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Complexities in post-wildfire governance: lessons from Colorado's 2020 wildfires

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Abstract

Background The increasing size and severity of western U.S. wildfires in recent years has generated greater attention towards post-wildfire response and recovery. Post-fire governance requires coordinating response and recovery capacities across jurisdictions, landscapes, and time scales. The presence of wildfire on federal public lands necessitates federal agency involvement in both suppression and recovery efforts, and program coordination with lower levels of government and non-governmental organizations. Using semi-structured interviews, we investigated experiences of leaders across the governance system with federal post-fire policies and programs following the record-breaking Cameron Peak and East Troublesome wildfires in the state of Colorado.

Results Our research found that persistent administrative and coordination challenges exist within and among federal agencies in the post-fire response and recovery space. Challenges included cross-jurisdictional coordination of key emergency response programs, program rules that affect post-fire project timing and effectiveness, the absence of a formal federal post-fire response strategy, and program funding issues. These factors revealed and exacerbated scale mismatches between existing agency capacities and the post-fire landscapes that result from unprecedentedly longer, larger, and more severe wildfires occurring in the western USA. Non-federal and non-governmental organizations were instrumental in overcoming these challenges through coordinating response and recovery efforts across both federal and private lands. To improve the federal post-fire response capacity, study participants stressed the importance of broader cross-jurisdictional use of federal resources, longer timeframes for recovery activities, and reforming the federal funding process.

Conclusions Our findings revealed a persistence of post-fire coordination and funding issues within federal land management agencies, and current agency capacities remain insensitive to the scale of twenty-first-century post-wildfire settings. Addressing the mismatches between existing agency resources and the spatial and temporal scale complexities of post-fire environments will require broader federal support for existing programs along with re-envisioning the overall approach to the post-fire response and recovery process.

Keywords Boundary organizations, Federal policy, Post-fire, Scale

Resumen

Antecedentes El incremento en el tamaño y severidad de los incendios en el oeste de los EEUU en años recientes ha generado una gran atención hacia la respuesta y recuperación en el post fuego. La gobernanza en el post fuego requiere de una capacidad de respuesta y recuperación coordinada entre jurisdicciones, paisajes, y escalas de tiempo. La presencia de incendios en tierras federales necesita del involucramiento de agencias federales tanto en los esfuerzos

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de supresión como de recuperación, y la coordinación de programas con niveles menores de organización estatales y no estatales. Usando entrevistas semi-estructuradas, investigamos las experiencias de líderes a lo largo del sistema de gobernanza sobre las políticas y programas que siguieron a los incendios sin precedentes como el Cameron Peak y el East Troublesome en el Estado de Colorado.

Resultados Nuestra investigación encontró que existe un persistente desafío en cuanto a la administración y coordinación de las respuestas en el post fuego y en su tiempo de recuperación. Estos desafíos incluyen entrelazar la coordinación jurisdiccional en programas de respuesta a emergencias, las normas que regulan y afectan el desarrollo en el tiempo y la efectividad de los programas, la ausencia de una estrategia federal formal para abordar la respuesta a la emergencia post fuegos, y un programa que atienda la provisión de fondos para esa emergencia. Estos factores revelaron y exacerbaron la escala de los desajustes entre las capacidades reales de las agencias y los paisajes posteriores, que resultaron en incendios más extensos y severos y que no tenían precedentes en el oeste de los EEUU. Las agencias por fuera de las federales, y otras organizaciones no gubernamentales, fueron instrumentales en superar esos desafíos a través de una respuesta coordinada y de esfuerzos en la recuperación tanto en tierras federales como privadas. Para mejorar la capacidad de respuesta de las agencias federales en el post fuego, los participantes de este estudio enfatizaron la importancia de una participación y uso más amplio, e jurisdiccionalmente interconectado de recursos federales, cronogramas más largos para las actividades de recuperación, y la reforma de los procesos de financiamiento para estos casos.

Conclusiones Nuestros resultados revelan la persistencia de una coordinación y financiamiento post fuego dentro de las agencias federales de manejo, y que las capacidades actuales de estas agencias permanecen como insensibles a la escala y desafíos de los post- fuegos que están ocurriendo en el siglo XXI. El afrontar los desajustes entre los recursos actuales de las agencias y las complejidades actuales a escalas espaciales y temporales, requerirá de aportes federales más amplios para programas existentes, junto con una revisión de forma amplia sobre la aproximación actual a las respuestas en el post fuego y los procesos de recuperación.

Background

Increases in the frequency and severity of wildfires have accentuated the importance and complexities of post-fire response and recovery across natural and built environments alike (Burke et al. 2021; Peterson et al. 2021). Since the 1990s, US response and recovery organizations have confronted larger wildfire footprints, more intense burn severity, and more frequent fires, with increased long-term post-fire risks that include flooding, debris flows, and sedimentation (Parks and Abatzoglou 2020; Congressional Budget Office 2022). Historically in the western USA (US West), post-fire governance, which we define as the policies and program processes executed by and between government and nongovernment entities in the aftermath of wildfire, has varied by location, land ownerships, and coordination capacities among participating organizations (Congressional Research Service 2015; Burned Area Learning Network 2018). These organizations are confronted with post-fire hazards across jurisdictional boundaries and both short- and long-term social, ecological, and economic impacts within and beyond wildfire footprints. From a "top-down" governing perspective, the response capacity of federal land management agencies is critical across the US West given the extent of federally managed public lands. Federal funding is also important, as states, counties, municipalities, and special districts lack the financial resources necessary for post-fire recovery. At the same time, state and local governments also play critical roles but often face uncertainty as to how, when, and where recovery begins and ends, especially as post-fire disturbances such as flooding can occur several years post-fire. While fire hazard reduction and incident response governance has seen ample attention in the literature (Steelman and McCaffrey 2011; Schoennagel et al. 2017; Schultz and Moseley 2019), research on policies that guide institutional response processes following wildfire incidents is lacking in the literature, particularly in the context of the wildfire severity now experienced in the US West. In this research, we tackle a piece of this puzzle by examining the role and effectiveness of post-fire policies for forest and watershed management after recent record-breaking wildfires on federal forestlands. The following sections introduce key federal post-fire policies and programs and provide a literature review of recent research on the intricacies of twenty-first-century post-fire response and recovery in the US West's forested watersheds.

An overview of federal post-fire policy

Understanding the federal role in post-fire settings first requires a survey of agency responsibilities and resources. Post-fire programs vary by agency missions and jurisdictions, funding sources, and operational timeframes (Table 1). Agencies in the U.S. Departments of Interior

Table 1 Federal-level post-wildfire response and recovery programs in the United States (*sources*: Department of Interior 2023; FEMA 2019, 2021; GAO 2021; Stubbs 2023; USDA 2022; Wang and Blackband 2023)

Program department/agency	Jurisdictional focus	Funding mechanism	Operational timeframes	Role in post-fire response and recovery process
Burned Area Emergency Response (BAER) USDA – *Forest Service* Interior – *Bureau of Land Management, National Park Service, Bureau of Indian Affairs, Fish and Wildlife Service*	Federally owned land managed by agency, including tribal reservations	Agency wildfire suppression budgets	Within 1 year of incident containment	Emergency stabilization and treatments on federal lands to protect and prevent further degradation of natural and cultural resources threatened by post-fire conditions, assess post-burn soil, plant, habitat, and hydrologic conditions, and prepare integrated plans to respond to threats
Burned Area Rehabilitation (BAR) USDA – *Forest Service* Interior – *Bureau of Land Management, National Park Service, Bureau of Indian Affairs, Fish and Wildlife Service*	Federally owned land managed by agency, including tribal reservations	USDA – Competitively awarded from National Forest System Budget Interior – Competitively awarded from Wildland Fire Management Program budget	Within 5 years of incident containment	Recovery of burned landscapes unlikely to recover without human interjection, including mitigation of invasive species threats, soil disturbance, reseeding/seedling planting, contouring for runoff control, or minor infrastructure/resource repairs
Emergency Watershed Protection (EWP) USDA – Natural Resources Conservation Service	Privately owned land/property	Supplemental congressional appropriations	EWP assistance requests within 60 days of disaster, NRCS provides plan and cost estimate within 60 days of sponsor request, construction must be completed within 220 days of EWP funding allocation for non-life-threatening disasters (10-day limit for life-threatening cases)	Conduct emergency measures to safeguard life and property and removing/reducing hazards caused by natural disasters, including streambank stabilization, channel sediment and debris removal, infrastructure repair, slope stabilization
Emergency Forest Restoration (EFRP) USDA – Farm Service Agency	Non-industrial, privately-owned forests	Supplemental and discretionary appropriations from Congress	Within 2 years of project approval	Provides up to 75% of cost-share funding for debris/downed tree removal for establishing new stands, replanting costs, reconstruction of forest roads, fire lanes, fuel breaks, erosion control structures, fencing, and wildlife habitat enhancement
Stafford Act Declarations and other Assistance DHS – *Federal Emergency Management Agency*	Private and publicly owned land/property	Annual appropriations from Congress for Disaster Relief Fund, emergency appropriations	Requests for funding required within 30 days of the incident for emergency and major disaster declarations, completion deadlines vary by type of project. FMAG requests must be approved by FEMA within 45 days of receipt. For HMGP-PF, within 6 months of the end of the fiscal year in which FMAG funding was awarded	For presidential declaration funding—*Public assistance*: debris removal, emergency protective measures, infrastructure repair/replacement; *Individual Assistance:* housing assistance, social programs, crisis counseling, etc. For Hazard Mitigation Grant Program-Post Fire Assistance: actions to prevent long-term risk to life and property from natural hazards, i.e., soil stabilization, flood diversion, reforestation

