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Fostering collective action to reduce wildfire risk across property boundaries in the American West

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Abstract

Large-scale, high-severity wildfires are a major challenge to the future social-ecological sustainability of fire-adapted forest ecosystems in the American West. Managing forests to mitigate this risk is a collective action problem requiring landowners and stakeholders within multi-ownership landscapes to plan and implement coordinated restoration treatments. Our research question is: how can we promote collective action to reduce wildfire risk and restore fire-resilient forests in the American West? To address this question we draw on collective action theory to produce an environmental public good (fire-resilient forests), and empirical examples of collective action from six projects that are part of the US Forest Service–Natural Resources Conservation Service Joint Chiefs' Landscape Restoration Partnership. Our findings are based on qualitative, semi-structured interviews conducted with 104 individuals who were purposively selected to represent the diverse stakeholders involved in these projects. Fostering collective action to restore fire-resilient forests entails getting as many landowners (especially large landowners) to participate in wildfire risk reduction as possible to increase its areal extent; and landowner coordination in planning and implementing strategically-designed restoration treatments to optimize their effectiveness. We identify factors that enabled and constrained landowner participation and coordination in the Joint Chiefs' projects. Based on our findings and theory about when collective action will emerge, we specify a suite of practices to promote collective action for wildfire risk reduction across property boundaries, emphasizing incentives and enabling conditions. These include proactive education and outreach targeting landowners; multi-stakeholder processes with broad landowner representation to develop coordinated management approaches; financial and technical assistance to support fuels treatments on all ownerships within similar time frames; strong partnerships; and using common forestry professionals to plan and implement treatments on different ownerships (especially private lands). Our findings can inform cross-boundary management for landscape-scale conservation and restoration in other contexts.

1. Introduction

Few environmental problems threaten fire-adapted forest landscapes of the American West as much as large-scale, high-severity wildfire, which has become increasingly common since the 1980s (Westerling *et al* 2006, Dennison *et al* 2014, Reilly *et al* 2017). Such

wildfires are a legacy of past forest and range management practices, particularly fire suppression; and are exacerbated by global climate change, population growth in the wildland-urban interface (WUI), and government priorities to invest funding in fire suppression rather than wildfire risk reduction (Calkin *et al* 2014, 2015, Moritz *et al* 2014, North *et al* 2015,

Fischer *et al* 2016a). Fire has social and ecological benefits for fire-adapted ecosystems, but large-scale, high-severity wildfire also causes social and ecological losses. Socially, these include loss of life and property, damage to cultural and aesthetic values, and the economic costs of wildfire suppression and post-fire rehabilitation; the US Forest Service (USFS) spent over two billion dollars on suppression costs alone in fiscal years 2017 and 2018 (USDA Forest Service 2018, 2019). Ecologically, these wildfires can negatively alter forest ecosystem structure, function, and composition, including erosion and water quality damage, loss of biodiversity, and undesirable ecological transitions (Benavides-Solorio and MacDonald 2005, Westerling *et al* 2011, Tracey *et al* 2018). Hence wildfire is a major challenge for the future social-ecological sustainability of the American West.

Land managers and stakeholders recognize that managing forests to mitigate wildfire risk requires landscape-scale management, in which landowners and other stakeholders who have an interest in a fire-prone landscape interact and make decisions about forest restoration, taking neighboring land ownerships into account (Charnley *et al* 2017a). In the western US, this often this means planning and implementing treatments to reduce hazardous fuels (flammable vegetation) on multiple landownerships and ownership types (public, private, Tribal) within shared landscapes. In this paper we consider restoring fire-resilient forests at large geographic scales in multi-ownership landscapes a collective action problem (per Ostrom 1990). We define this here as one in which landowners in an interdependent situation organize and coordinate forest management to improve joint outcomes.

Our research question is: how can we promote collective action to reduce wildfire risk and restore fire-resilient forests in the American West? To address this question we examine collective action in six case-study projects that are part of the US Forest Service–Natural Resources Conservation Service Joint Chiefs’ Landscape Restoration Partnership (Joint Chiefs). These projects include multiple landowner types and have wildfire risk reduction as a central goal. Cyphers and Schultz (2019) describe the program in detail. We draw on lessons from the cases and insights from collective action theory to identify incentives and enabling conditions that promote collective action to restore fire-resilient forests.

