OXFORD

The Fire Adapted Communities Pathways Tool: Facilitating Social Learning and a Science of Practice

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Abstract

Wildfire science, policy, and practice lack systematic means for "tailoring" fire adaptation practices to socially diverse human populations and in ways that aggregate existing lessons. This article outlines the development and initial operationalization of the Fire Adapted Communities Pathways Tool, an inductive set of processes that help facilitate dialogue about needs and priorities for wildfire adaptation strategies across ownership boundaries or partners. We outline the stages and considerations organized by the tool, including how its components build from decades of social science and practitioner experience facilitating fire adaptation choices among communities spanning the United States. We then outline examples for how the pathways tool provides opportunities to reflect and respond to the needs of diverse human populations implementing fire adaptation in distinct places. Finally, we discuss how the tool can help advance a "science of practice" for wildfire adaptation by promoting social learning or gathering monitoring information at multiple scales.

Study Implications: The pathways tool provides a series of empirically informed processes, choices, and engagement tactics designed to foster shared agreement about the best practices for wildfire adaptation across site-specific local conditions. We outline how the tool can advance adaptation processes for a variety of users, including (1) a community oriented planning process that will help reinforce or catalyze collective action about fire management, (2) a systematic approach for monitoring differential progress toward development of fire-adapted communities, and (3) a potential feedback mechanism that informs programmatic foci or allocation of future resources across potential actions designed for diverse social conditions.

Keywords: wildfire, fire adapted community, planning, monitoring, wildland urban interface

Wildfire science and policy lack approaches for systematically understanding, guiding, or monitoring the complex and varied social *processes* that are noted as crucial determinants of wildfire adaptation. Meanwhile, the field continues to focus on goals of creating "fire-adapted communities" (FACs): collections of residents, land management professionals, fire managers, social service providers, emergency responders, and politicians who collaborate effectively to plan for, respond to, and recover from wildfire while stewarding or supporting its role as a fundamental ecosystem process (FAC Net 2023; Paveglio and Edgeley 2020; USDA 2023). FACs implicate a need to build shared will, resources, and deliberations that conceive of potential wildfire management actions as a series of trade-offs that need to be sustained though coordinated efforts by many actors who develop a common understanding of their shared landscape. Yet decades of wildfire social science demonstrate that social diversity among human populations at risk from wildfire, including evolving local cultures, varied histories, and different capacities of people who work across landownerships and with professionals in specific places, can result in the adoption of very different strategies, decision processes, and adaptation actions among human populations operating at different scales (e.g., a drainage, neighborhood, or homeowners association) (Champ et al.

2022; Copes-Gerbitz et al. 2022; Paveglio et al. 2009, 2015, 2018). Existing research also indicates that the scale at which people are willing to act on changing wildfire conditions are variable across conditions, and that diverse actors must be empowered to make choices about the ways they can take collective responsibility for wildfire management to achieve progress on FACs (Jakes et al. 2011; McCaffrey et al. 2020; Paveglio et al. 2019a).

We suggest that continued challenges surrounding the advancement or monitoring of FACs implicate an important need to further develop science/practice partnerships that conceive of ongoing fire adaptation efforts as an informed *learning process* whereby local people collectively deliberate in the design of actions that reflect their local circumstances and desired relationships with wildfire. An associated "*science of practice*" should help synthesize systematic insights or suggest innovative actions by engaging with and learning from "tailored" adaptation efforts in the reflexive design of contextually relevant strategies that help build various actors' capacities for contributing to wildfire management (see Daniels and Walker 2001; Pahl-Wostl 2009; Paveglio 2021; Williams 2017). Accordingly, at least some of the processes or data collection associated with ever-evolving wildfire adaptation efforts should focus on empowering informed choices

and place-based flexibility by articulating diverse options or "paths" for sustained local action (see Paveglio et al. 2018; Paveglio 2023).

