vital tool to achieve the scale required for landscape restoration (North et al. 2012).

Despite some notable policy shifts in recent decades to more explicitly recognize the need to leverage wildfire for management objectives, decision makers in the Southwest US use it conservatively, often far away from significant human values like infrastructure or residential areas (Young et al. 2020; Iniguez et al. 2022), where both potential risks and potential benefits

remain low. Multiple factors present obstacles to using wildfire, including individual risk aversion (Calkin et al. 2011; Thompson et al. 2018; Fillmore et al. 2021), disconnects through layered and distributed 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 in performance measurement (Donovan et al. 2008; Wilson et al. 2018). This research focuses on the latter of these factors, as fire professionals in the Southwest US noted the difficulty in connecting beneficial wildfire to existing metrics (Franz et al. 2024). To buck the suppression status quo, we must balance the inherent risks of wildfire management with suitable rewards for decision makers.

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 simple 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 the lack of connecting metrics to local levels makes it difficult for individual decision-makers to prioritize actions that both reduce 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 to dictate strategy for 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.

When faced with problems of sufficient complexity or uncertainty, eliciting expert opinion can help characterize dynamic systems where empirical data is difficult to collect and analyze (Kuhnert et al. 2010). A common technique in environmental research, studies rely on experts to validate modelling (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 towards 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 Delphi techniques as an option to address these concerns, which involve anonymously eliciting opinions and allowing individuals to amend their input after considering others' responses. Delphi techniques can help access to the positive impacts of group meetings like multi-perspective exposure and idea synthesis, while mitigating their negative impacts such as groupthink, personal or sociopolitical conflicts (Hasson et al. 2000; Martin et al. 2012; Belton et al. 2019).

Delphi studies often measure group consensus on a topic, which is best described as a level of agreement across participants and the relative stability of that agreement over time (Dajani et al. 1979; Rowe and Wright 2001). While most studies agree to define consensus a priori (prior eliciting responses from participants), studies differ on how to do so or more fundamentally, if it is the primary goal of the study (Belton et al. 2019; Franc et al. 2023). Policy-focused Delphi studies, for example, consider consensus only one piece of the puzzle, as stable disagreement, or dissensus, can play an important role as well (Turoff 1970; Nowack et al. 2011). Policy Delphi studies can function as a catalyst for wide and deep explorations of pros and cons for a given topic and enable more robust policy formulation and analysis (Franklin and Hart 2006; Von Der Gracht 2012).

While some studies in forest management have used Delphi techniques (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?

Materials & Methods

We conducted a Delphi survey with 13 wildfire professionals in the U.S. 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).

Expert Sampling

Candidates had to meet the following criteria in order to be eligible to participate in this Delphi survey: (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 both for the research team's proximity and connections to wildfire management organizations in the region and the region's extended history of successfully managing wildfire using OTFS strategies (Young et al. 2020; Iniguez et al. 2022). We consulted with wildfire and public policy experts to determine these criteria. These key informants provided insights to determine that this array of positions encompassed the relevant components of wildfire management for the study. 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 beginning with (1) publicly available rosters for land management agencies in the geographic scope of our inquiry, (2) public communications regarding open positions in land management agencies that listed contact information for fire management professionals, and (3) existing personal networks of both authors. Candidates received an email invitation to the study as well as weekly follow ups for two 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, 118 individuals that met our inclusion criteria were invited to participate, of which 14 individuals started the survey and 13 completed all rounds (attrition rate of 7%), which satisfies a generally accepted sample frame between 5 and 20 experts (Hasson et al. 2000; Belton et al. 2019; Franc et al. 2023). For the sake of data continuity, we omitted responses from the individual that did not complete all survey rounds.

Survey Construction and Feedback

Figure 1. Flow diagram outlining the Delphi process for this study.