(Interior) and Agriculture (USDA) support ecological recovery, and the Department of Homeland Security's Federal Emergency Management Agency (FEMA) supports recovery in the built environment. Projects can be led exclusively by agency teams or contracted with non-federal government or non-government partners through special use permits or participating agreements. Funding varies by agency, with some programs supported via annual appropriations and others operating through supplemental funding bills passed by Congress (US Forest Service 2019; GAO 2021). Program timeframes also differ, from less than 1 year for emergency watershed protection needs to several years for replanting programs. Figure 1 summarizes the operational timeframes and jurisdictions of the federal post-fire programs described herein.

A variety of programs exist for funding post-fire assessment and action on federal lands. For the USDA Forest Service (Forest Service), which manages 76 million ha across 154 national forests, fire suppression and timber management were historically the agency's top priorities, with limited attention to post-fire needs (Congressional Research Service 2023a). By the 1990s, however, the agency began to formalize Burned Area Emergency Response (BAER) teams to assess post-fire conditions within its jurisdiction (US Forest Service 2019). Prior to or immediately following containment, assigned BAER teams conduct emergency post-fire stabilization actions to protect undisturbed agency infrastructure and cultural assets. Teams also survey post-fire soil, vegetation, and hydrology on Forest Service land and must complete a post-fire condition report within 1 year (National Interagency Fire Center 2023). Interior land management agencies also operate separate BAER programs within their jurisdictions. The Forest Service's BAER program is supported through the agency's annual fire suppression budget. Beyond the immediate post-fire assessment and response phase, Interior agencies and the Forest Service increasingly utilize Burned Area Rehabilitation (BAR) programs for longer-term forest recovery through reseeding, invasive species mitigation, and erosion control. The Forest Service estimates that nationwide, the 2021 wildfire season alone resulted in over US $1 billion in long-term burned area restoration needs within its jurisdiction (US Forest Service 2023). The Forest Service's BAR program was defunded in 2011, but a US $325 million Bipartisan Infrastructure Law appropriation reestablished the program through 2026 (US Forest Service 2023). Interior's BAR program relies on the department's Wildland Fire Management budget to competitively award proposals from individual bureaus, and awarded projects must be completed within 5 years (Department of Interior 2006). The US Geological Survey provides analytical capacity of post-fire environments (e.g., debris flow modeling) for federal and non-federal partners (Congressional Research Service 2023b).

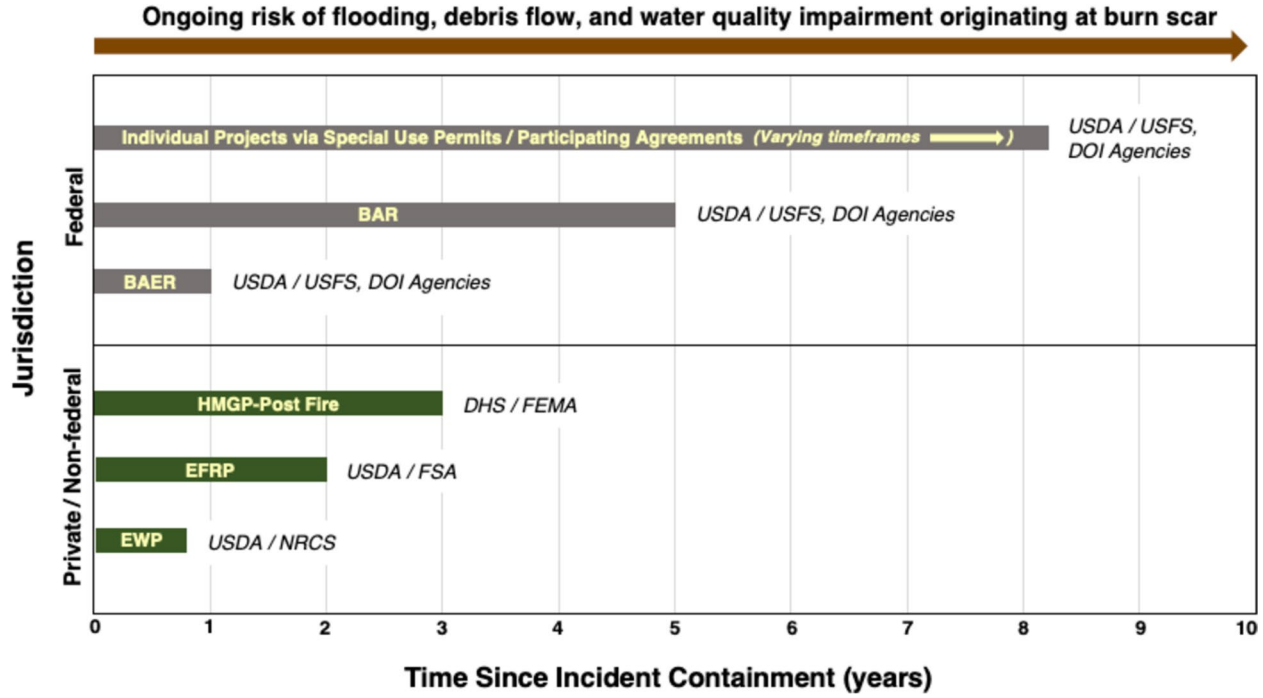

Fig. 1 Timeframes and jurisdictional responsibilities of various federal post-wildfire response programs

Different programs fund post-fire efforts on private lands. The USDA Natural Resources Conservation Service (NRCS) assists private and non-federal landowners under the Emergency Watershed Protection (EWP) program following presidential or agency-led emergency declarations. Under this program, the NRCS enters into cooperative agreements with local government sponsors (i.e., states, counties, municipalities, special districts). The NRCS reimburses sponsors 75% of costs upon completion of sponsor-led projects. For NRCS-led projects, sponsors must cost-share 25% of expenses upon project completion, and projects must be completed within 220 days (GAO 2021). The scope and complexity of EWP projects vary but generally involve addressing needs on individual or neighboring properties (e.g., for stream bank stabilization). Following project completion, sponsors are also responsible for site maintenance for durations specified by the NRCS. The EWP is not part of the USDA's annual budget and relies solely on supplemental congressional funding (GAO 2021). Also, the USDA Farm Service Agency supports post-fire recovery through the Emergency Forest Restoration Program on private (non-industrial) forests. This program assists landowners with debris removal, road restoration, erosion control, habitat enhancement, and replanting (Stubbs 2023).

FEMA supports post-fire recovery through two categories of Presidential disaster declarations (emergency and major disaster) allowed under the Stafford Act (Robert T. Stafford Disaster Relief and Emergency Assistance Act of 1988, 42 U.S.C. 5121 *et seq*. (1988)). Emergency declarations provide public assistance program funding for debris removal and emergency protective measures as well as individual assistance program funding for homeowners (Congressional Research Service 2017). Major disaster declarations can provide a wider range of assistance for public entities (e.g., emergency stabilization, infrastructure repair/replacement) and individuals (e.g., home repair/replacement, hazard mitigation); however, a disaster declaration does not guarantee funding, and neither public nor individual assistance is necessarily included in major disaster declarations (Congressional Research Service 2014; FEMA 2019). The Stafford Act also provides states Fire Management Assistance Grants that do not require presidential approval and provide funds to cover wildfire containment costs on non-federal public or private lands. Recipients of these grants are also eligible for FEMA's Hazard Mitigation Grants Program-Post Fire, which supports stabilization projects for up to 3 years post-fire on private and non-federal lands (FEMA 2021a).