The authors of this article recently built from decades of wildfire social science and practitioner experience helping facilitate wildfire adaptation to produce the Fire Adapted Communities Pathways Tool (hereafter referred to as the pathways tool) (Paveglio et al. 2022). The purpose of this article is to review how the pathways tool emerged from existing research and practitioner syntheses about wildfire adaptation, give an overview of the theoretical concepts that structure processes facilitated by the tool, and link the tool with ideas about social learning to demonstrate its use. The pathways tool helps residents, emergency management professionals, politicians, and fire managers more quickly identify and adapt coordinated sets of approaches, policies, programs, and messages that are tailored to the unique strengths, needs, and circumstances of specific communities that users define. The tool is intended to help empower *adaptive choices* about implementing the myriad of fire adaptation practices or variants promoted in current fire policy or investments (i.e., an inductive reasoning process) rather than attempting to prescribe or predict answers about the "best" or "only" ways to adapt (i.e., a deductive reasoning process) (Bryman 2012; Chambliss and Schutt 2016; Graziano and Rubin 2007). More specifically, the tool provides local populations with structured information they use to articulate the unique local social context (e.g., local culture, norms, networks, relationships with a landscape) most likely to influence ongoing choices about implementing fire adaptation practices, suggests a corresponding range of practices that existing lessons/research indicate are more likely to be effective in the social context articulated by users, and provides users with resources, examples, or ideas necessary to further adapt those lessons in catalyzing ongoing innovation. That process matches an inductive reasoning process in that action is not predetermined, but rather emerges through the interactive exchange of information, ideas, and potential lessons that are rooted in specific, place-based observations applied to additional cases.

We suggest that the pathways tool represents a tangible step forward in advancing or catalyzing an informed learning process for fire adaptation at the community scale. Likewise, the tool builds from and provides processes that could advance a science of practice for wildfire by collecting information about the influences on and reasons for local adaptation that can take a variety of forms across locations. We spend the remainder of this article briefly expanding on existing syntheses of wildfire science and practice that informed development of the pathways tool, give an overview of the process by which it operates, and describe how it might advance fire adaptation at multiple scales, including as (1) a choice-based planning process for communities struggling with the challenge of shared agreement or collective action about fire adaptation, (2) the foundations of a systematic approach for monitoring differential progress toward FACs, and (3) a potential feedback mechanism or needs assessment that informs programmatic foci or allocation of future resources to a wide variety of potential wildfire adaptation actions that reflect diverse social conditions (e.g., fuels reduction projects, critical infrastructure hardening, evacuation safety zones, etc.). We tie each of the above outcomes to literature about social learning, including their advancement of or contradiction with predominant wildfire science as a means to demonstrate

how the new process might structure future advancements in the field. We conclude the article by discussing next steps for the pathways tool and providing suggestions for how it might evolve through shared use.

Local Wildfire Adaptation and Social Diversity: The Need for Pathways

Perhaps the most robust finding in wildfire social science is the recognition that a "one-size-fits-all" blueprint for wildfire adaptation at the local level is not possible (Brenkert Smith et al. 2017; Paveglio and Edgeley 2020; USDI and USDA 2014). Decades of research and practitioner insight surrounding fire adaptation programs or mitigations all regularly identify site- and place-specific dynamics (e.g., relationships between residents and professionals, place-based knowledge, connections to or predominant uses of the landscape, shared perceptions) as important influences on differential adoption, implementation, or needs surrounding various fire adaptations (e.g., participation in landscape fuels projects or collaboratives, engagement with the Firewise USA program, initiation of a cooperative burn program). As such, long traditions of science and practice have focused on uncovering, articulating, and responding to combinations of local conditions and associated cultures that interact to characterize the social and physical landscapes where people and their actions are a predominant influence (McCaffrey 2015; Paveglio 2021; Varela et al. 2014). However, wildfire management efforts continue to be driven predominantly by hierarchical, "expert driven" recommendations that struggle to incorporate the above recognitions into a broader range of investments or potential mitigations, in part because the understandings that emerge inductively from certain segments of social science are not always easy to quantify, simulate, or map in ways that match more deductive science approaches focusing on prediction or standardized measurements across populations (Essen et al. 2022; Goldstein and Butler 2011; Schultz et al. 2019).