We administered our Delphi survey using the Qualtrics software platform. We constructed three rounds (Figure 1): one unstructured round (R_0), and two structured rounds ($R_1$and R_2). Existing literature suggests that the number of structured rounds should depend on the stability of answers across time (Rowe and Wright 2001; Von Der Gracht 2012; Belton et al. 2019). However, due to financial and temporal constraints and to minimize participant attrition, our study could only span two rounds, which still meets a basic threshold for patterns of stability and consensus to emerge (Belton et al. 2019; Franc et al. 2023). In R_0, we asked participants to list 3 to 6 incentives that they believe do help or could help facilitate the use of OTFS strategies in wildfire management. By soliciting responses to an open-ended question, we allowed participants to identify issues to address instead of deciding without their input, which helps develop suitable questions and elicit focused responses (Rowe and Wright 2001; Frewer et al. 2011). In addition, we asked participants to provide their job title and any qualifications earned in AA or IC position task books (WFA3, WFA2, WFA1 and ICT5, ICT4, ICT3, ICT2, and ICT1, respectively).

We then gathered the submitted incentives, consolidated to remove duplicates, and categorized suggestions by general approach. In R_1, we asked participants to assess these incentives on rank-ordered Likert scales, the most common type used in Delphi studies (Belton et al. 2019). Participants were first asked to assess each incentive's expected impact on use of OTFS strategies using a five-point Likert scale (ranging from 1 - "Not impactful at all" to 5 - "Extremely Impactful"). For each incentive category, respondents were invited to offer the

rationale behind their answers as open-ended text entry, prompting them to consider and explain a wholistic set of pros and cons for a given issue (Franklin and Hart 2006). We aggregated these qualitative responses into an anonymized summary and provided this summary, along with a visual distribution of responses for each incentive (Figure 2), for each participant to review. After six days, we executed R_2, inviting participants to take the same survey again after reviewing feedback from the previous round.

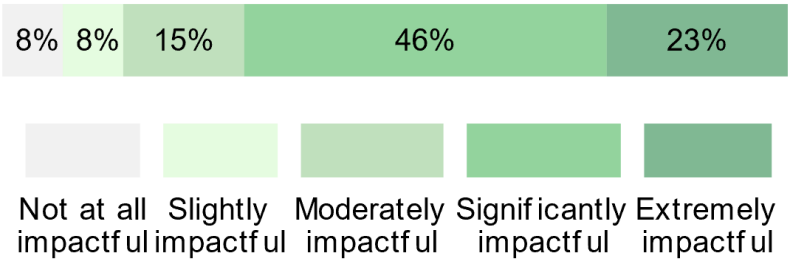

Figure 2. Example of visual distribution of responses provided to participants between rounds. This stacked bar chart shows the responses for a single incentive.

Analysis

Many studies on Delphi techniques 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 (Belton et al. 2019). However, there is little agreement on a standard means to define and measure consensus, with many such studies omitting a defined threshold altogether (Diamond et al 2014). A range of options, from simple thresholds of similar opinions (i.e., percentage of respondents with the same answer) to more complex mathematical approaches, including non-parametric statistical analysis (Belton et al. 2019). Franc et al. (2023) argue that parametric methods have little practical difference than more complex non-parametric methods, while simultaneously being easier for non-statisticians to interpret. Given our goals and the purview of Delphi studies to elicit decision-making options and alternatives as well as serve as the exploratory springboard for more rigorous studies (Franklin and Hart 2006; Franc et al. 2023), we opted to model our definition of consensus from Franc and others' (2023) approach, using sample standard deviation and a test for homogenous variance.

For each incentive, we first calculated sample standard deviation for R_1 and R_2 (s_1 and s_2). We defined the threshold for agreement a priori to be $s_j \leq 1$ for an incentive in round j. Given that agreement is a relatively arbitrary threshold, we do not consider stability to be simply an incentive with response standard deviation below this threshold in both rounds, but rather when at least one round saw agreement ($s_1 \leq 1 \cup s_2 \leq 1$), and response variance in R_1 and R_2 is statistically homogenous. To calculate homogenous variance, we first used the Shapiro-Wilk test to determine if we could assume our sample data comes from a normally distributed population. Results indicated that the data was not normal, thus we opted to use Levene's Test to test homogeneity of variances between the responses for each round, as it is less prone to error when data appears non-normal (Levene 1960). Using a 90% confidence interval, we defined stability

as any incentive with homogenous variance across R_1 and R_2, indicated by a p-value from Levene's Test $p_{lev} > 0.1$. 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).