2. Background: wildfire as a collective action problem in multi-ownership landscapes

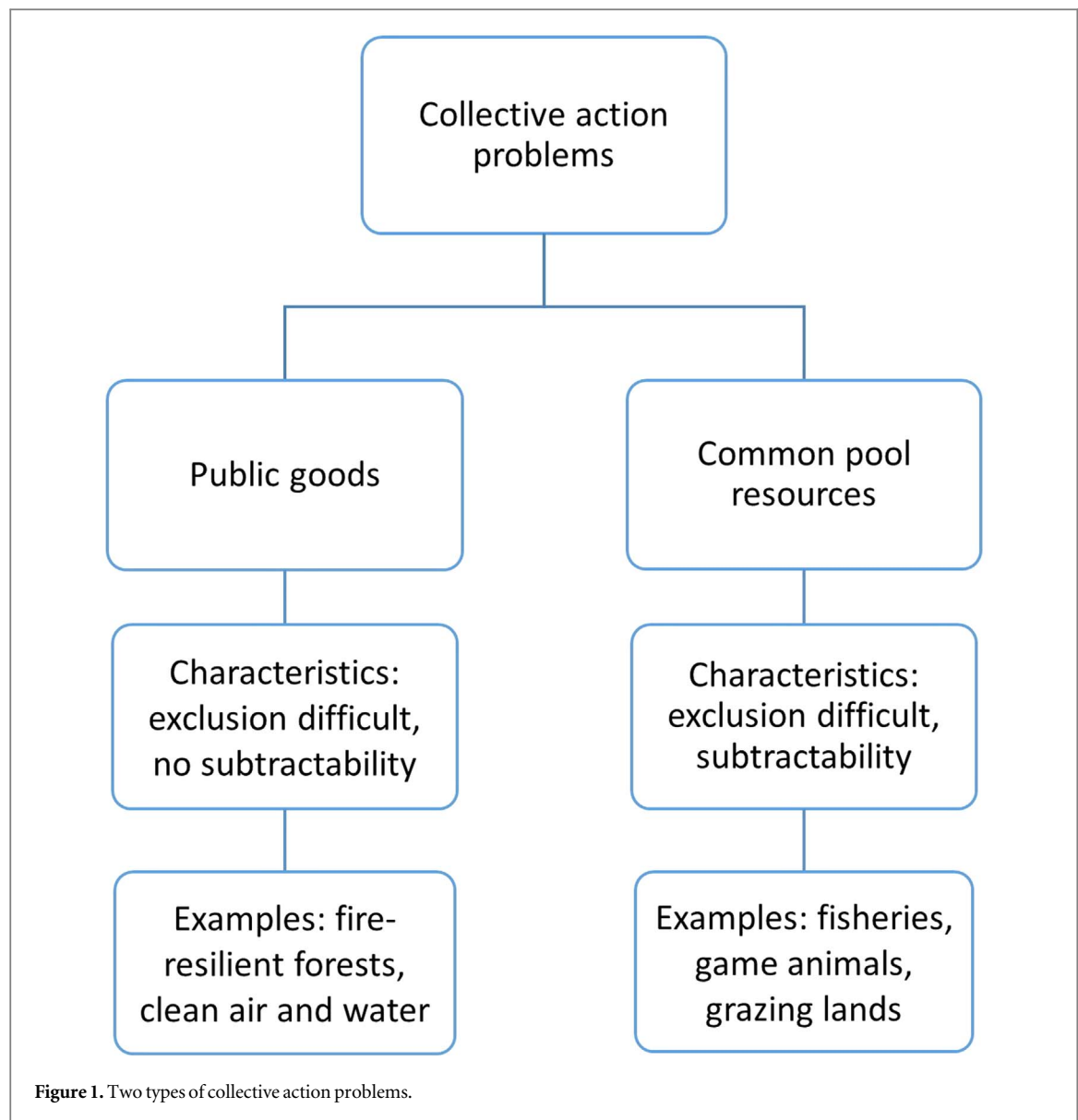
Wildfire risk reduction in multi-ownership landscapes is a collective action problem for both ecological and social reasons. From an ecological standpoint, wildfires can burn large areas (>40 000 ha) and

wildfire transmission occurs across land ownerships (Ager *et al* 2015, 2017, Hessburg *et al* 2015, Palaiologou *et al* 2019). It is neither practical nor necessary to treat hazardous fuels everywhere to reduce wildfire risk; nevertheless, thousands of hectares must be treated to change fire behavior and reduce its severity (Finney *et al* 2007, North *et al* 2012, Krofcheck *et al* 2017, Tubbesing *et al* 2019). To be most effective, treatments should be strategically-placed and target high-hazard locations where wildfires are most likely to ignite and to burn (Finney *et al* 2007, Ager *et al* 2015, Tubbesing *et al* 2019). Uncoordinated fuels treatments on individual land ownerships do not necessarily add up to, or optimize, landscape-scale wildfire risk reduction (Finney *et al* 2007, North *et al* 2012, Loudermilk *et al* 2014, Hessburg *et al* 2015, Palaiologou *et al* 2019).

From a social standpoint, these fire behavior characteristics mean that multiple landowners should take action and coordinate with one another to design and implement strategically-located fuels treatments that optimize joint benefits. Landowners within a fireshed are interdependent because the likelihood that one’s property will burn is a function of conditions there (which a landowner has some control over), and conditions on neighboring properties (which a landowner cannot control) (Butry and Donovan 2008). Thus, each landowner’s actions affect the collective good: when one landowner reduces fuels on their property, their neighbors should benefit; if they fail to treat, their neighbors may suffer (Busby and Albers 2010, Busby *et al* 2012).

There are two types of collective action problems: those involving public goods and those involving common pool resources (Ostrom 2003) (figure 1). Both are characterized by the difficulty of excluding non-contributors from a collective benefit (Ostrom 2003). Extensive social science research on collective action for environmental management has been undertaken in the context of common pool resources, in which the benefit is subtractable—resource consumption by one person subtracts from resource availability to others (e.g. Ostrom 1990, Bromley 1992, Ostrom *et al* 1994, Baden and Noonan 1998, Ostrom *et al* 2002, Dolšák and Ostrom 2003). In contrast, fire-resilient forests are public goods because people who reside in or near them can all benefit from them without decreasing that benefit to others, making the benefit non-subtractable (Ostrom 2003).

As with common pool resources, the characteristics of public goods affect the nature of collective action to provide them (Marwell and Oliver 1993, Ostrom 2000b, 2003, Abele *et al* 2010). Fire-resilient forests are a type of public good that has a ‘convex production function’ (Marwell and Oliver 1993). The first people who produce the good create a small collective benefit, but as more people contribute, the marginal benefit becomes greater, a phenomenon



termed ‘positive interdependence’. The more people who treat hazardous fuels, and the larger the area treated, the greater the overall benefit. Large participation numbers also mean more people share the cost of providing the public good, and more resources are brought to the table, increasing capacity to provide the benefit (Ostrom 2003). This type of public good differs from those having a ‘step-level’ production function, whereby no one benefits until a minimum contribution level needed to provide the good is reached, after which additional contributions may or may not add value (Marwell and Oliver 1993, Abele *et al* 2010). Thus fostering collective action to restore fire-resilient forests in multi-ownership landscapes calls for getting as many landowners as possible (especially large landowners) to treat hazardous fuels in priority locations. In contrast, in common pool resource management it is important to limit group size to avoid resource depletion (Ostrom 1990, Ostrom *et al* 1994).