Prior research on post-fire governance

The complex, interdisciplinary nature of post-fire recovery is reflected in diverse areas of scholarship, from forest ecology to disaster risk science and sociology, to adaptive governance and resilience literature (see, e.g., Toman et al. 2008; Long et al. 2014; Paveglio et al. 2015; Kooistra et al. 2018). Early efforts centered on understanding best practices for forest and watershed restoration in burned landscapes (Robichaud et al. 2000; Beschta et al. 2004). More recently, ecological literature has focused on challenges of post-fire regeneration (Stevens-Rumann et al. 2022), changes to watersheds (Hasan et al. 2020; Williams et al. 2022), and principles for post-fire management and ecosystem assessment (Meyer et al. 2021; Long et al. 2021). More broadly, the complexities of post-fire settings align with the challenges encountered following disasters in other U.S. locations, particularly with sharing of authority and responsibility within and between various layers of government (Finn 2022; Zarb and Taylor 2023).

Scholarship on federal post-wildfire policy is limited primarily to grey literature sources. At a national level, the Government Accountability Office (GAO) (2003) found that a lack of inter-agency coordination between USDA and Interior programs hindered recovery efforts, and that neither implementation nor effectiveness monitoring were prioritized across Interior's BAER programs. While more recent findings indicate that Interior and USDA agencies have adopted broader BAER monitoring protocols, program limitations persist, such as monitoring natural recovery or the effects of BAER activities in post-fire environments (Burned Area Learning Network 2018). Cheng et al. (2015) documented stakeholder perceptions from workshops following several Colorado wildfires in the early 2000s and found that following nearly every incident studied, funding delays within the EWP program hindered project implementation for several months. Another long-term challenge highlighted was the lack of continued financial support in the Stafford Act for secondary floods originating on burn scars. Also, local non-profit groups were found to be instrumental in connecting affected communities and federal agencies post-wildfire, and the report recommended increased funding for such groups in fire-prone settings. Subsequently, a GAO (2021) investigation of EWP concluded that project time limits, uncertainty in where EWP projects are allowed, program funding, and cost-matching requirements obstructed program effectiveness. The report did find, however, that EWP sponsors considered the program beneficial in disaster response, and federal agencies in updates to the report have indicated that these issues have been addressed. In September 2023, the Congressional Wildland Fire Management and Mitigation Commission (WFMMC 2023) released

its report on the nation's wildfire crisis with 41 post-fire-related recommendations. Specifically, the report called for funding enhancements for existing federal programs; expanding federal investments to spur state and local response capacity; organizational restructuring, program enhancement, and inter-agency coordination to improve response and recovery efforts; and expanding the spatial coverage of post-fire federal support for longer durations than current programs operate.

Beyond policy, community-based and other non-governmental organizations can fulfill important roles in governance as boundary organizations, which connect across public and private entities to provide leadership, capacity, and collaborative venues to help groups navigate federal program rigidity (Hannigan 2019; Davis et al. 2021). The adaptive and network governance literatures indicate such organizations are critical to addressing the scale mismatches that are extensive in fire management and throughout environmental governance, such as mismatched timelines of political and ecological processes, jurisdictional complexities in land management, or the presence of ecological characteristics (e.g., species habitat or processes such as fire) at and across various spatial and temporal scales (Folke et al. 2005; Cumming et al. 2006; Schultz et al. 2019a). Boundary organizations also can operate at different levels to connect managers, scientists, and community members and have become central to federal forest management (Cash et al. 2006; Abrams 2019). Those who work across jurisdictions in pre-incident wildfire risk management have increasingly taken on roles of navigating post-fire response and recovery in the US West (Edgeley and Paveglio 2017). Multiple factors can affect the need for and level of community-agency engagement, including fire size and severity, community dependence on forests, or the history of agency-community relationships (Ryan and Hamin 2008).

Scholars also have asked whether fires present opportunities for policy change. The literature primarily focused on state and local changes to building codes or land use policies. Schumann et al. (2020) contend that the post-fire period offers a policy "hot moment" to incorporate more fire-adapted practices in (re)construction and landscape management, but prior findings by Mockrin et al. (2016, 2018) indicate that only modest change in local ordinances has typically occurred in post-fire settings. They observed that state and local governments have generally refrained from broader land use planning and revised building codes post-wildfire. Kramer et al. (2021) further substantiated this trend and found that in California's post-fire settings between 1970 and 2009, new construction projects increased wildfire risk. Huber-Stearns et al. (2019) also found that watershed partnerships between the US Forest Service and water utilities in Colorado emerged when large fires in the early 2000s set the stage for governance innovations.

The post-fire space has also gained increasing attention through a social justice lens. In assessing social vulnerability discrepancies to wildfire, Davies et al. (2018) found that U.S. census tracts with greater than 50% minority populations faced greater vulnerability to extreme wildfire than other census tracts. Moloney et al. (2023) found that the effectiveness of long-term recovery organizations in providing post-fire assistance was "greatly" impacted by the amount, timing, and accessibility of FEMA recovery resources, which has further exacerbated community inequities. This work substantiated prior research on the potential for FEMA's individual assistance program to widen financial inequality in disaster-stricken communities (Emrich et al. 2022). Edgeley and Paveglio (2017) found that social conflict and distrust of federal agencies can be exacerbated post-disaster when program inefficiencies limit recovery resource access and perpetuate inequality among affected individuals.

With this literature in mind, we investigated the policy and governance of post-fire response for wildfires situated predominantly on federal forestlands. Our research questions were (1) what are the successes and challenges leaders experience with federal post-fire policies? and (2) what governance approaches (e.g., engagement with community-based organizations, timing of funding, data sharing, or policy improvements) are needed to successfully navigate the post-wildfire response and recovery process?

Methods

We conducted a qualitative case study across a multi-jurisdictional area in northern Colorado that experienced the state's two largest wildfires to date—the Cameron Peak Fire (Cameron Peak) and the East Troublesome Fire (East Troublesome), which burned 843 and 784 km^2, respectively, between August and December of 2020 (Colorado Division of Fire Prevention and Control 2023). The case study area (Fig. 2) was selected based on the size and impact of the wildfires, the multiple landownerships affected (Fig. 3), and the unique biophysical and social contexts present. We chose to investigate both fires as one case study because they occurred in the same year and in the same national forest, with many of the same state and federal agency personnel involved, but with some differences in local contexts (e.g., different communities, watersheds, and approaches to response coordination).

The Cameron Peak Fire burned from 14 August to 2 December across Forest Service, National Park Service, state, county, and private lands within three montane watersheds (the Cache la Poudre, Big Thompson,