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 1. Spectrum of consensus and corresponding criteria.

Results & Discussion

Respondent Qualifications

Respondents' positions varied: of our total sample frame of 13, five 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. Their qualifications varied as well: eight participants listed ICT qualifications (ranging from ICT5 to ICT2) and seven listed WFA qualifications (ranging from WFA 3 to WFA1). Two participants held some level of both ICT and WFA qualifications.

R_0: Elicited Incentives

When prompted to provide between 3 and 6 incentives to increase the use of OTFS strategies in wildfire management, participants offered 45 total suggestions. After merging duplicate answers, 25 remaining incentives were categorized into six thematic groups: organizational (7), sociopolitical (2), ecological (1), performance (3), financial (9), and liability (3). The full list of incentives is presented in Table 2. Organizational incentives consisted of both material changes to wildfire management agencies, such as increased capacity or creating OTFS-specific qualifications or positions, and immaterial gestures, like explicit support or recognition from agency leadership prior to using OTFS strategies and after successfully using them. Financial incentives ranged from funds directed specifically to OTFS management, such as bonuses for successful use, to more general allocations, such as a broad increase in financial compensation for the wildland firefighting workforce. Liability incentives pointed to both pre- and post-fire issues, insufficient NEPA coverage and liability coverage for decision-makers in the event a fire managed with OTFS strategies escaped control. Performance incentives centered on the ability 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.

Organizational
Verbal / written support from agency for OTFS strategies prior to an incident
Adding OTFS-specific qualifications to workforce development and training (i.e., taskbooks)
Adding OTFS-specific positions to organizational capacity and hierarchy
Positive recognition by agency leadership (at regional and national levels) of a unit's successful use of OTFS strategies
Remove regional approval requirement to manage wildfire OTFS
Increased capacity to manage wildfire OTFS (i.e., larger workforce)
Increased availability of capacity to manage wildfire OTFS (i.e., fewer restrictions at PL 4 or 5[1] to manage OTFS locally)
Sociopolitical
Verbal / written support from local elected officials for OTFS strategies prior to an incident
Media coverage and education for the public
Ecological
Ecological benefits linked to wildfire managed OTFS (i.e., nutrient cycling, fuel loads, or other measures of landscape health)
Performance
Claiming acres treated with wildfire managed OTFS the regional fuels target
Claiming acres treated with any wildfire toward the regional fuels target
Resilience-based targets, beyond those based on measurements of acres
Financial
Funding to increase public understanding of wildfire
Funding to increase smoke monitoring by experts where OTFS is common
Funding to increase fire effects monitoring capacity
Monetary awards or bonuses for successful use of OTFS strategies
Time off awards for successful use of OTFS strategies
Monetary awards or bonuses for utilization of local partner capacity to support OTFS operations
Increases in overall financial compensation (i.e., base pay, overtime)
Increases in region / unit funding to cover the cost of OTFS resources
Availability of national suppression funds for incidents managed OTFS
Liability
Liability coverage for Burn Bosses & Line officers
Sufficient NEPA coverage with resources identified (i.e., heritage sites, habitat, etc.)
Claiming acres treated with wildfire managed OTFS even if no NEPA coverage exists

Table 2. Incentives elicited from participants, categorized by incentive type.

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. Amongst those measured Stable Agreement, six incentives saw agreement in both rounds (Figure 3a).