Much existing research on fire adaptation attempts to apply psychological, hazard, or geospatial theories to the wildfire "problem" while noting the difficulty of integrating unique social and biophysical contexts that many scholars have documented as important influences on collective action (see Dupey and Smith 2018; McWethy et al. 2019; Wall et al. 2017 for arguments and examples). As a result, some segments of wildfire science and policy have focused on the development of mechanisms, processes, or peer learning networks that seek to foster more efficient implementation of broad goals (e.g., fuels treatment prioritization, engagement with communities, prioritization of vulnerable populations) or synthesis of on-the-ground lessons for state and federal policymakers (see Abrams et al. 2015; Charnley et al. 2020; Huber-Stearns et al. 2022). Early examples of such mechanisms for wildfire included Community Wildfire Protection Plans, which opened avenues for residents and professionals to collaboratively define their wildfire risk or prioritize fuels reduction treatments at smaller scales (Abrams et al. 2016; Jakes et al. 2011; Palsa et al. 2022). Likewise, efforts such as the Collaborative Forest Landscape Restoration Partnership model, the Fire Learning Network, the Fire Safe Councils, prescribed burn associations, and Rangeland Fire Protection Associations are all designed to establish processes or avenues for shared dialogue, experimentation, or learning among diverse groups of residents and professionals who work
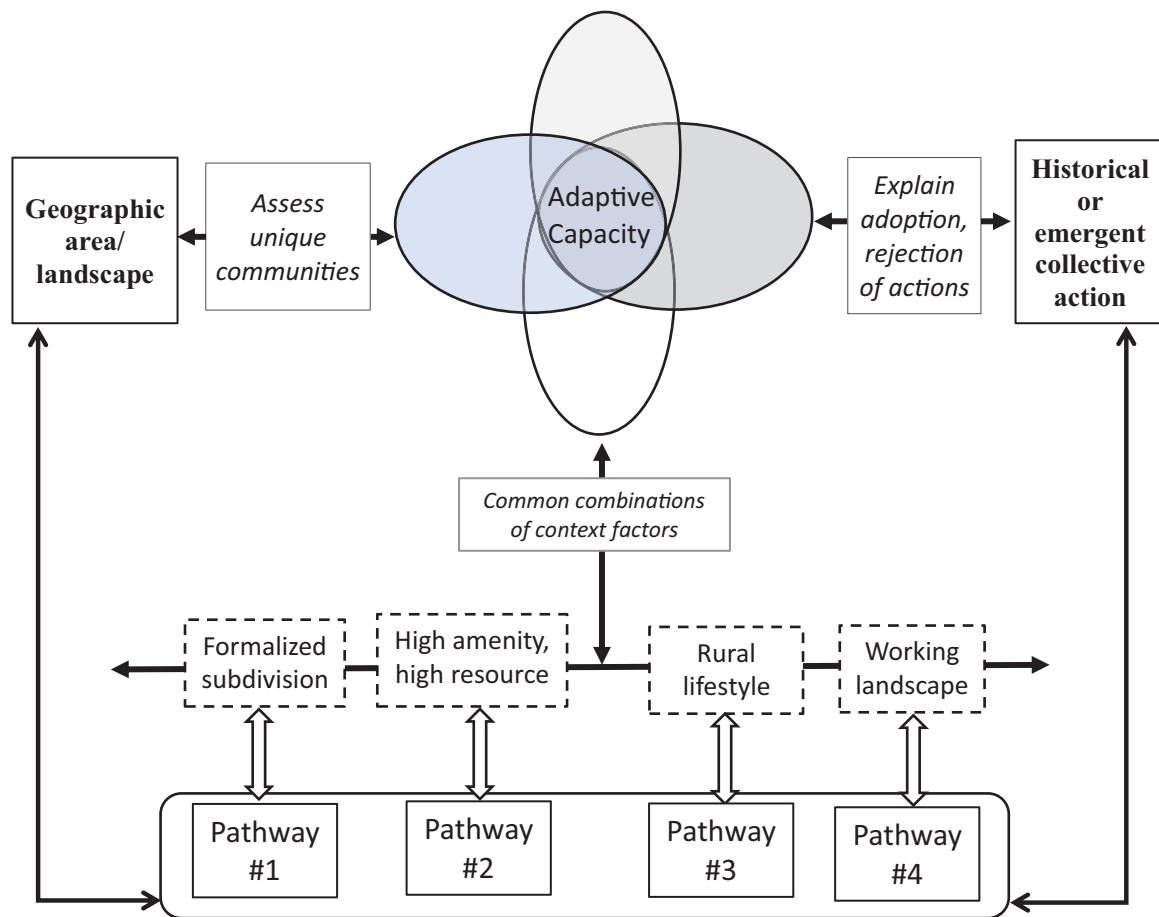
Figure 1 Evolution and uses for the Interactional Approach to Adaptive Capacity (hereafter the Interactional Approach) (adapted from Paveglio et al. 2018). The Interactional Approach can be used to determine unique communities in a geographical area, explain emergent or historic collective action, or identify potential strategies best suited to local context through the systematic documentation of local social context. Researchers initially proposed 22 adaptive capacity characteristics, organized in four conceptual realms (interlocking ovals at the center of diagram) that combine to help document and articulate local context relevant to fire adaptation (See Paveglio et al. 2012, 2019 or Paveglio 2023 for full list). Meta-analyses of cases using the interactional approach uncovered a continuum of "archetype" communities (e.g., formalized subdivision; high amenity, high resource) that share common combinations of social context (See Paveglio et al. 2015; 2018 for details). Each "archetype" community features different "pathways" for fire adaptation, comprised of different programs, policies, incentives, and messages that ongoing research indicate are more likely to be effective in those social conditions (see Paveglio et al. 2018; 2019b for more details).