In both public goods and common pool resource scenarios, self-interested actors that can benefit without contributing to the provision cost may be tempted to ‘free-ride’ (Ostrom 1990). Free-riding can undermine collective action in common pool resource management by causing over-exploitation of resources and breaking trust in reciprocity among resource users (Ostrom 1990, 1998, 2000a). This problem makes the negative consequences of non-participation potentially high (Ostrom 1990, 2003). To deter free-riding and rule-breaking, incentives to invest in rather than over-exploit resources are needed (Ostrom *et al* 1999). Provisions for monitoring behavior and enforcing rules by imposing graduated sanctions are also important (Ostrom 1990, Cox *et al* 2010). In wildfire risk reduction, there is a risk of landowners free-riding on the fuels reduction benefits created by neighbors (Busby and Albers 2010, Prante *et al* 2011, Busby *et al* 2012). Participation creates more benefits than free-riding, however, because individual landowners

Table 1. Differences between collective action for common pool resource management and restoring fire-resilient forests as a public good.

Characteristic	Public goods (e.g. fire-resilient forests)	Common pool resources
Group size	Maximize group size	Limit group size
Consequences of free-riding and non-participation	Small impact on overall benefit (unless very large landowner)	Potentially large impact on overall benefit
Means of assurance	Create incentives and enabling conditions to encourage participation	Create incentives and monitor and enforce rules by imposing sanctions on group members

benefit more if they treat fuels on their property than if they do not. But if one person fails to participate in creating a public good, the impact on others is likely small (Ostrom 2003), unless, in the context of wildfire, a very large landowner fails to participate. Thus in a public goods context, incentives to participate, along with enabling conditions that facilitate participation, are needed. Table 1 characterizes some differences between collective action to create fire-resilient forests as public goods, and managing common pool resources.

Despite differences between public goods and common pool resources, a shared challenge is how to encourage and enable coordination to produce joint benefits (Ostrom 2003). Collective action to reduce wildfire risk in multi-ownership landscapes is difficult because landowners have diverse perceptions of wildfire risk, management goals and approaches, capacities to take action, regulatory frameworks governing their behavior, and incentive systems for engagement (Fischer *et al* 2016b, Ager *et al* 2017, Charnley *et al* 2017a, Schultz *et al* 2018). Collective action can also be costly because time, energy, and other resources are required to search for information, come to acceptable agreements with other parties, and ensure other parties adhere to agreements.

Moreover, collective action theory was developed using logic about how individual actors make decisions when confronted with a ‘social dilemma’ (Ostrom 1998). A social dilemma in the context of providing public goods occurs when people who would benefit from a public good prefer that others pay the cost of producing it, but if no one does, it will not be provided so no one reaps the benefit. Therefore individuals must choose whether, when, and how much to invest resources in collective action to create the benefit, versus some alternative (Ostrom 1998). Our cases involving coordinated planning and implementation for wildfire risk reduction involve federal and state land management agencies and corporate land managers as key actors with large ownerships, making their participation critical. The choices, decision-making processes, transaction costs, and incentive systems of organizational actors such as the USFS are different from those faced by individuals (e.g. Cortner *et al* 1990, Koontz *et al* 2004, Charnley *et al* 2015, Schultz *et al* 2019). Understanding these

differences can provide insight into how to engage diverse landowner types in collective action for wildfire risk reduction in multi-ownership landscapes.

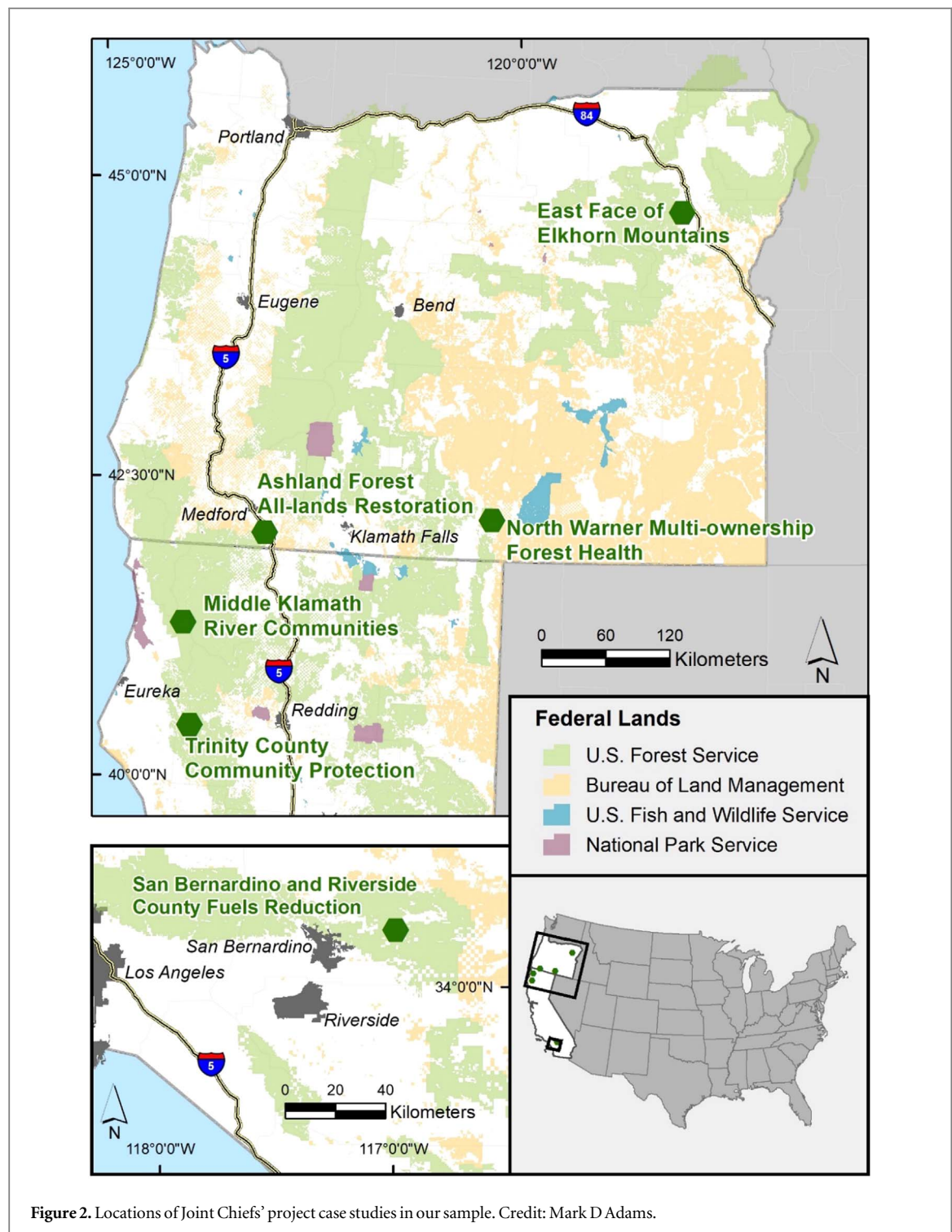
Much of the research about collective action for common pool resource management has been driven by questions of (1) when collective action will emerge, and (2) what the attributes of successful institutions for managing common pool resources are (Agrawal 2014). Here we are concerned with the former. There are no universal conditions under which collective (versus individual) action will emerge (Oliver and Marwell 2001, Ostrom 2003, Poteete and Ostrom 2004). However, general principles developed from research on common pool resource management may apply to creating public goods. As formulated by Ostrom (1992, 2000a, 2000b), and adapted to wildfire risk reduction to restore fire resilient forests, these include:

- (1) *Shared understanding*: landowners understand how wildfire operates, how their actions affect it, and that acting collectively to reduce wildfire risk will have a better outcome than acting individually, or in an uncoordinated fashion.
- (2) *Communication and coordination*: landowners communicate and develop coordinated strategies for wildfire risk reduction.
- (3) *Capacity*: landowners have the capacity to participate in these strategies.
- (4) *Trust and reciprocity*: landowners trust that if they change their behavior (and treat fuels), their neighbors will too.
- (5) *Benefit-cost ratio*: landowners perceive the long-term, joint benefits of coordinated wildfire risk reduction exceed the short-term, individual costs of collective action.

These principles provide a useful analytical framework for identifying practices that promote collective action to reduce wildfire risk across property boundaries.

3. Methods

The Joint Chiefs’ Partnership was established in 2014 to support forest restoration at the interface of public



and private lands. Local collaborative groups self-organize and compete for project funding (lasting three years), which goes to the USFS to support restoration on federal lands, and the Natural Resources Conservation Service (NRCS) to provide cost-share funding for restoration on family forest lands through the Environmental Quality Incentives Program (EQIP). Projects typically span multiple land ownership types, include partner organizations, and take place within relatively large landscapes (>20 000 ha). We chose six projects for study in Oregon and California, building on earlier work by the

authors (Charnley *et al* 2017a) (figure 2, table 2). Criteria for selection included (a) year project was funded (the earlier the better to capture both planning and implementation); (b) diversity of landowner types across the sample; and (c) diversity of social-ecological contexts, although all in fire-prone landscapes.

We reviewed project documents, websites, and other written materials to obtain information about the projects. We also collected primary data through semi-structured interviews with a purposive sample of project participants (Bernard 2006) using a common interview guide for consistency across cases. We

Table 2. Cases in our sample (in alphabetical order, by state) and information about support from the Joint Chiefs' program (support also came from other sources).

Project	State	Project area (ha)	Years funded	Total funding ^a	Funding split USFS-NRCS ^a	Landowners	Hectares treated or planned for treatment w/Joint Chiefs' funding ^b
Ashland Forest All-Lands Restoration (Ashland)	OR	21 450	2015–2017	\$6 169 410	35%–65%	USFS, BLM ^c , City of Ashland, private corporate, family	USFS: 1619 BLM: 0 City: 22 Private Corp: 0 Family: 1295 (53 NRCS contracts)
East Face of Elkhorn Mountains (East Face)	OR	51 800	2014–2016	\$4 939 000	43%–57%	USFS, BLM, ODFW ^d , private corporate, family	USFS: 8 903 BLM: 297 ODFW: 89 Private Corp: 0 Family: 2223 (61 NRCS contracts)
North Warner Multi-Ownership Forest Health (North Warner)	OR	165 920	2017–2019	\$5 036 777	67%–33%	USFS, BLM, private corporate, family	USFS: 11 736 BLM: 0 Private Corp: 0 (treatments occurred with funding from other sources) Family: 1389 (20 NRCS contracts)
Middle Klamath River Communities (Klamath)	CA	4050 (sub-region of a larger 485 625 ha project)	2014–2016	\$4 787 615	70%–30%	USFS, family	USFS: 3869 Family: 150 (NRCS contracts on 18)
San Bernardino and Riverside County Fuels Reduction (San Bernardino/ Riverside)	CA	736 800	2014–2016	\$11 887 665	37%–63%	USFS, tribal, family	USFS: 1799 Tribal: 25 Family: 4 735 (111 NRCS contracts)
Trinity County Community Protection Project; Rural Community Fire Protection and Forest Management ^e (Trinity County)	CA	300 680 (phase 1) 253 230 (phase 2)	2016–2018 (phase 1); 2019–2021 (phase 2)	\$2 349 250 (phase 1) \$710 833 (phase 2, in 2019)	89%–11% 93%–7%	USFS, BLM (phase 2), private corporate, family	Phase 1: USFS: 4 636 Private corp: 0 Family: 971 (3 NRCS contracts) Phase 2: ongoing

^a Source = NRCS (2019). Funding indicates amount received through the Joint Chiefs' Partnership only. Total project funding was higher owing to money obtained from other, leveraged sources (e.g. grant funding).

^b Total Joint Chiefs' funding may support other forest restoration activities in addition to fuels treatments. Hectares reported are for hazardous fuels reduction and were funded with Joint Chiefs' funds. Total hectares treated under the projects may be greater, as leveraged funding supported additional fuels treatments. Not all treatments were completed within the three-year project time frame; some occur in subsequent years.

^c Bureau of Land Management.

^d Oregon Department of Fish and Wildlife.