[1] 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

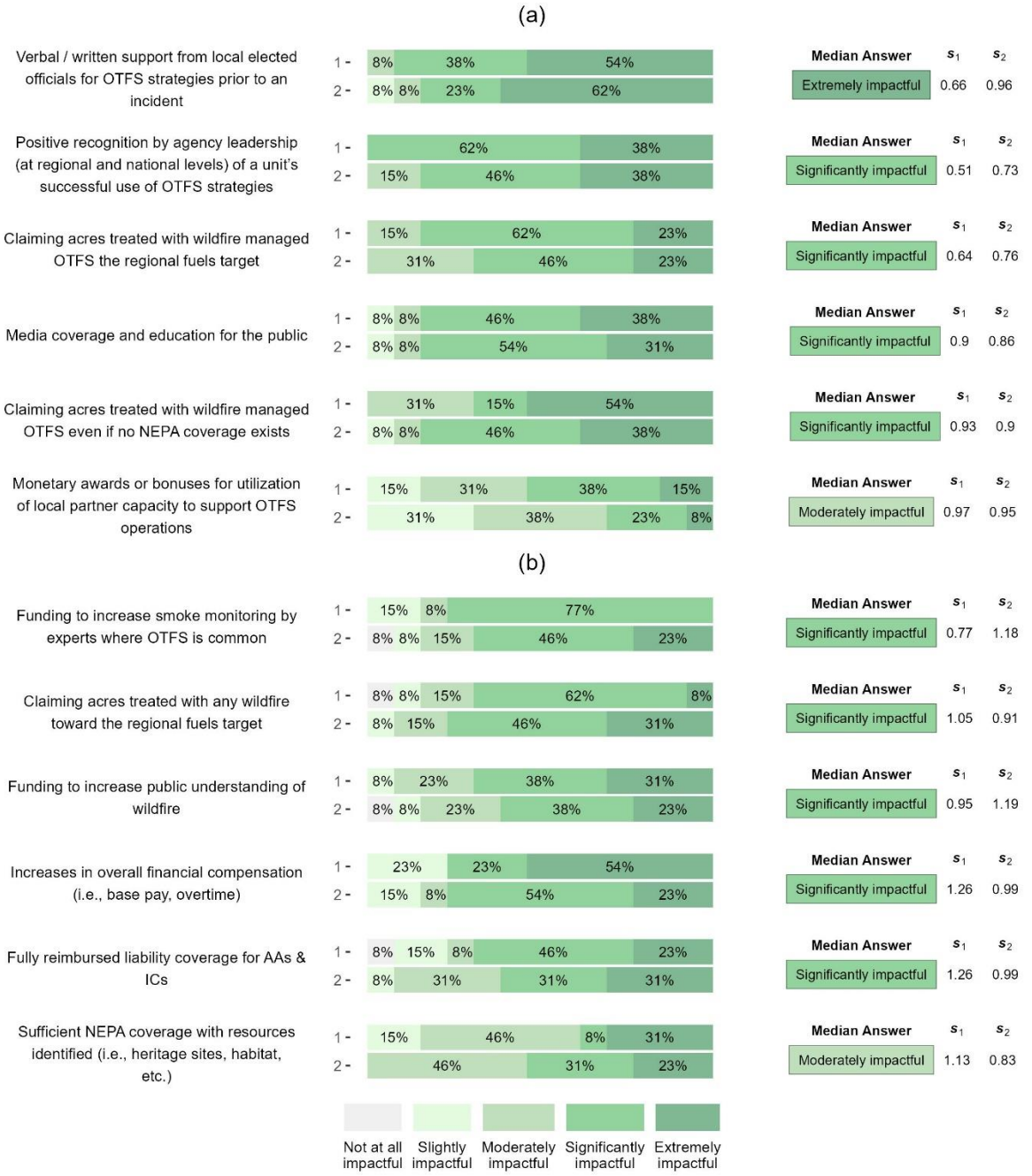

Figure 3. Incentives that saw Stable Agreement after two Delphi rounds. This figure lists incentives, a visualization of response distribution on our 5-point Likert scale for the given incentive in each round, the median answer for the incentive, and the standard deviation from both rounds (s_1, s_2). 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).