together to address landscape scale wildfire issues by developing shared understandings, priorities, or coordinated efforts that reflect a broader array of capacities they can lend to a shared problem (see Davis et al. 2021; Goldstein and Butler 2011; Kooistra, Sinkular, and Schultz 2022b; Stasiewicz and Paveglio 2018).

Although lessons from the programs and research described above provide helpful insights about the ways to structure collaboration around wildfire management, fewer efforts have attempted to aggregate wildfire-specific lessons about collective action into more comprehensive theoretical approaches or processes that help explain differential fire adaptation. Two examples of theoretical perspectives that emerged explicitly from research and practice surrounding human adaptation to wildfire, and that attempt to aggregate cross-cutting lessons from a range of fire, natural resource, or hazard literatures are the so-called "Interactional Approach to Adaptive Capacity" (hereafter the Interactional Approach) and the Fire Adapted Communities Framework. We briefly review both these approaches in the following paragraphs and later describe how we draw from and extend those perspective in producing the pathways tool.

The Interactional Approach emerged from empirical case studies and existing wildfire social science lessons about human interaction in fire prone environments. Researchers initially proposed 22 adaptive capacity characteristics nested within four broader conceptual realms that help document, organize, and articulate the unique range of social conditions that combine to influence differential wildfire adaptation at local scales (see figure 1 and Paveglio et al. 2009, 2012; Paveglio 2023). The adaptive capacity characteristics are intended to help residents, practitioners, professionals and/or researchers collectively reason through the ways that local context might influence support or adoption of various wildfire adaptations or best build on resources, capacities, and strengths of those populations in ways that might increase shared capacity to act (Edgeley et al. 2020; Paveglio et al. 2016; Paveglio and Kelly 2018).