^e Represents a second phase of the Trinity County Community Protection Project.

interviewed 104 individuals (Ashland = 17, East Face = 11, North Warner = 15, Klamath = 25, San Bernardino/Riverside = 15, Trinity County = 21). Interviewees included personnel from participating organizations, other stakeholders involved in the project, and landowners whose lands were within the project area. Interview topics included motivation for project participation, nature of coordination between landowners, strategies for reducing wildfire risk, factors enabling and constraining participation by and coordination with other landowners, and benefits and drawbacks of coordination.

Interviews were recorded, transcribed, and analyzed according to these topics. We developed analytical memos to explore and distill the data, and matrix displays to summarize findings and compare and contrast cases on key variables (Miles *et al* 2014). We organized findings into two matrix displays—one pertaining to factors that motivated and enabled people to participate in the project (or not), and one pertaining to coordination among landowners for wildfire risk reduction. We synthesized findings across the cases by topic.

4. Results

As discussed in section 2, two things are needed to restore fire-resilient forests across land ownerships: (1) maximizing the number of landowners (especially large landowners) who conduct wildfire risk reduction by treating hazardous fuels on their properties to enlarge its areal extent; and (2) fostering coordination among landowners in planning and implementing strategically-designed restoration treatments to optimize their effectiveness. We present our results according to these two topics.

4.1. Landowner participation in wildfire risk reduction

4.1.1. Landowner participation

National forests and family forest owners are participants in all Joint Chiefs' projects owing to the nature of the program. The number of family forest owners formally participating in our case studies via NRCS EQIP contracts ranged from 3 to 111. The proportion of total project funding received by the agencies to support restoration varied by project, though the area treated on Forest Service lands was greater than on family forest lands in all but one case (table 2). All projects included other landowner types within their boundaries; however, inclusion did not always mean participation. A common motivating factor for participation was a desire to reduce wildfire risk, perceived by landowners as a threat on their properties, the broader landscape, or a specific place (e.g. municipal watershed, WUI area). Some landowners were also motivated by a desire to improve overall forest health

and wildlife habitat. A key factor motivating participation, however, was availability of funding.

In some cases, landowners did not conduct fuels treatments because they did not receive funding (i.e. private corporate, city, BLM). Other landowner types participated if they could obtain Joint Chiefs' funding from the USFS (e.g. the state, East Face case) or leverage funding from other sources (e.g. a private corporate owner, North Warner case). Some family forest owners did not participate because of inability to obtain NRCS cost-share funding—they did not qualify, funding ran out, the application process was too arduous, or they couldn't or wouldn't pay their share of the cost.

4.1.2. Factors enabling and constraining landowner participation

Availability of funding for fuels reduction was a critical enabling factor for collective action in the Joint Chiefs' projects. The program made millions of dollars available to fund forest restoration on national forests and nearby family forest lands through the EQIP program. The USFS and family forest owners also obtained funding from leveraged sources to treat additional acreage. Other landowner types were sometimes able to obtain funding from the USFS or alternative sources to simultaneously treat their properties. For some landowners, particularly the USFS, Joint Chiefs' funding created an opportunity to continue fuels treatments that had begun, or been planned but not implemented, in previous years. Although these funds supported restoration on individual ownerships, projects encouraged landscape-scale approaches entailing coordination with neighbors.

Another enabling factor for all landowner types was *pre-existing relationships or partnerships* with other landowners, agencies, or organizations having a stake in wildfire risk reduction. These catalyzed participation by facilitating communication about the projects and funding opportunities, and resource sharing to make participation easier. *Community support* for hazardous fuels reduction was particularly critical for public landowners by providing the social license needed to conduct fuels treatments. *Proactive landowner education and outreach* on the part of agencies, non-governmental organizations (NGOs), and other entities were key in helping family forest owners participate, especially because these owners had to initiate the process of applying for EQIP funding. *Prior experience* was also important. Public and private landowners who had previously cooperated in forest management with neighbors, and family forest owners who had participated in the NRCS EQIP program, indicated that this experience helped them do so again. Other variables enabling participation in collective action in our cases were *dedicated professionals* (e.g. agency employees, local NGO leaders) who played a role in facilitating it and thinking creatively about how to make projects work; the presence of a *local workforce*

to increase capacity for planning and implementing fuels treatments on different ownerships; and *legal authorities and policy tools* making it possible to move money and other resources between partners and landowners.

Constraints to participation not associated with funding varied by landowner type and were generally the converse of the enabling factors. A common reason for non-participation was *no perception of high wildfire risk* by landowners (private corporate, family), or *other land management priorities* (family forest owners, BLM in three cases). *Unwillingness to work with neighbors, engage in partnerships, or consider others' input into management decisions* were barriers attributed to a federal landowner in two cases, and family forest owners in three cases. Related constraints were *lack of engagement by federal agency leadership* (cited in three cases), and *absentee land ownership* among family forest owners. The *time and investment needed* to participate was mentioned as a constraint for public and private landowners in three cases. In two cases, *lack of NRCS capacity* to administer Joint Chiefs' funding because of inadequate staffing, and a failure to create the partnerships needed to fill this capacity gap, limited participation by family forest owners. Partners are critical for contacting private landowners, helping them apply for funding, and planning treatments. Lack of participation in the Joint Chiefs' projects did not necessarily mean landowners failed to treat hazardous fuels altogether; they simply failed to do so as part of these projects.

4.2. Coordination in wildfire risk reduction

4.2.1. Coordinated planning and implementation

Following Fischer and Charnley (2012) and Fischer *et al* (2019) we group coordination into two categories: planning and implementation. Coordinated planning includes designing and locating treatments in a manner that takes neighbors' treatments into account; communicating and sharing information about treatment plans and actions; coordinated fundraising to finance management activities; and cooperation in conducting analysis or other activities required to meet regulatory or program requirements pre-treatment. Coordinated implementation refers to getting work done on the ground in a coordinated fashion, whether or not treatments are implemented jointly and simultaneously.