Furthermore, that subset represented five of the six incentive categories used in Table 1: organizational (positive recognition by agency leadership), performance (claiming acres treated with OTFS strategies toward the regional fuels target), sociopolitical (2, media coverage and

education for the public and verbal or written support from local elected officials), liability (claiming acres treated with OTFS strategies even if NEPA coverage does not exist), and financial (monetary awards or bonuses for utilizing local partner capacity to support OTFS operations).

The remaining six incentives that saw Stable Agreement (Figure 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 Figure 3a, with three from financial ("*funding to increase smoke monitoring by experts where OTFS management is common"*, *"funding to increase public understanding of wildfire"*, and *"increases in overall financial compensation"*), two from liability (*"Sufficient NEPA coverage with resources identified (i.e., heritage sites, habitat, etc.)"* and *"fully reimbursed liability coverage for AAs and ICs"*), and one from performance (*"claiming acres treated with any wildfire toward regional fuels targets"*).

One incentive saw Unstable Agreement: verbal or written support from their agency for OTFS strategies prior to an incident (Figure 4). Though it met the 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.

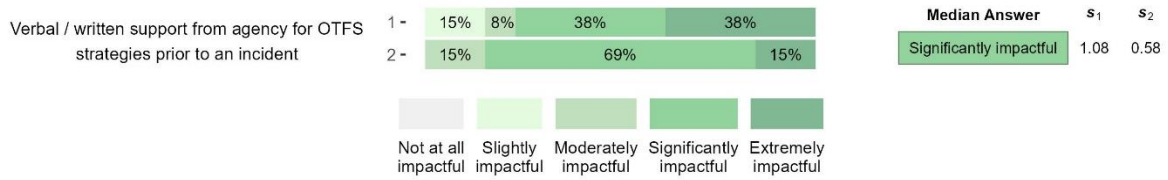

Figure 4. Incentives that saw Unstable Agreement after two Delphi Rounds.

Of the 12 incentives measured as Stable Disagreement (Figure 5), most came from two categories: organizational and financial. Organizational incentives in this group, specifically "*adding OTFS-specific qualifications to workforce development (i.e. taskbooks)"* and "*adding OTFS-specific positions to organizational capacity and hierarchy"*, had variance beyond our agreement threshold in both rounds and had among the lowest median responses for any incentive (3 – Moderately Impactful). Of note within the Stable Disagreement group: multiple incentives, such as "*funding to increase fire effects monitoring capacity"* and "*increased availability of capacity to use OTFS strategies (i.e., fewer restrictions at PL 4 or 5 to use OTFS strategies locally)"* 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.

Between R_1 and R_2: Qualitative Feedback from Participants

6 out of 13 respondents contributed rationale for their answers in R1 that was then summarized and provided to participants to review before completing R2. Regarding organizational incentives, multiple participants argued that additional qualifications or positions related to