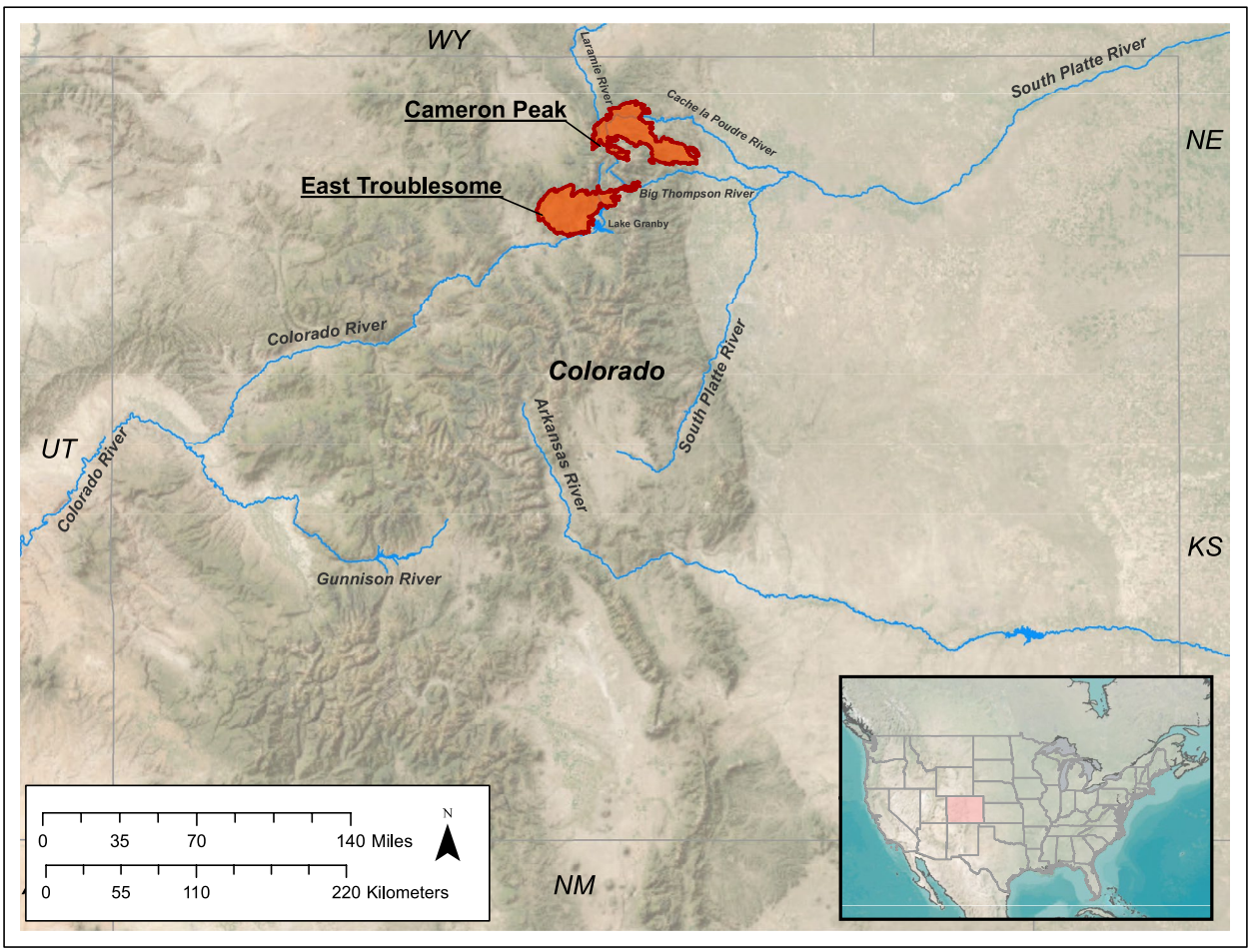

Fig. 2 Footprints of the 2020 Cameron Peak and East Troublesome wildfires in northern Colorado (map courtesy of E. Carter)

and Laramie Rivers). Combined, these watersheds provide water for over one million users and support irrigated agriculture, industry, recreation, and ecosystem needs in multiple states. The Cameron Peak footprint also included wilderness areas within the Arapahoe and Roosevelt National Forests and Rocky Mountain National Park (Fig. 3). The 14 October East Troublesome ignition on U.S. Bureau of Land Management land led to an eastward propagation of fire that engulfed Forest Service, National Park Service, state, county, and private lands in the Colorado River headwaters region. Both incidents experienced steady and rapid growth, including on 21 October when high winds fueled the expansion of East Troublesome by nearly 69,000 ha in 36 h. Figure 4 displays a timeline of the case study incidents and subsequent response efforts. Based on the number of homes destroyed, East Troublesome was the second most destructive wildfire in state history at the time of containment (Colorado Division of Fire Prevention and Control 2023). While the East Troublesome area had been absent of major wildfires historically, the Cameron Peak area had experienced the 2012 High Park Fire (35,000 ha) and major flooding from late summer storms in 2013 (Blumhardt 2022; Colorado Division of Fire Prevention and Control 2023). In January 2021, the President approved Major Disaster Declaration 4581, which provided over $40 million for FEMA's Public Assistance program in Colorado's Larimer and Grand Counties (FEMA 2021b).

We conducted semi-structured interviews with 27 individuals who had direct experience with or knowledge of the governance response for either or both wildfires (one interview involved two participants). Interviews were conducted primarily in the latter half of 2022. We sought participants with influential roles in post-fire governance, including individuals in government (i.e., federal, state, local, and special districts), non-governmental organizations (NGOs), private sector consultants, and academia (Table 2). Individuals from these organizations were solicited primarily for their direct experience with the federal programs utilized in the aftermath of the

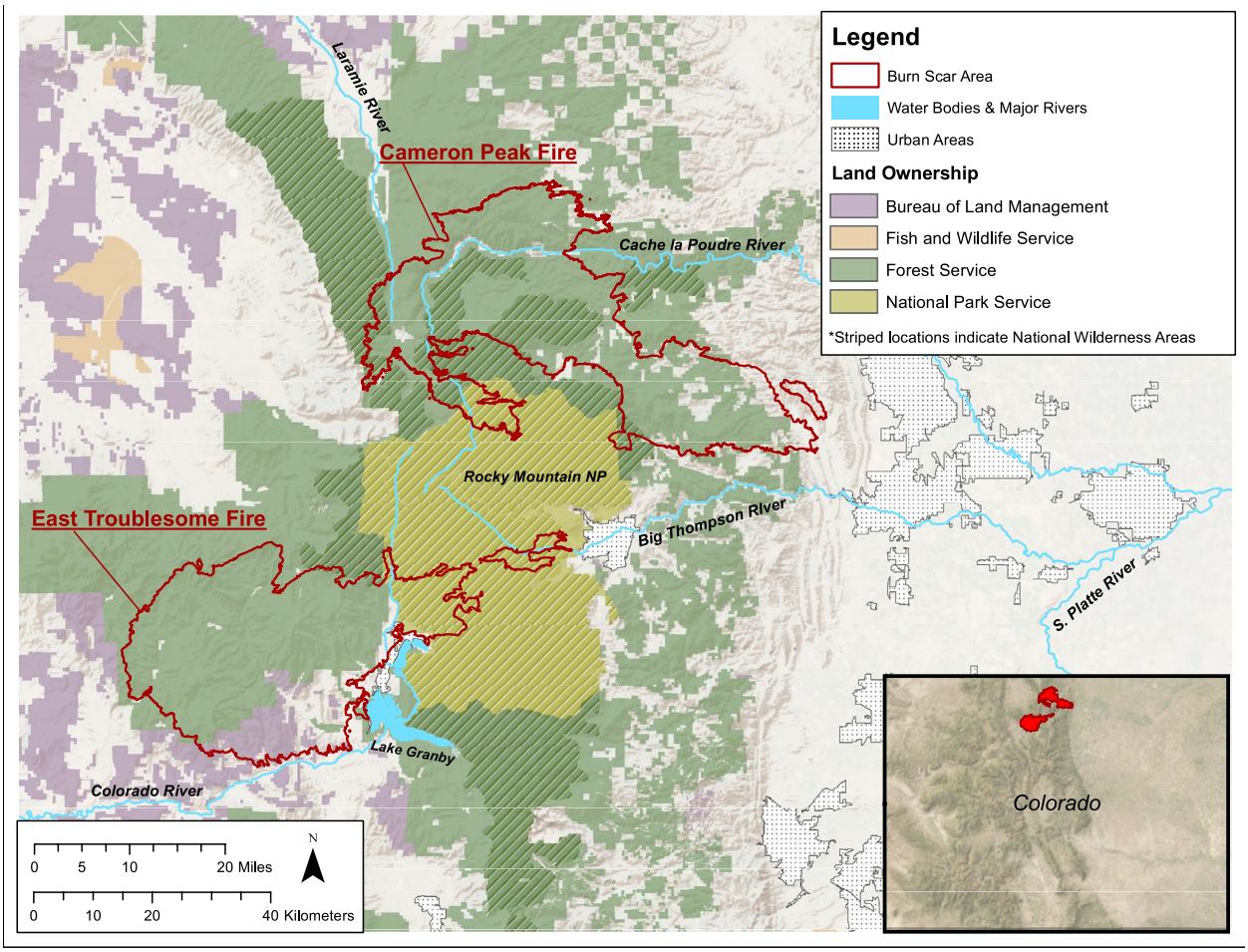

Fig. 3 Mosaic of land ownerships within and adjacent to the footprints of the Cameron Peak and East Troublesome Fires (map courtesy of E. Carter)

case study fires, including the planning and execution of post-fire projects. Additionally, several participants were involved in the inter- and intra-government negotiations and agreements reached between the federal government and non-federal entities. For participant recruitment, a list of potential interviewees was developed by first identifying contacts within the entities involved in post-fire response and through network queries of individuals acquainted with the authors. Purposive sampling from this list was used initially to solicit individuals familiar with the recovery efforts in either incident or post-wildfire processes in general. Initial interviewees were primarily affiliated with state or local agencies and NGOs. Subsequent interviews were arranged based on recommendations (i.e., snowball sampling) from the initial interviewees and included individuals with federal agencies, special districts, and regional water providers (Bernard 2017). Several interviewees were involved in or had knowledge of the recovery process during both case study incidents, given the overlap in state and federal agencies involved. Some interview candidates did not respond to repeated solicitations to participate in this research. In line with our research questions (see end of introduction), our interview guide specifically addressed (1) participants' experience with and connections to post-wildfire work; (2) governance of post-fire, including allowable actions on jurisdictions, program funding, role of participating actors, and implemented recovery practices; and (3) the challenges encountered and recommendations for improvement. Interviewees were asked also to share successes, surprises, failures, and missed opportunities. We note that additional research would be needed to understand individual landowners' perspectives of post-fire governance and its effects on their lands or livelihoods, as this was not the focus of this study.