Our cases included several types of coordinated planning and implementation for hazardous fuels reduction among landowners (table 3). Although landowners often coordinated in planning fuels reduction treatments, they rarely coordinated in implementation. Key reasons were that landowners have different time frames for undertaking management activities, have different administrative processes for planning and implementing treatments, and may use different treatment designs and methods.

We found that large landowners, including public and private corporate landowners, coordinated directly with one another when planning and implementing treatments. In contrast, family forest owners rarely coordinated directly with one another or with other landowner types (unless they participated in collaborative groups). Instead, they worked individually with NRCS partners (e.g. Oregon Department of Forestry, local NGO) or an NRCS forester in planning treatments on their properties, and usually hired contractors to implement them. NRCS and partner organizations represented them when coordinating with other landowners. Reasons included NRCS privacy policies regarding landowner identity and treatment information; lack of forest management skills among some family forest owners; distrust among some family forest owners of federal agencies; high transaction costs for small landowners of coordinating with neighbors versus working with intermediaries; and for large landowners, prioritizing hazardous fuels reduction on their own properties over coordinating with neighbors. A partial exception to this model was the San Bernardino/Riverside case, in which homeowner organizations comprised of family forest owners applied jointly for NRCS funds, indicating family-family coordination.

Coordinated planning and implementation facilitated strategic placement of fuels treatments across land ownerships and in priority locations. One common approach was to plan treatments on either side of a property boundary shared by different landowner types (e.g. federal-state, federal-family), or on strategic ridgelines to reduce wildfire transmission risk from one ownership to another. Another was to plan treatments in priority locations to reduce wildfire risk there (e.g. WUI, municipal watershed). A third was to plan treatments on multi-ownership blocks in order to create large, fairly contiguous treatment areas across individual ownerships to increase their cumulative impact. Sometimes this meant targeting large private ownerships, or ownerships near places where treatments had recently occurred. The NRCS and partner organizations developed criteria for prioritizing which family forest owners within the project areas to provide cost-share funds to, with ownership size and location a key factor, and targeted them for outreach and technical assistance to promote coordinated fuels reduction.

4.2.2. Factors enabling and constraining coordination

Coordination was enabled by the presence of *local collaborative groups and other organizations* (such as Fire Safe Councils in CA) in which landowners or their representatives (for family forest owners) regularly participated by attending meetings where they communicated about and planned hazardous fuels reduction activities. Collaborative groups whose focus was on natural resource issues across ownerships (San Bernardino/Riverside, North Warner, Klamath

Table 3. Ways in which landowners in our cases coordinated for wildfire risk reduction.

Landowner types between which coordination occurred (cases) ^a	Nature of coordination
Federal—Family (All)	<i>Planning:</i> • NRCS, USFS, and partner organizations worked together to identify and map priority areas for treatment on USFS and family forest lands where treatments would subsequently focus • NRCS, USFS, and partner organizations jointly developed criteria for prioritizing private landowners who would receive NRCS cost-share funding • NRCS, USFS, and partner organizations coordinated outreach efforts to family forest owners; USFS provided funding to intermediary organizations conducting outreach to them • USFS helped fund private lands treatments in strategic locations • One entity planned treatments on the majority of private lands in the project area, and helped plan treatments on federal lands • USFS planned and implemented treatments in priority areas on national forest lands, and communicated this information to family forest owners directly or via intermediary organizations so that they could take it into account when planning private lands treatments • USFS considered where treatments had previously occurred on adjacent private lands and planned complementary treatments on its side of the property line • Environmental analysis was planned to occur across federal and private ownerships per federal and state requirements to increase efficiency <i>Implementation:</i> • The same contractor(s) conducted treatments on USFS and family forest lands
Federal—Federal (East Face, Trinity)	<i>Planning:</i> • USFS conducted NEPA analysis for treatments planned along a shared border on both USFS and BLM lands • Two neighboring national forests shared information about treatments while participating in a local forest collaborative group
Federal—State (East Face)	<i>Planning:</i> • The USFS and State planned complementary treatments using similar prescriptions along a shared border, taking each other's management goals into account
Federal—Municipal (Ashland)	<i>Planning:</i> • The USFS and City together planned treatments on land within a shared watershed that provides the municipal water supply • The City forester often wrote treatment prescriptions on both USFS and municipal lands <i>Implementation:</i> • The same contractor implemented most of the treatments on USFS and municipal lands
Federal—Private corporate (Trinity)	<i>Planning:</i> • The USFS and a private corporate owner planned treatments along a shared boundary to create a fuel break in a priority WUI area; implementation on private lands depends on funding from a state grant program
Federal—Tribal (San Bernardino/Riverside)	<i>Implementation:</i> • The USFS participated in a demonstration fuels reduction project on neighboring Tribal lands • Work crews from another Tribe implemented fuels treatments on their lands and neighboring national forest lands along a shared property boundary
Family—Family (Ashland, East Face, N Warner, San Bernardino/Riverside) ^b	<i>Planning:</i> • Family forest owners communicated informally about treatments on their lands, and sometimes encouraged neighbors to conduct fuels treatments • One entity (contractor, state forester) planned most or all treatments on family forest ownerships in the project area with other ownerships in mind

Table 3. (Continued.)

Landowner types between which coordination occurred (cases) ^a	Nature of coordination
	• Intermediary organizations brought family forest owners together for training workshops where they shared information • Some landowners formed homeowner associations to apply for NRCS funds jointly • Some landowners applied simultaneously to NRCS for funds so that they could meet the minimum acreage requirement to qualify, and coordinate implementation (share equipment and contractors, accomplish work on a similar schedule)
	<i>Implementation:</i> • One or a few contractors implemented treatments on all private lands in the project area

^a The activities are drawn from all cases having coordination between the named actors, but did not occur in every case.