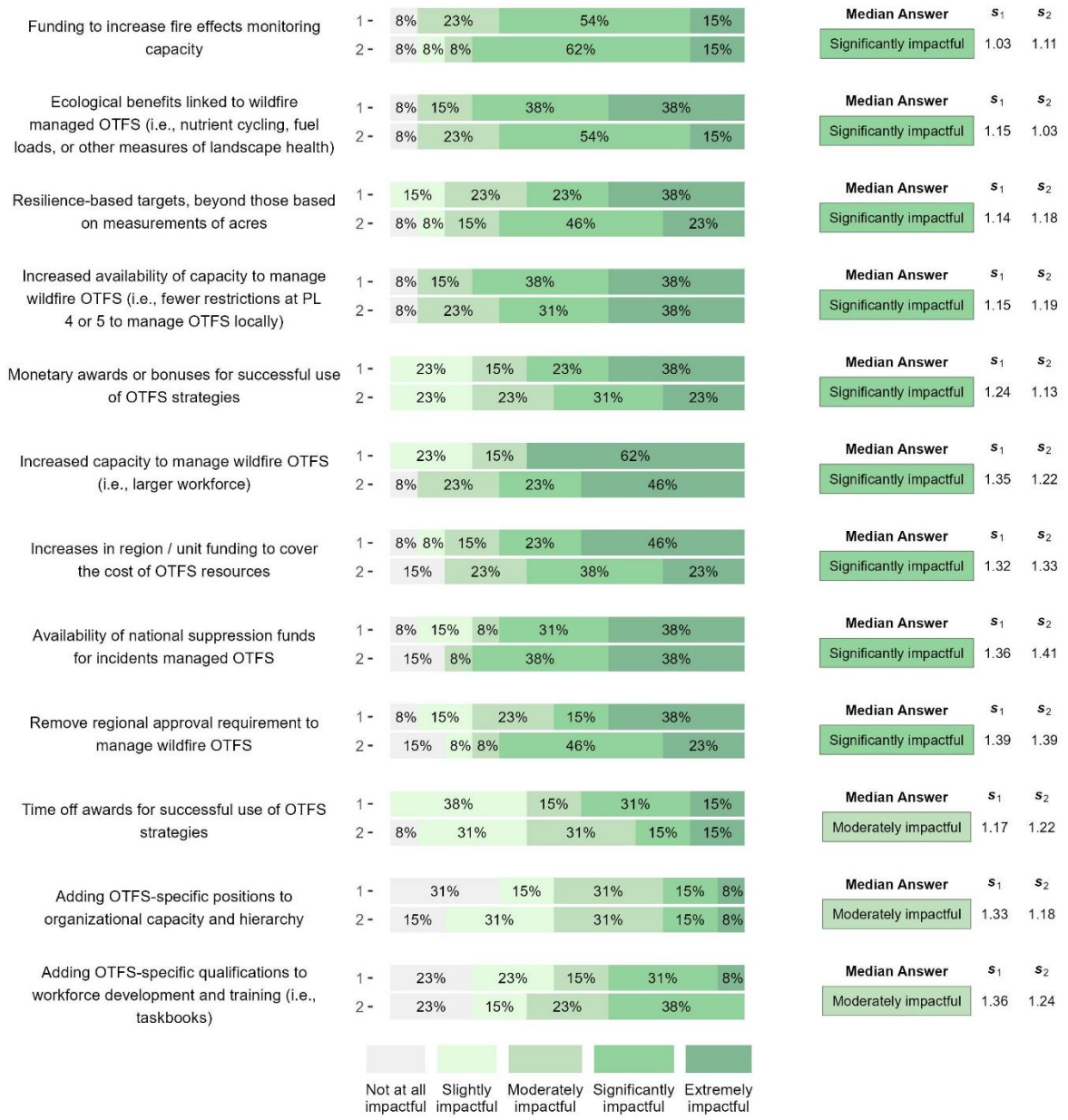

Figure 5. Incentives that saw Stable Disagreement after two Delphi rounds.

OTFS management 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 such themes.

Discussion Overview

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 Delphi techniques proved suitable to facilitate such a discussion. Our findings inform and extend the literature in two ways. First, we demonstrate that professionals can reach consensus on a diverse array of incentives to begin developing more actionable public policy. These incentives corroborate existing research across three key facets of OTFS management: cash, capacity, and commitment (McFayden et al. 2022). Second, we show that Delphi techniques can serve as an empirically grounded vehicle for meaningful policy development. Though shifting the wildfire management paradigm in the United States involves complexities beyond what we captured in our data, this study and the discussion below provide insight for improving wildfire policy incentives and identifying methodological approaches that facilitate those improvements.