Researchers later organized and synthesized lessons from 20 years of case study research across diverse communities using the adaptive capacity characteristics to propose a series of "community archetypes" (Paveglio et al. 2015). Community archetypes articulate repeatable patterns of local context characteristics that combine to produce shared values, cultures,

and approaches to wildfire adaptation. The archetypes can serve as an empirically oriented waypoint or heuristic—they help residents, professionals, or policymakers more quickly understand the complex interaction of factors that influence the ways that people in a given place respond to ongoing wildfire management efforts. The archetypes also help populations with common circumstances share lessons about how they might adapt or innovate new means for advancing fire adaptation that fit their circumstances (Paveglio et al. 2019a; Paveglio and Edgeley 2017; Stasiewicz and Paveglio 2017). Subsequent advancements in the interactional approach used empirical findings and lessons from broader wildfire social science to articulate the composition of "fire adaptation pathways"—combinations of policies, programs, incentives and messages that people likely need to consider when attempting to advance fire adaptation in a given place (Paveglio et al. 2018; Paveglio et al. 2016). Additional case studies and evaluation of pathway components across communities with diverse local contexts (i.e., the community archetypes or other patterns of social conditions not yet documented) have since led to the proposal and testing of diverse pathway components for each community archetype and that ongoing research indicates are more likely to be adopted or adapted given associated local social context (see figure 1 for a representation of the full approach) (Billings et al. 2021; Paveglio et al. 2019b).

Practitioners with the Fire Adapted Communities Learning Network (FAC Net) also recognized the need to more systematically tailor the activities, practices, and programs (what they call "fire adaptation practices") that communities can use to improve fire outcomes and their associated capacity to "live with fire." FAC Net was initiated in 2013 to support place-based practitioners working on fire adaptation across the United States (FAC Net 2023). The organization is focused on facilitating the advancement of FACs, which emerged as a national goal through processes such as the Quadrennial Fire and Fuels Review (NWCG 2005), efforts by the National Wildfire Coordinating Group, and policy guidance such as the National Cohesive Wildland Fire Management Strategy (USDI and USDA 2014). FAC Net also grew from many independent efforts by residents, local professionals, and practitioners who were working with their communities to strengthen their ability to withstand the impacts of wildland fire (e.g., Trinity County Fire Safe Council, Chumstick Wildfire Stewardship Coalition, Austin Fire Department Wildfire Division, and the Chestatee Chattahoochee Resource Conservation and Development Council) using a variety of mechanisms (e.g., stewardship contracting, land use planning, defensible space incentivization, reintroduction of prescribed fire, etc.). FAC Net connects practitioners, supports professional development, provides resources or demonstrations of fire adaptations across a variety of social or biophysical contexts and works to accelerate community ability to adapt to wildland fire. It has grown into a network of more than 400 practitioners, community leaders, and professionals spanning the United States. Network members regularly share lessons about the best ways to apply fire adaptation practices across populations.

The characterization of practices that FAC Net members use to advance FACs has evolved over time. Initial representations depicted nine practices as contributing to community fire adaptation. However, ongoing interaction with practitioners across the country made it clear that the concept of fire adaptation, and what it meant to communities, continues to evolve. No two communities used the exact same set or sequence of practices to increase their community resilience, and additional practices were continually being innovated across the country. In addition to continual sharing of lessons, FAC Net completed an analysis and prioritization of lessons learned across their work in 2017 to better organize the range of FAC practices being promoted or developed by diverse populations at risk from wildfire, and to characterize similarities and differences across communities. FAC Net staff used that information to produce the "Fire Adapted Communities Framework," a more approachable way for practitioners, residents, and professionals to organize existing and emerging community adaptation practices across ten thematic categories (USDA 2023, see also the inner teal ring of figure 2). The group uses the associated "FAC graphic" to consider how practitioners might apply, sequence, or prioritize adaptation practices differently in response to place- and community-specific conditions (FAC Net 2021).