We followed a research protocol approved by our university's Institutional Review Board. Interviews were typically conducted by two research team members via telephone or a video conferencing medium (e.g., Microsoft Teams) to minimize the risk of COVID-19

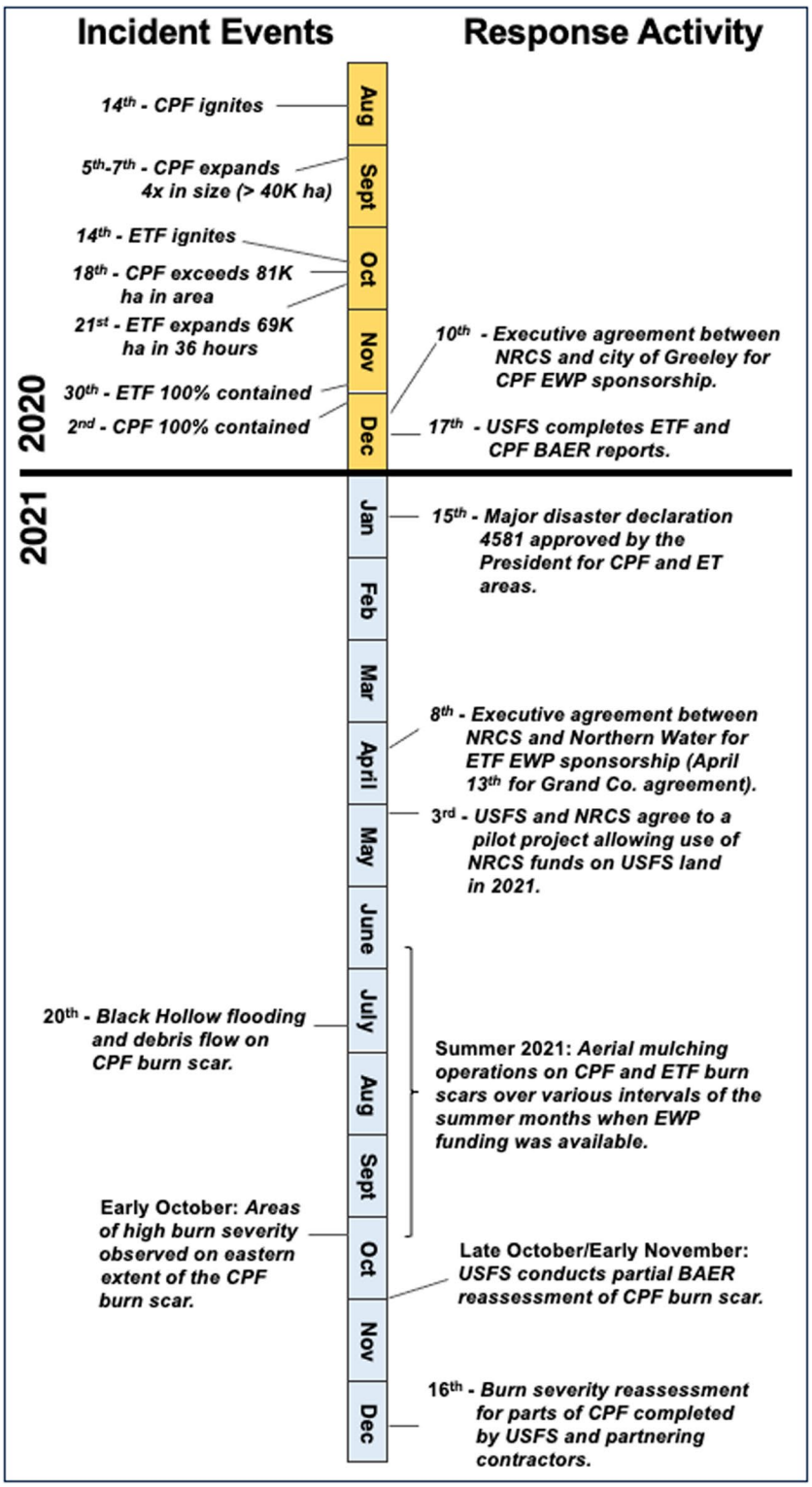

Fig. 4 Timeline of the Cameron Peak (CPF) and East Troublesome (ETF) fires and subsequent milestones in post-fire program response efforts at the federal level (sources: Prentzel 2021; FEMA 2022; Rodman et al. 2022; personal comms with T. Boldt (NRCS))

Table 2 Study participant affiliations

Affiliation	Number of participants
Non-governmental organizations	7
Local governing entity (i.e., county, municipal, special districts)	7
State agencies	4
Federal agencies (US Forest Service, NRCS)	4
Water providers (i.e., conservancy districts, wholesale distributors)	3
Academia	1
Private consultancy	1
Total	27

transmission. During interviews, the team lead followed an interview guide but allowed for flexibility in the order of questions based on interviewee expertise and the direction of their responses. Interviews were recorded (except for one interviewee who requested notetaking only) and typically lasted 60–75 min. Audio recordings were transcribed, deidentified, and cleaned prior to analysis. We followed an inductive coding approach using `Dedoose` analytical software to identify emerging themes in the participant responses and identify subthemes of nuanced content relevant to the preliminary themes coded (Saldaña 2015). Two team members developed an initial codebook through independently coding the first half dozen interviews after which intercoder agreement was reached on similarly identified themes (Campbell et al. 2013). Additional coding was completed by the lead author. We tested for and verified thematic saturation in our codebook utilizing a method by Guest et al. (2020). We utilized a final memoing process as part of our data analysis to organize representative themes and quotes relevant to key post-fire issues shared by interviewees (Charmaz 2006). In adherence to our confidentiality protocol, quotes are attributed to individuals by a unique number and general role, and not by name or position.

Results

We present a narrative of the most salient themes from our interviewees relative to each research question. Representative quotes are included to demonstrate key findings and nuanced perceptions of the interviewees. Additional quotes relative to key findings are provided in the Additional file 1.

What are the successes and challenges leaders experience with federal post-fire policies?

Interviewees identified multiple administrative and coordination challenges with the EWP and BAER programs that hindered systematic and timely post-fire response and recovery (summarized in Table 3). Several interviewees recounted that coordination challenges

Table 3 Administrative barriers encountered with federal post-wildfire programs following the 2020 wildfires in northern Colorado

Program Coordination and Jurisdictional Limitations	• BAER program provides minimal response and recovery capacity on burned landscapes; primary focus is on protecting agency assets that remain intact following a wildfire • EWP focused solely on rudimentary post-fire stabilization projects on individual private properties • Disparities between existing federal programs operating only within specific land ownerships precludes holistic approach to forest and watershed recovery • BAER program stabilization efforts intended only for federally owned lands • Absence of long-term response and recovery program options for secondary disasters sourced at wildfire burn scars that consider all land ownerships in affected areas
Program Rules	• BAER program's requirement to complete watershed assessments within one year limits how agencies account for seasonal conditions and the extent of burn scars • EWP rules on completion timeframes do not account for specific post-fire conditions (i.e., seasons, location of project work) or project requirements such as contract arrangements and permits • EWP does not allow for accounting of future post-fire conditions (i.e., new hydrologic regime) in project designs
Funding	• Forest Service BAER programs are funded from the agency's suppression budget, which can limit the funding resources available to support BAER efforts when containment priorities exhaust annual suppression appropriations • Reliance on supplemental funding for EWP does not provide adequate amounts of money for new post-fire regimes; timing of EWP funding distribution is ill-suited for the timing of when stabilization activities are most critical in the 24-month timeframe following wildfire • Matching requirements for EWP sponsors and operations and maintenance costs are becoming cost-prohibitive with increasingly larger wildfire footprints

among the federal agencies and between federal and non-federal partners became evident by early 2021. Interviewees noted that the two fires burned primarily on federal land but resulted in watershed impairment and threats to non-federal public infrastructure and private property that manifested over time. BAER funding was available for immediate soil stabilization on Forest Service land to protect that agency's resources, but resources were lacking to influence downstream water quality and flows. Non-federal entities therefore sought EWP funding to stabilize high-risk areas on Forest Service land to mitigate threats to non-federal jurisdictions. However, there were, in the words of one interviewee, "tremendous policy tensions" (14, special district employee) between the Forest Service and NRCS over whether and how EWP funds could be used on Forest Service land. Multiple interviewees shared that these tensions were rooted in increasingly strict agency adherence to their jurisdictions and separate funding sources that emerged following program audits by the Office of Management and Budget (OMB) in the early 2000s. Interviewees told us that the agencies eventually compromised on a "pilot program" that allowed the use of EWP funds on Forest Service lands during summer 2021 only, a process that nonetheless resulted in delayed planning and execution of critical stabilization activities. Another interviewee shared that this inter-agency friction led to: "the most frustrating series of conversations I've ever been in…There was so much struggle between those two agencies to be able to apply EWP funding to Forest Service land, especially in the aftermath of the BAER program" (9, former NGO employee).