^b The Mid-Klamath and Trinity (Phase I) cases involved very few family forest owners, and their properties were dispersed across landscapes dominated by public land ownership, so little coordination occurred among them.

cases), or wildfire management specifically (e.g. California's Fire Safe Councils) were a better venue for coordination than forest collaborative groups focused solely on management of federal forests (East Face, Trinity County cases). In some cases (San Bernardino/Riverside, Trinity County, North Warner), *multi-stakeholder processes to identify high wildfire hazard areas and prioritize where to target treatments* across the landscape pre-dated Joint Chiefs' projects, resulting in planning documents that were used to guide fuels reduction strategies in these projects. In most cases, some treatment areas had already been planned on federal lands, and Joint Chiefs' funding made implementation possible; planning may or may not have entailed coordination with other landowners.

Coordination across land ownerships was facilitated when *one forester or contractor planned or implemented treatments on multiple ownerships* within the project area, creating consistency across ownerships. *Strong partnerships and collaborative relationships*—some of which pre-dated the Joint Chiefs' projects, others of which formed during the projects—were key for effective coordination in planning and implementing treatments. Other variables important for enabling coordination across ownerships were *shared mutual goals and priorities for forest restoration* among landowners; *simultaneous funding to different landowner types*, allowing them to engage in hazardous fuels reduction on a similar time frame; *legal authorities and policy tools* that facilitated resource sharing and cross-boundary implementation; and *local workforce capacity* (e.g. contractors) to conduct treatments on different ownerships.

Constraints to coordination included *frequent turnover of federal agency staff* and *low staff capacity* to invest in coordination, which limited relationship-building and engagement. *Absentee private landowners* were hard to coordinate with. *Unwillingness of landowners (public or private) to give up control over management decision-making, or to collaborate* were

additional constraints. The *amount of time* it takes to coordinate was also limiting. *Time lags in implementing treatments* on adjacent ownerships sometimes generated uncertainty and lack of trust, undermining coordination. Specifically, federal landowners were usually slower to plan and implement treatments than other landowner types owing to legal requirements and bureaucratic processes. Non-federal landowners who completed their treatments sometimes worried that a wildfire would occur on nearby federal lands before treatments there were complete. Finally, *landscape characteristics* may not be conducive to coordination. In our cases these included checkerboard land ownership patterns and forest types where there was social controversy over treatment (e.g. moist mixed conifer), leading to inaction on public lands in particular.

Prescribed fire was a treatment that had its own unique set of constraints. Prescribed fire is conducive to cross-boundary hazardous fuels reduction because treatment areas are typically large, and it makes sense to plan treatments according to landscape features rather than property boundaries. But *air quality regulations* or *weather conditions* often cause short windows of opportunity for burning that make it difficult for adjacent landowners to simultaneously mobilize the necessary resources. And, *family forest owners are often reluctant to conduct prescribed burns* because, unless performed by state or federal agency personnel, they are liable should the fire escape and damage other properties. Nevertheless, interviewees in four cases stated that they were planning to implement future cross-ownership boundary burns once the Joint Chiefs' project ended.

5. Discussion

How can we promote collective action to reduce wildfire risk and restore fire-resilient forests in the

American West? Previous studies that examine this question have focused on family forest owner behavior (e.g. Fischer and Charnley 2012, Ferranto *et al* 2013, Gan *et al* 2015, Canadas *et al* 2016, Fischer *et al* 2019) and governance (e.g. Schultz *et al* 2018, Cyphers and Schultz 2019, Kelly *et al* 2019, Schultz and Moseley 2019). Family forest owner studies suggest that they are more comfortable cooperating with one another in cross-boundary management than with state or federal agencies (Bergmann and Bliss 2004, Fischer and Charnley 2012, Ferranto *et al* 2013). The Joint Chiefs' Partnership provides a model of collective action to reduce wildfire risk involving diverse landowner types, inherently more challenging (Ager *et al* 2017, Charnley *et al* 2017b). Governance studies find that key elements promoting cross-boundary wildfire risk reduction include a history of collaborative relationships among participants, strong leadership, capacity of landowners and partners, effective coordination among participants, supportive policies, and multi-year funding investments in specific landscapes (Cyphers and Schultz 2019, Kelly *et al* 2019, Schultz *et al* 2018). These findings are consistent with our own.

We turn now to frame our case-study findings around the five principles underlying collective action introduced in section 2:

- (1) *Shared understanding*: Risk perception is one important influence on wildfire risk reduction behavior among landowners and homeowners (McCaffrey 2008, Fischer and Charnley 2012, Olsen *et al* 2017). Family forest owners who participated in our cases perceived a high level of concern about wildfire occurring on their property and spreading to their property from adjacent ownerships (unpublished survey data), as did public landowners interviewed. In five cases, both public and private landowners also expressed a belief that fuels reduction on their ownerships would be more effective if their neighbors participated. This principle emphasizes the importance of outreach and education to increase landowners' understanding of how wildfire operates, how their actions affect it, and the benefit of acting collectively to reduce wildfire risk.
- (2) *Communication and coordination*: Our cases indicated that strong partnerships, and communication among landowners and partners, were critical for developing coordinated wildfire risk reduction strategies. The nature of coordination, which emphasized planning (table 3), ranged from multi-stakeholder processes, to creation of treatment plans on individual landownerships—often by common forestry professionals—that were communicated to neighbors for consideration when planning treatments on adjacent parcels. Communication was facilitated by meetings that included multiple landowner types, especially when they did not focus exclusively on one ownership. But communication and coordination may be difficult in extremely large landscapes that involve numerous landowners and stakeholder types, because coming to agreement can make transaction costs high. There are likely optimal sizes for landscape-scale management endeavors in particular places (Brunckhorst *et al* 2006, Bixler *et al* 2016, Fischer *et al* 2016b).
- (3) *Capacity*: The capacity of landowners to participate in wildfire risk reduction hinged on financial and technical assistance, and partnerships that filled capacity gaps. Other enabling factors were legal authorities and policy tools that made resource sharing across land ownerships possible, and the presence of a local workforce to implement treatments when landowners did not have the ability to do so themselves. The importance of these factors for collective action has been highlighted in other studies (e.g. Charnley *et al* 2017a, Cyphers and Schultz 2019, Kelly *et al* 2019).
- (4) *Trust and reciprocity*: We did not find evidence of free-riding on the fuels treatments of neighbors. In contrast, in three of our cases, family forest owners indicated that neighbors treating their properties was an incentive for treatment, and failure of neighbors to treat (especially public landowners perceived to have high hazard) was a disincentive. Limited coordination in implementing treatments, and time lags of several years in treating different ownerships, threatened trust in reciprocity. Fire simulation models for the western US suggest that smaller parcels (e.g. state, family forest) experience more incoming fire transmitted from other ownerships than large parcels (e.g. USFS) (Palaiologou *et al* 2019). Federal landowners in our cases were usually slower than other landowner types to complete treatments, a concern among nonfederal owners who worried a wildfire would occur and compromise their efforts. These findings emphasize the importance of timely treatment by large landowners for building trust and reciprocity in wildfire risk reduction among neighbors.
- (5) *Benefit-cost ratio*: The perceived benefits and costs of engaging in collective action influence whether an actor will participate. The distribution of benefits and costs will likely vary by actor (Ostrom 2000b). Our finding that absentee land ownership among family forest owners was a barrier to participation and coordination may signify that for absentee landowners, the benefit-cost ratio of collective action is particularly unfavorable. Nevertheless, interventions that increase benefits or reduce costs will help incentivize participation.