The parity and complementarity of the inductive approaches outlined by the Interactional Approach and Fire Adapted Communities Framework led to conversations about the collaborative development of a tool that might allow for the convergence of practitioner and research experience, suggesting the need to empower tailored fire adaptation among people who inhabit fire-prone lands. That same effort might help advance a common framework or process for approaching the challenge of fire adaptation choices across diverse social conditions, including continued evolution of best practices and scientific efforts.

Collaboration between researchers and FAC Net members about what eventually became the pathways tool began with targeted engagement of broader FAC Net members about processes that might help them adapt or tailor a variety of wildfire adaptation strategies to diverse communities. More specifically, we developed an interactive online workshop attended by FAC Net members to explore what such a tool might look like, propose the theoretical basis for the effort (i.e., the Interactional Approach and Fire Adapted Communities Framework) and receive feedback about the types of resources that might be included. The initial workshop also included interactive exercises, during which FAC Net members discussed a hypothetical landscape and identified the steps or information that they would need to be included in a process for reasoning through tailored adaptation approaches. Insights from the initial workshop and subsequent feedback solicited from residents, practitioners, or agency members who viewed the workshop made it clear that potential end users of the tool wanted (1) a systematic but flexible process for progressively cataloging unique local circumstances using existing approaches (i.e., components of the Interactional Approach), (2) a structured set of steps that would help them narrow in on potential options that they could choose from (i.e., the Fire Adapted Communities Framework), and (3) a "menu" of potential adaptations they could adapt to different circumstances (i.e., Pathways and the FAC graphic) or use to share lessons about application in similar local contexts.

Responding to potential end-user needs meant first developing a systematic process through which to build out an FAC graphic (USDA 2023) or initial pathway for each of the community archetypes outlined by Paveglio et al. (2015, 2018, 2019). The authors organized existing or proposed

Importance

Some categories have a star icon indicating they are of particular importance for this archetype. The starred categories indicate topical areas typically associated with significant opportunity or concern for this archetype.

Category

The same categories of practices are present in every archetype. These categories are found in the inner teal portion of the graphics and are used as headers for the associated descriptions and resources.

Practices

Practices are customized for each archetype. Each practice also has a more complete description (located below the graphic in each archetype-specific section). Considerations resources and/or case studies are provided in the descriptions as applicable.

Landscape Treatments

Fuel breaks: Consider managing vegetation in natural areas adjacent to the community, in/near public parks, and/or around utility transmission lines to create conditions which are not conducive to high intensity fire....
Case Study: Shaded Fuel Breaks (Austin, Texas)

Figure 2 Example pathways graphic provided by the Fire Adapted Communities Pathways Tool (hereafter the pathways tool) (Paveglio et al. 2022). A selection of any given community archetype (example in the red center below) provides a baseline, customizable graphic that organizes suggested fire adaptation practices (outer green ring) by the conceptual realms first developed in the Fire Adapted Communities Framework (middle teal ring) (FAC Net 2021; 2023). Users can explore details about each practice, including existing guidance or case studies, in an associated description of practices created for each pathway. Users can also explore similar categories of practices suggested for other archetypes or build their own graphic in the design of their final pathway.

pathways components uncovered through their interaction with communities or during research on fire adaptation, including broader insights from wildfire social science results (see for instance the literature cited above), for each archetype using the FAC graphic thematic categories as organizational framework (see inner teal ring of figure 2). Organization and comparison of these potential pathway components across archetypes were achieved through a graphical interface developed in the Mural visual collaboration program (LUMA Institute 2023).