Numerous interviewees also observed that BAER objectives often lack connectivity with EWP or other projects on adjacent non-federal lands. We heard that this program disconnect presented challenges to coordinating overall watershed recovery. As one interviewee explained, "What's difficult with all the [federal] programs is they don't interact with one another. Each one has to be done separately. So, it's very difficult to do projects across a wide scale that have a strong impact because we have to piecemeal them out" (5, former state employee). According to our interviews, the lack of program interaction, coupled with the BAER and EWP program's focus on site-specific needs over small areas, necessitated that EWP sponsors and other non-federal entities coordinate post-fire stabilization projects to protect non-federal assets, across multiple jurisdictions. For example, interviews revealed that pre-existing organizations with experience in post-fire and post-flood settings such as the Coalition for the Poudre River Watershed and the Big Thompson Watershed Coalition sought to address the needs of public and private interests affected by Cameron Peak through cross-jurisdictional project planning on Forest Service and adjacent private lands as well as funding coordination for cross-boundary work. Following East Troublesome, interviewees said that the Northern Colorado Water Conservancy District (Northern Water) provided similar capacity coordination for cross-jurisdictional projects, although its emergence in this role, with support from Grand County, was novel, as neither organization had familiarity with post-fire response and recovery.

While both programs are intended for rapid response measures, several participants explained that their focus on expedited assessments was incompatible with the seasonal conditions following both fires' containment in December 2020. Post-fire BAER and EWP assessments were conducted in winter conditions and, therefore, yielded unreliable surveys of burn severity across large areas of both wildfire footprints, according to interviewees. One East Troublesome interviewee shared that in winter 2021, "Our damage assessment surveys, we were trying to do in the middle of the winter because the timeline for EWP requires that these surveys be done [in that timeframe]. And that's not really practical when you are at 8,000 feet [2,438 m] elevation in February. They're not very accurate" (17, special district employee). Consequently, programs failed to detect some high-burn severity areas in early 2021. In the eastern reaches of the Cameron Peak burn scar, interviewees said that nearly 11 months post-containment, field crews discovered severely burned terrain contributing high sediment loads in the Big Thompson River. Although reassessment by private contractors and the Forest Service eventually provided more accurate data, interviewees said EWP funds were unavailable for stabilization efforts because the severely burned terrain was discovered after the EWP implementation deadline.

Interviewees also shared that EWP project timing requirements were ill-suited for settings commonly above 2400 m in elevation, with short seasonal windows in which to complete projects, and did not account for the time required for regulatory permitting and contracts. To this point, one interviewee shared:

> *"One of the problems with EWP, is they only give you 220 days and they want to start clocking it right away... but they don't factor in the time it takes to get landowner permission or to hire design engineering firms to design the actual timeline for permitting and then construction.... So that piece [of EWP] is just super clunky."*
> *(7, state agency employee).*

Interviewees also noted that EWP rules further limit the types of stabilization actions allowed. Site conditions

must be returned to their pre-fire state and do not account for short-term hydrologic alterations or the longer-term effects of climate change. As one interviewee explained, "The biggest thing is that the EWP program will not pay for restoring an area beyond what it was before. So, if the 12-inch culvert blew out, you can't now put in a 20-inch culvert, you have to put in the 12-inch culvert, you have to bring everything back to where it was. It does not take into consideration future climate change, floods, anything like that" (2, NGO employee). Although EWP emphasizes "emergency" conditions, some interviewees noted that even slight adjustments to procedural rules could alleviate many of the aforementioned obstacles to both meeting the program's current objectives while also accounting for future watershed conditions.

Several interviewees also discussed the lack of a comprehensive federal post-fire strategy that accounts for near- and long-term recovery needs at and beyond burn scars, given ongoing threats from flooding, debris flows, and sedimentation. These secondary events, while often destructive, are typically not eligible for federal resources. Interviewees explained that even if a fire is declared a federal disaster, subsequent flooding is not covered under the disaster declaration. Yet over time, such incidents threaten lives and livelihoods and result in substantial public and private sector costs. As one interviewee mentioned, "Each one of those floods can cost a significant amount of money, but they are not necessarily going to be significant enough to meet the threshold of a national disaster. So, this keeps pushing more cost back to the states, locals, and property owners" (1, NGO employee). We heard that after initial response actions, addressing long-term burn scar conditions often falls to local agencies or NGOs who pursue individual projects through agreements with federal agencies to compliment any agency-initiated BAR program activity. While these arrangements are the current practice for addressing long-term post-fire challenges across jurisdictions, most interviewees stressed the need for an overarching federal approach to recovery, restoration, and disaster relief.

Most interviewees identified funding shortfalls as a major barrier to the federal post-fire response process. For the BAER program, interviewees observed that the inadequacy in funding is readily apparent with the limited number of on-the-ground measures implemented following wildfire. As one interviewee observed, "They [the Forest Service] come up with a list, and they're only going to get a few things done off that list, just because of budget constraints specific for BAER" (6, special district employee). Currently, the Forest Service's BAER program is supported with wildfire suppression funds, and in FY 2023, BAER received 0.27% ($3 M) of the agency's overall suppression budget (US $1.1B) (USDA 2022). Several interviewees recognized the discrepancy between the Forest Service's BAER funding levels versus expectations of the program in light of the US West's changing fire regimes. As one individual suggested, the BAER program should be "Responsive to the needs of today. In light of these mega-fires that we're dealing with, this program is not well-fitted any more to do what it needs to do" (14, special district employee). Another interviewee (20, federal employee) noted that increasing the BAER program's budget to even 5% of the Forest Service's suppression funds would be "massive" for promoting more responsive actions and supporting agency relationships with local organizations.

Funding challenges with EWP centered on matching requirements for program sponsors, as well as the availability and timing of funds to commence projects. For matching requirements, interviewees shared that the standard 25% match can be cost-prohibitive even for organizations with large operational budgets when overall EWP project costs are in the tens of millions of dollars. Commenting on EWP sponsorship following East Troublesome, one interviewee shared that "25% of $32 million is a whole lot of money. And it's especially a whole lot of money if you're a really small county with very small revenues. That's a problem" (14, special district employee). Interviewees explained that state funds were eventually granted from the Colorado Water Conservation Board to East Troublesome's co-EWP sponsors (Northern Water and Grand County) and to the city of Greeley for Cameron Peak-related EWP projects. In conjunction with matching challenges for local-level sponsors, complications at the national level also hindered EWP efforts. Colorado's 2020 post-fire costs alone exceeded US $70 million dollars, yet the NRCS in 2021 had limited EWP funds available nationally to meet all post-disaster funding requests through most of 2021. This predicament resulted in-part from the program's reliance on supplemental appropriations from the U.S. Congress. To meet Colorado's recovery costs, the national NRCS office consolidated unused funds from other states to use in Colorado, a process that, while beneficial, took a considerable period of time and delayed or interrupted stabilization efforts. It should be noted that a continuing resolution in Congress did provide EWP US $300 million in September 2021.

Some interviewees also stressed that even when EWP funds were available, the OMB approval process further delayed funding transfers to individual states. One interviewee involved in post-Cameron Peak planning reflected on the implications of such delays, saying:

"We would put in a request for [EWP] funds and it would have to go up all the way to DC usually. And we might not hear back on a guarantee for six months. It took a long time, and we're sitting here trying to make a plan and get contractors in place, but you can't get a contractor in place if you don't have guaranteed funding"
(22, federal agency employee).