Table 4. Actions to foster collective action for landscape-scale wildfire risk reduction.

Principle	Actions
1. Shared understanding	• Encourage organizations that landowners trust to implement proactive education and outreach campaigns that make landowners aware of wildfire risk on their properties, the importance of doing something about it, and the value of acting collectively to reduce it • Acknowledge and publicize positive social and ecological outcomes from treatments • Use public education and outreach methods to generate community support for wildfire risk reduction
2. Communication and coordination	• Promote communication among landowners—whether direct or indirect through intermediaries—by creating opportunities to interact, such as landowner trainings or local meetings where forest management is discussed; avoid too much focus on one ownership • Use inclusive, multi-stakeholder processes with landowner representation to develop coordinated management approaches • Foster strong collaborative relationships and partnerships for coordinated planning and implementation • Enable common forestry professionals to work on multiple ownerships, if possible, when planning and implementing treatments to enhance coordination • Dedicate agency personnel to the project who plan to stay throughout its lifespan to make communication, collaboration, and coordination easier; or create institutional memory within agencies to allow new employees to quickly come up to speed • Assess optimal project size to allow for efficient communication and coordination
3. Capacity	• Make technical and financial assistance available to all landowners in shared landscapes to support fuels treatments across ownerships • Engage intermediary and partner organizations to help fill capacity gaps and reduce transaction costs • Raise awareness of, and utilize, legal authorities and policy tools that facilitate resource sharing for cross-boundary management; develop new tools if needed • Encourage development and maintenance of local forest restoration workforce
4. Trust and reciprocity	• Collaboratively plan projects that involve neighboring landowners • Widely publicize project information, including plans to treat multiple ownerships • Implement coordinated treatments when possible, including cross-boundary treatments • Minimize time lags between treatments on different ownerships, especially federal and non-federal lands
5. Benefit-cost ratio	• Provide financial assistance to landowners to help pay for treatments • Provide technical assistance to family forest owners and other landowner types as needed • Seek efficient ways to share information and communicate • Look for efficiencies in conducting environmental analyses required for project implementation (e.g. NEPA), for example by sharing resources • Minimize the time investment required to participate (e.g. apply for funding, attend meetings, coordinate with others)

Table 4 suggests actions that can spur collective action for wildfire risk reduction based on these five principles, and the incentives and enabling conditions identified by our cases. All five principles were important in our cases; when one was not operative, landowners were less likely to engage in Joint Chiefs'

projects. For example, lack of funding to some landowners meant the benefit-cost ratio was unfavorable. Failure of neighbors to treat, reflecting lack of reciprocity, was a disincentive to participate for some. Projects having particularly strong outreach efforts to family forest owners had higher levels of participation

by them than others (unpublished survey data). These findings indicate that a comprehensive strategy for promoting collective action to reduce wildfire risk should take all five principles into account.

6. Conclusions

In this article we draw on collective action theory and empirical research from six cases in which diverse landowners coordinated planning and implementation of wildfire risk reduction across property boundaries to identify practices for promoting collective action to restore fire-resilient forests in western landscapes. Our approach is novel in that we analyze wildfire risk reduction through a collective action lens, and compare and contrast collective action theory for creating an environmental public good (fire-resilient forests) versus managing common pool resources. Although a set of basic principles underlie them both, there are differences that imply different approaches to addressing wildfire risk reduction as a collective action problem. We also examine factors that enable and constrain collective action among heterogeneous groups of public, private, and Tribal landowners who often share fire-prone forest landscapes in the West.

Collective action to reduce wildfire risk—where appropriate—has many potential social-ecological benefits. It has potential to catalyze forest restoration at the scale needed to protect values at risk and promote the ecological benefits of fire. It can lead to relationship-building and partnerships among landowners and other stakeholders, providing a strong foundation for future collective action to conserve and restore large landscapes. It can increase knowledge and skills associated with wildfire risk management among landowners. It builds the institutions needed for landscape-level resource management. Successful projects often attract additional funding to continue investments in environmental restoration across property boundaries. Acting collectively can be efficient and economical owing to opportunities to share equipment, forestry professionals, information, and other resources. Successful social-ecological outcomes also build support in local communities for continuing forest restoration.

Landscape-scale environmental management has gained momentum not just as an approach to wildfire risk reduction, but as an approach to managing rangelands, wildlife, water, invasive plants, and forest insects and diseases as well (Bobzien and Van Alstyne 2014, Charnley *et al* 2014, Scarlett and McKinney 2016, Fischer *et al* 2019). Insights derived from this study about how to promote wildfire risk reduction through collective action across property boundaries can be applied to other environmental management contexts for large landscape conservation in the American West.

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Data availability statement

Some of the data that support the findings of this study are available from the corresponding author upon reasonable request. Other data are not publically available for legal and/or ethical reasons following the research with human subjects protocols used in this study.

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