Initial development of practices (i.e., pathway components) associated with each potential archetype were then introduced to a broader array of FAC Net members and select researchers who have experience working with communities for initial ground-truthing, expansion, or revision of specific practices. This included review of the Mural board that allowed for comparison across archetypes. Additional FAC Net members and researchers were also engaged in the suggestion of guides, resources, or case study lessons that are provided for practices outlined in the tool (see the next section for a full description of tool components). Shared development and review of the practices organized for each archetype, including linkages to existing research results, consultation with practitioners or researchers conducting similar work, or engagement with community members who had used such practices, continued

for approximately six months. A preliminary version of the pathways tool was presented at the annual FAC Net meeting in the spring of 2022. That workshop reintroduced the purpose of the tool and challenged small groups of FAC members to apply the tool to communities of their choosing in assessing its potential utility. Subsequent breakout sessions at the annual, all-day FAC Net meeting asked participants to identify potential changes to the approach of the tool, discuss potential strategies for prioritization of practices, or suggest additional practices to be included in the tool. FAC Net members also were provided with opportunities to provide additional feedback on the tool by contacting FAC Net staff after the meeting. Suggestions from each stage described above were incorporated in the initial version of the tool that is now available for end users.

A "Choose Your Own Adventure" Process: An Outline of the Pathways Tool

The pathways tool follows a five-step *inductive process* structured to encourage engagement, dialogue and choices among users (see Paveglio et al. 2022 to access the tool). Each step of the pathways tool provides a two-way flow of contextually relevant information—users engage with a range of considerations or guiding criteria before providing place-specific

insights and meanings about their community. In turn, users receive sets of coordinated fire adaptation practices that research and practice indicate are more likely to be useful in the circumstances they articulate, not unlike an empirically informed "choose your own adventure story." As such, the focus is less on prescribing answers or assigning answers, but instead providing a means by which users can plan approaches that best fit local circumstances, and articulate why those choices are plausible steps forward in addressing shared wildfire risk.

The first step of the pathways tool prompts tool users to select the community that will be the focus of their effort. Community is a concept that has many definitions in policy, practice, and science, including wildfire management. However, both research and practice indicate that eliciting user-generated notions of community at scales relevant for ongoing interaction has documented utility in making the selection of a focal population and associated place more meaningful when planning shared action (Fairbrother et al. 2013; Paveglio et al. 2017a; Wilkinson 1991). A shared frame of reference for community often results in selection of more specific or realistic mitigation actions that are more likely to be sustained at local scales. It can also provide more detail, context, and action-oriented information when compared with geospatial approaches or wildfire risk evaluations that use existing jurisdictions or arbitrary aggregations of data (e.g., census tracts and blocks) (Jakes and Strutevant 2013; MacDougall et al. 2014; Paveglio 2023). As such, the pathways tool prompts users to focus on particular places and provides empirically derived suggestions for conceiving of community in ways that help articulate, name, describe, and potentially map out the community that users will focus on during the remaining steps in the tool (the process can be repeated for each community in an area of interest). The tool also provides explicit suggestions about the important need to ensure diverse representation of people who comprise a given community, including underrepresented populations and cultural diversity that provide richness to community capacity or help ensure wildfire adaptation initiatives that will be supported across the community. Documentation of such inclusion could help identify research case studies on the ways that cultural diversity or Indigenous fire practices may influence collective wildfire adaptation, and that some authors indicate need to be augmented in scientific and management literature (Essen et al. 2022; Lake et al. 2017; Nikolakis et al. 2020).

The second step of the pathways tool engages the community archetypes (Paveglio et al. 2015, 2019a) described above to help guide choices about tailored adaptation. More specifically, the tool provides three different options (i.e., descriptions of each archetype, comparison of grouped characteristics across archetypes, and a tabular assessment and assignment of archetype) for selecting an initial archetype that best reflects the local social context of the users' community. Both existing literature and directions in the tool stress that selection of an archetype is not the same as a stereotype of local conditions. Instead, the archetypes serve as a heuristic or initial wayfinding exercise used to help users articulate important conditions operating in their community and as an initial narrowing of the potential suggestions that comprise different pathways outlined in a later section of the tool. Different options for selecting an initial archetype reflect varying preferences for information exchange or learning styles of collaborators (e.g., more structured or suggestive)

and ask users to identify and consider any additional aspects of local social functioning that might not be represented by existing archetypes. The pathways tool also introduces a new community archetype (i.e., the "commercial and highly developed archetype") that has emerged from more recent wildfire research and reflects the increasing impact of wildfires to a broader range of human populations. And if users decide that none of the archetypes reflect their local circumstances, a "build your own" pathway option allows users to consider the full range of adaptive practices or variants currently organized in the tool (i.e., 173 practice descriptions) to produce a graphic supplied in the third step of the process (see below).