Some interviewees noted that the inherent uncertainty with EWP funding, coupled with tight project deadline rules and short work seasons, often led sponsors to pursue simpler, less impactful undertakings instead of higher-priority but more complex stabilization projects. Summarizing this challenge, one interviewee observed,

"What ends up happening is you only are able to get the projects done that are the least complicated, but they're typically not the projects that are the most needed [and] that will have the biggest impact. A lot of times the funding that does come down, you have to pick those easy projects because that's the only way that you get the money spent in the timelines that you're given"
(4, county employee).

What governance approaches (e.g., engagement with community-based organizations, timing of funding, data sharing, or policy improvements) are needed to successfully navigate the post-wildfire response and recovery process?

Interviewees recommended a range of federal policy and program reforms for improving ecological post-fire response and recovery capacity. First, nearly half of the interviewees stressed the importance of enhancing interagency coordination across jurisdictional boundaries and including non-federal actors in planning stabilization projects on federal lands. Most study participants recommended reforms to existing laws or programs, rather than new federal initiatives. BAER-related recommendations focused on expanding the program's assessments beyond federal boundaries and mitigation actions on burned landscapes to protect non-federal assets. To this point, one interviewee involved with East Troublesome recovery noted:

"One thing that we learned is that maybe the BAER program needs to expand to include more focus on not just the Forest Service land or Park Service land, but also the bordering private lands that are impacted as well. That was something that the five MOU partners agreed on is that it [the BAER report] didn't provide us with the information we necessarily needed"
(17, special district employee).

Multiple interviewees also called for greater flexibility regarding where EWP funds can be used, including locations on federal lands where post-fire conditions threaten non-federal assets. To this point, one interviewee remarked:

"My magic wand wish is EWP funds could be used on any land jurisdiction…If the work needed to be done on a combination of Forest Service, state, and private land to protect those private values, it wouldn't matter. You're getting those protections in place and land ownership doesn't play into it."
(23, federal agency employee)

To bolster cross-boundary collaboration in mitigation projects led by non-federal interests, some interviewees recommended that federal agencies streamline agreement processes for non-federal partners. For instance, one study participant suggested the Forest Service: "develop a culture of collaboration and customer service that, in partnership, make it stronger and maybe puts a little bit different filter on the bureaucratic nature of a lot of the things they do" (14, special district employee).

Several interviewees emphasized the necessity for reforming operational timeframes of BAER and EWP to (1) account for seasonal contexts of specific post-fire settings and local conditions that may hinder adequate post-burn assessments and stabilization actions and (2) extend the timeframe in which applicants are eligible for EWP funding. In discussing how federal agencies view the fire season, one individual recommended:

"Looking at the timelines for some of these programs like EWP to take into consideration the new year-long disaster season that we have nowadays, and… reassessing some of those deadlines that might not be realistic anymore. And reassessing some of those deadlines to make it more feasible for sponsors to be able to get good quality data and get good projects on the ground."
(17, special district employee)

Study participants articulated several reform measures for federal funding models that could potentially improve the responsiveness of federal post-fire programs. One interviewee observed, "Emergency funding cannot continue to be [allocated through] this ad hoc funding process. It needs to be an annual appropriation" (14, special district employee). Others offered that a permanent funding model for EWP could ameliorate many of the delay issues, particularly if the distribution process eliminated OMB review of the funding disbursement. More broadly speaking, and related to the new reality of wildfire in western North America, some interviewees indicated that a post-fire specific

funding source should be established to support all federal response and recovery efforts in the US West. For example, one individual remarked,

> *"I think my highest priority would be to create an annual pot of funding for the western [US] region that can be delegated to states that are affected by fire and flood disasters, in a manner that doesn't require additional authorization processes. Something that has some level of preapproval, the money is already there each year, and there's no time lag."*
> *(9, former NGO employee).*

Funding program arrangements to deal with secondary disasters is also a critical need identified by our interviewees, whether for a new federal program, extending existing program responsibilities, or providing direct funding support for non-federal agencies dealing with secondary disasters. Illustrating this challenge, one interviewee shared:

> *"The suite of post-fire disasters should be treated as one sort of funding pool and not separate disasters. Some of the federal dollars right now treat the fire as one disaster. And then you have to go through a different process to address and acquire funding for post-fire flooding. And we know that those are a predictable train of problems. So, some set of policies [should] provide authorizations and funding for the suite of effects that we know are going to happen"*
> *(9, former NGO employee).*

Finally, several interviewees also stressed that matching requirements for EWP and other Forest Service-funded restoration projects should be reduced or eliminated to promote broader use of federal resources. Fiscal barriers can be problematic for potential EWP sponsors in rural settings and for other organizations confronted with up to 50% matching costs for projects on Forest Service land. Moreover, local response and recovery capacity through the flexibility enabled by organizations was identified as a key need for communities impacted by wildfire. To this point, one interviewee suggested, "When we have catastrophic event, or if we're trying to mitigate for a future catastrophic wildfire, we need to figure out how to stand up like local groups or maintain capacity for local groups, so that they're ready to go" (10, state employee). In summary, interviewees recognized the importance of boundary organizations in the post-fire environment and the flexibility they provide in navigating federal programs in complex jurisdictional environments; thus, they are key actors in confronting the US West's larger and increasingly more complex post-fire environments.

Discussion

Our study investigated the policy and governance of post-fire response and recovery following the state of Colorado's two largest wildfires to date. Interviewees discussed administrative barriers of existing federal programs and circumstances where federal resources are incompatible with the evolving complexities of wildfire in the US West. The most frequent hindrances interviewees told us about involved separate agencies and programs for federal and non-federal lands, despite the cross-boundary nature of fire and post-fire hazards and recovery, the problematic timing of program requirements and funding requirements, and limited federal funding. These barriers often occurred simultaneously, resulting in response organizations seeking approaches to address these limitations and serving a coordinating function. Based on experiences with participating federal agencies, interviewees recommended several program reforms to improve post-fire response capacity, including greater flexibility in cross-jurisdictional use of federal resources, expansion of program timeframes and restoration activities, adjusting federal funding processes, and eliminating program match requirements.

Substantiating findings by Cheng et al. (2015) and the GAO (2003, 2021), this research revealed a legacy of federal post-fire program deficiencies that neither Congress nor the federal land management agencies have substantively addressed. For example, delays in EWP funding noted by Cheng et al. (2015) after Colorado's early 2000s wildfires were also experienced in 2020, and reform measures on expanding Stafford Act resources for post-fire secondary disasters have also remained elusive. Moreover, inter-agency cooperation issues identified by the GAO (2003) continue to obstruct post-fire recovery. Since 2020, the US West's record-breaking wildfires have prompted greater attention to pre- and post-fire needs at the federal level, including the establishment of the WFMMC and draft legislation focused on enhancing ecological post-fire recovery capacity (Reid 2024). Numerous priorities, several of which align closely with the barriers found in this research, were included in the 2023 WFMMC report for Congress and the federal agencies to address. While time will tell if these recommendations catalyze enduring legislative actions, the early 2020s momentum represents a potential "hot moment" for federal post-fire policy reform.

Findings in this research demonstrate that ecological post-fire response and recovery in the US West is replete with scale mismatch issues, similar to previous literature on scale mismatch in fire management and environmental governance more generally. Due to the enormity of the US West's forested landscapes and increasingly larger wildfires, eliminating scale

mismatch is not likely nor what we propose, but programs and policies can and should be improved to be more functional in light of scale mismatches and the need for scale flexibility (Schultz et al. 2019b). The Forest Service has contended with scale-related challenges for decades, but policy innovations have focused mainly on improving incident management or forest restoration, with minimal attention devoted to post-fire needs (Charnley et al. 2017; Schultz et al. 2019a, 2021). Scale mismatches encountered in this research exhibited both "cross-level" (mismatches within a specific scale type) and "cross-scale" (interactions between scale types) characteristics as defined by Cash et al. (2006), with complexities involving the physical, temporal, and jurisdictional realities of the case study area. For example, the spatial extent of the burn scars on Forest Service land far exceeded the BAER program capacity to conduct necessary actions on terrain that threatened both federal and non-federal assets. The response by non-federal organizations, including EWP sponsors, to address this mismatch ultimately accentuated temporal scale mismatches between the timing of agency programs and funding and the need for immediate stabilization on the burn scars. As non-federal entities pursued projects on Forest Service lands with NRCS funds, temporal mismatches manifested in multiple ways. First, the combined effects of inter-agency discord over use of NRCS funds on Forest Service jurisdictions with delays in the release of funds from the NRCS national office slowed proposed projects at a time when stabilization actions were most critical. Second, EWP program rules exacerbated temporal mismatch in the response process due to requirements that impeded sponsors from aligning recovery projects within limited field seasons. As multiple interviewees disclosed, the combined effects of these mismatches often led to the completion of only a limited number of desired projects where stabilization actions were most critical. Spatial and temporal cross-scale mismatches were also evident beyond the short-term objectives of EWP and BAER. As some interviewees noted, no federal policy exists that provides a systematic resource continuum from immediate stabilization to longer-term ecological recovery and restoration actions in multi-jurisdictional settings. While Interior and Forest Service BAR programs offer longer-term recovery resources, program funding for affected areas is not guaranteed. The legacy of treating secondary events separately from initial wildfire disasters further reflects cross-scale mismatch between temporal and spatial/jurisdictional aspects of post-fire settings. These scale mismatches result in chronic challenges for downslope interests regardless of land ownership. Ideally, watershed recovery efforts post-fire should be inclusive of social and ecological needs within timeframes commensurate with the disaster events associated with past wildfires.