Incentives

Participants proposed more financial and monetary incentives than any other category with a relatively high rate of consensus. Broader incentives such as "increases in overall financial compensation" speak to well-established financial barriers and imbalances in wildfire management (Steelman and Burke 2007; Thompson et al. 2018; Schultz et al. 2019; Westphal et al. 2022). While specific circumstances, such as hazard pay for activities on prescribed burns, have been addressed in FS policy (FS and NFFE 2024), organizations like the Wildland Fire Mitigation and Management Commission (WFMMC) have called for wholesale increases to the wildfire workforce and their compensation, akin to other organizations tasked with national security (WFMMC 2023).

Public education and communication on wildfire management remains a challenge both in the U.S. and abroad, where inadequate reporting mechanisms and oversimplification or distortion in public media can hamper attempts to push against suppression bias (Anderson et al. 2018, Pietruszka et al. 2023). The two more specific incentives also corroborate existing independent research. Smoke monitoring to support public adaptation is a needed but 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 local partner capacity aligns with a workshop run by Schultz et al. (2022) that recommended it as way to ground acres treated measurements into local priorities, which could fill a gap identified by wildfire professionals in the Southwest U.S. (Franz et al. 2024).

Participants also proposed and reached consensus on a number of incentives that address the next need beyond adequate funding: the capacity to act upon that funding. Capacity consists of more than just personnel and funds; it begins with legal justification and liability coverage and ends with an appropriate metric to count towards (Franz et al. 2024). Sound strategies sometimes result in adverse outcomes, and wildfire decision-makers have expressed fear of the personal and professional risks associated with OTFS strategies in existing research (Fillmore et al. 2021;

Fillmore et al. 2024). Before making the decision to use OTFS strategies, land units must complete NEPA assessments that establish where and how wildfire will help accomplish management objectives and include them in management plans (Steelman and McCaffrey 2011). This need emerged in *"NEPA coverage with resources identified (i.e., heritage sites, habitat, etc.)"*, to justify the decision prior to an incident, and *"fully reimbursed liability coverage for AAs and ICs"*, to provide protections after the fact. Once documentation and planning permits taking the risk inherent to OTFS strategies, participants also agreed that suitable rewards are needed, reaching consensus on *"claiming acres treated with wildfires managed OTFS toward the regional fuels target"*. While NEPA assessments make this possible, the effort needed to complete one is likely an obstacle given how many have expired (Franz et al. 2023), and possibly explains the consensus seen for *"claiming acres treated with wildfires managed OTFS toward the regional fuels target even if no NEPA coverage exists"*. Given these obstacles, wildfire management organizations should develop a Key Performance Indicator (KPI) that specifically tracks acres treated with OTFS management (Schultz et al. 2022).

Agencies struggle to hire and retain staff at currently appropriated levels and likely need significant increases in personnel (National Park Service 2021; Westphal et al. 2022). Our participants failed to reach consensus on the type and skillsets of personnel needed, highlighted by the two most polarized incentives: *"Adding OTFS-specific qualifications to workforce development and training (i.e., taskbooks)"* and *"Adding OTFS-specific positions to organizational capacity and hierarchy"*. In Delphi studies that focus on policy, consensus is not always the primary objective, as dissensus can create a "structured conflict" that facilitates creative exploration of policy issues and alternatives (Franklin and Hart 2006; Von Der Gracht 2012). In both quantitative and qualitative responses, our participants engaged in this debate and clarified opposing viewpoints about capacity. This indicates that they may be uncertain about the kinds of personnel needed to achieve landscape-level restoration via wildfire use in Region 3. 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. A future Delphi study, given adequate time, could take topics that reached stability (consensus or dissensus) and incorporate a ranked-choice exercise to determine relative priority.

Organizational commitment to utilize OTFS strategies in wildfire management reached consensus on several incentives, including *"positive recognition from agency leadership (at regional and national levels) of a unit's successful use of OTFS strategies"* and saw agreement on *"verbal / written support from agency for OTFS strategies prior to an incident."* Though the latter was unstable, both speak to what wildfire professionals have expressed in existing literature: explicit and public support of OTFS management from leadership, both before and after incidents, will help facilitate its use and shift agency culture away from suppression bias towards a more balanced wildfire management paradigm (Fillmore et al. 2021, Franz et al. 2024). Furthermore, leadership intent and direction help support not just the strategies and their implied paradigm, but are also crucial for driving 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).