Given the scale mismatch complexities in post-fire settings, the literature suggests boundary organizations fulfill vital roles following wildfire (Kocher et al. 2012). In this case study, formal (local NGOs) and informal (partnering government entities) boundary organizations contributed to overcoming current deficiencies in watershed-scale response and recovery capacity at the federal level and demonstrated a post-fire version of Nowell et al.'s (2022) approach to co-management of jurisdictionally complex crises. Specifically, organizations such as the Coalition for the Poudre River Watershed, the Big Thompson Watershed Coalition, and Northern Water sought collaborative and innovative approaches in partnership with state and federal agencies. Together, they coordinated site-specific restoration efforts within and beyond the purview of the BAER and EWP programs, reflecting unique arrangements expected from boundary organizations in meeting contextually diverse challenges as suggested by Davis et al. (2021). By combining Forest Service project agreement options with state funding support, these entities facilitated the stabilization of affected areas on and adjacent to Forest Service land that threatened non-federal assets.

Our case study substantiates prior findings (McCaffrey et al. (2013); Edgeley and Paveglio (2017); Davis et al. (2021)) regarding the progression of boundary organization roles from pre- to post-wildfire functions: from forest restoration and wildfire readiness in past decades to more recently engaging government and non-government actors to provide critical post-fire support. However, nuances in the trajectories of key boundary organizations were found in the case study's two wildfires. Northern Colorado's watershed coalitions benefited from the experience following earlier wildfires and flooding events in the Cameron Peak area. And, in alignment with trends in networked forest governance as suggested by Abrams (2019), the Coalition for the Poudre River Watershed utilized its position within northern Colorado's network of wildfire-related organizations to coordinate grant proposals that optimized matching state and federal funds and designed cross-jurisdictional recovery strategies involving multiple stabilization practices. Its role as a centralizing forum for actors seeking recovery assistance further exemplifies what Steelman et al. (2021) characterize as a pathway for practitioner representation in multi-jurisdictional disaster settings. In contrast, Northern Water's role as an informal boundary organization post-East Troublesome was hindered by coordination issues and inexperience with wildfires at the onset of the recovery process. By 2021, however, Northern Water

became an EWP sponsor and coordinated projects on affected Forest Service lands that threatened its infrastructure. The partnerships developed post-East Troublesome are noteworthy when considering the historic tensions between Northern Water and Grand County interests over trans-basin water transfers (Booth 2021). Through the East Troublesome experience, however, contentiousness over water was sidelined to collaboratively mitigate the impacts of fire. As Carroll et al. (2011) observed, however, long-term tensions between organizations can resurface after successful short-term recovery efforts, and it is unclear whether post-disaster comity will endure. Finally, it must be acknowledged that despite the coordinating capacity that boundary organizations can provide in addressing some scalar mismatches, funding issues, and federal program rules can still limit the effectiveness of local organizations in the post-fire space, illustrating the need for explicit updates to policies and other institutions that generally lack adaptability to change (Steelman 2016). The scale of the case study wildfires also transcended the recovery strategies and funding models of prior decades. For example, the 49 km^2 of the East Troublesome burn scar mulched (as of 2022) covered roughly 6% of the impacted area. Hence, while boundary organizations have served to ameliorate certain facets of the US West's fragmented approach to post-fire governance, relying on resource-limited NGOs and ad hoc groups unfamiliar with post-fire recovery is not a viable long-term policy solution.

We acknowledge the limitations in our findings that are based on a case study of the post-fire experiences from a single region and fire season in the US West. One case study cannot be assumed to represent all post-fire situations experienced in recent decades. It should also be noted that interviewees offered limited insights on FEMA's post-fire involvement, as most entities in the response process, aside from Larimer County, did not utilize FEMA resources. However, our findings corroborate ongoing challenges identified in previous research. Moreover, many of the challenges and policy recommendations discussed in the 2023 WFMMC report refer to obstacles revealed in this research. The administrative barriers stemming from jurisdictional responsibilities, program rules, and funding are in-part an outcome of agency "siloization" and resistance to change, as well as fragmented responsibility inherent to the U.S. federalist system (Steelman 2016). Despite recent Forest Service initiatives to advance cross-jurisdictional collaboration (Schultz et al. 2018; 2019a), overcoming agency inertia remains evasive (Harvey-Marose 2021). Models of collaboration exist, however, within the Forest Service domain that could be adapted for improving coordination between federal agencies and non-federal partners. For example, the 2018 Shared Stewardship Initiative's emphasis on involving agency and non-agency interests in collaborative forest management, across jurisdictions, and at scales beyond typical Forest Service project sizes offers one approach to re-envisioning post-wildfire policy (Kooistra et al. 2022). Our research has illustrated several ongoing challenges in federal post-fire response policies and programs, any of which addressed individually or in the aggregate could provide greater organization and response capacity across spatial and temporal scales. Such program tweaks could "buy time" for improving post-fire response capacity in the interim while longer-term evolution in post-fire response governance progresses from continued experimentation to long-term, systematic response and recovery processes that are inclusive of all social and ecological interests and account for the duration and scale of secondary disasters originating on burn scars. It is also important to note that while issues of equity were not explicit in interviewee responses, future research could broaden our understanding of policy inconsistencies that can result in some actors not being able to take full advantage of federal programs. Moreover, insights on EWP sponsorship challenges facing local governments post-fire, particularly in rural and underserved areas, could enrich our understanding of why some entities forego federal program participation and inform policy measures that enable federal post-fire resources for all affected individuals, communities, and landscapes.

Conclusions

The increasing magnitude of wildfires in recent decades has accentuated the focus on post-wildfire response and recovery across the US West. Enhancing federal program capacity and support for non-federal entities will be critical in the twenty-first century as aridification in western North America will likely increase wildfire frequency and size (Overpeck and Udall 2020; Abatzoglou et al. 2021). Our research revealed multiple scale-related barriers inherent to federal post-wildfire policies and programs that limit timely and effective response and recovery. Addressing the mismatches between existing federal, state, and local resource capacities and the scale of wildfire impacts will require bolstering federal support for existing programs as well as broader consideration of society's relationship with fire and governance in managing the US West's accelerated pre-fire-suppression-post-fire recovery cycle.

While our research focused on federal policy performance involving post-fire ecological recovery, key questions remain regarding federal programs focused on post-fire response and recovery in the built environment. Hence, additional research can elevate our understanding

of federal post-fire policy impacts beyond ecological recovery. Further research is also warranted regarding the inertia at the federal level to enact program reforms despite having information available from key sources, including the GAO, the Congressional Budget Office, and NGOs. While the WFMMC report provides a wildfire mitigation roadmap for the US West, a key consideration for researchers will be how these recommendations become actionable. Insights to these questions are critical for policymakers, agencies, and local governments seeking to develop more coordinated and effective approaches to post-fire response and recovery.

Despite the existing shortcomings in federal post-fire policies, opportunities exist to enact reforms that consider the challenges of scale in post-fire response and recovery. Analogous to Mockrin et al.'s (2018) argument that the post-fire space can serve as a potential policy window for land use changes following wildfire, a broader policy window also exists for reforming the federal post-fire response and recovery apparatus. Such advancements could promote and expand local capacity and catalyze forest, watershed, and community resilience across the US West through reframing how federal agencies consider scale in executing short-term response and long-term recovery actions following wildfire.

Supplementary Information

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Additional file 1. Supplemental interviewee quotes representative of the key federal post-fire program barriers discussed in the results section of the article**,** as well as insights regarding the role of boundary organizations in coordinating post-fire response and recovery efforts.

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Authors' contributions
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