Future research on OTFS incentives should investigate other geographic regions to see if similar recommendations to national leadership emerge from contexts that differ from the Southwest United States. Though our sample frame is a suitable vertical sample through a land management organization like the Forest Service, it lacks the diversity necessary to clarify robust policy incentives that could be proposed to decision-making bodies. Furthermore, as qualitative feedback complements and clarifies responses in ways that quantitative data cannot capture, a future study could utilize a combination of techniques used here and in Schultz and others' workshop (2022).

Delphi techniques

Participants reached consensus on numerous incentives that corroborate existing independent research, indicating that the often-overlooked Delphi approach can offer valid data to accelerate discussions about OTFS fire and other land management strategies. First, simply defining agreement, stability, and consensus before conducting this study is a step in the right direction for Delphi techniques that historically lack consistent criteria (Diamond et al. 2014). Furthermore, our results seem to warrant the use of simpler, parametric criteria for Delphi studies, especially in an exploratory context (Franc et al. 2023).

Though our results aligned with existing research, we offer some additional considerations for future Delphi research. Though past studies do not agree on a standard definition for consensus, many use percentage of respondents giving the same or similar responses to define consensus, e.g., 66% or 75% (Von Der Gracht 2012; Belton et al. 2019). Principles of supermajority exist in the legislative branches of government in the United States, such as the thresholds to override a presidential veto or to propose a constitutional amendment (McGinnis and Rappaport 2008; CRS 2023). Some incentives that measured Stable Disagreement in our study saw a supermajority consider them at least Significantly Impactful, such as, *"funding to increase fire effects monitoring capacity"*. Given the inherently arbitrary nature of defining consensus and the variety of ways to do so, future studies should thoughtfully consider one best suited for the study context and questions. For example, questions with a unipolar scale (i.e., 0 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. A future policy Delphi study, especially done in conjunction with an in-person workshop, could present multiple such options and allow participants to define consensus and dissensus themselves. A wider breadth of participants, along with both Delphi and in-person methods, could yield robust results.

Science Delivery Activities

We shared findings of this project via an oral presentation at the 4th Southwest Fire Ecology Conference in Santa Fe, New Mexico in November 2024. We plan to submit a version of this manuscript to *Fire Ecology* in January 2024.

Conclusions and Management / Policy Implications

Whether with people or with policy, culture shifts are generational. Undoing past habits and biases requires adequate incentives to change behavior, persistent evaluation to measure progress, and incremental adjustment to adapt as we learn. Wildfire management professionals in the Southwest US showed that an array of incentives, from explicit messages of support from leadership to quantifiable performance metrics, could significantly impact how decision makers balance rewards with the inherent risks of facilitating fire's natural role on the landscape. They showed Delphi techniques can serve as both a control for cultural and organizational biases and a vehicle to explore options, alternatives, and tradeoffs in policy formulation. Future research should collect a more diverse set of participants and incorporate both Delphi and traditional group techniques to maximize the quantitative and qualitative feedback. Policymakers and land managers should engage in these types of activities and consider how such feedback loops can be built and maintained to strengthen the connection between policy vision and policy implementation.

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Appendix B: List of Completed / Planned Scientific / Technical Publications / Science Delivery Products

Articles in peer-reviewed journals

Franz ST, Edgeley, CM. In preparation. Bucking the suppression status quo: Eliciting incentives to shift our wildfire management paradigm using Delphi techniques. *Fire Ecology*.

Conference Proceedings

Franz, ST, Edgeley CM. 2024. Bucking the suppression status quo: Incentives to shift the wildfire management paradigm around natural ignitions. 4th Southwest Fire Ecology Conference. Santa Fe, NM.