The third step of pathways tool process begins the process of tailoring pathways to the unique conditions of diverse communities by providing users with a baseline customizable graphic that corresponds to each archetype (see example in figure 2). Each archetype graphic provides an organized range of customizable practices that existing research and practitioner experience suggest are most likely be effective or supported by people whose local context approximate a given community archetype. Every unique practice implicated in the archetype graphics includes a more complete description, including suggestions for implementation and links to resources, guidance, or case studies for how that practice has been adapted in other communities. Practices in all five archetype graphics are organized using the ten thematic categories of practices co-developed for the FAC Net graphic (see inner teal ring of figure 2), which allows for comparison of similar practices across archetypes while also providing the opportunity for systematic documentation of practices chosen by different users (FAC Net 2021, 2023). In fact, the third step of the tool prompts highly engaged users to compare categories of practices suggested across adjacent archetypes to finalize their selections, especially if users identify that conditions in their community are changing at a rapid pace or if their conditions reflect multiple archetypes along the spectrum. Select categories in each archetype graphic also feature a star icon, indicating that they often are of particular importance to communities in that archetype or represent significant opportunities for advancing adaptation outcomes.

Step four of the pathways tool process provides users with a worksheet for refining the fire adaptation practices they chose, prioritizing which practices are most important for their next steps, and evaluating the partnerships or resources necessary for practice implementation. They are also encouraged to write in or swap out practices from other archetypes to finalize their initial pathway. Next, an action guide process encourages users to plot their prioritized selections along an x and y axis of impact and feasibility when considering how they might advance fire adaptation as a community.

The fifth and final step of the pathways tool provides users with initial tips for using the community specific pathways graphic and action guide they have created. For instance, the tool and associated facilitation guide prompt users to consider how their graphic, worksheet, and action guide might help identify new initiatives to pursue in the community, or more quickly articulate community needs and capacities when seeking partnerships with local professionals/policymakers. Another tip encourages users to consider whether and how the results of their informed planning process might help structure, revise, or advance Community Wildfire Protection Plans (CWPPs) and hazard mitigation plans that are often required to apply for additional adaptation resources and are used by

government and private entities to help understand risk mitigation priorities across landscapes. Each of these processes or next steps are another opportunity to promote interactive engagement of the diverse individuals who comprise the community, and whose shared learning can result in agreement about adaptation practices they can perform to improve their local relationship with fire. They also reflect longstanding lessons from wildfire social science research pointing toward the importance of two-way information exchange, shared deliberation, and co-development of knowledge when promoting sustainable collective action across individuals or landownerships (Essen et al. 2022; Jakes et al. 2011; McCaffrey 2015).

Fire Adapted Learning, Information, and a Science of Practice

While the final step of the pathways tool implicates initial ways that a community might use their outputs, application of the tool across communities also provides opportunities for emergent lessons or information collection at multiple scales (e.g., among communities, regionally, and at state or federal policy levels). Understanding how those lessons might materialize and the ways the pathways tool serves as a methodological step toward a science of practice for wildfire adaptation means considering how the wildfire specific social theory underlying the tool builds from or intersects with broader theory about social learning, including previous applications to wildfire (see Brummel et al. 2010; Cash et al. 2006; Daniels and Walker 2001). Broadly speaking, social learning occurs when diverse groups of people engage with one another to share perspectives, ideas, and meanings that help transform the collective understandings, behaviors, or frameworks they use to promote shared action. Social learning often includes iterative cycles of reflection, experimentation, and negotiation of shared contributions or meanings among different groups of interdependent actors (e.g., agencies, local governments, residents, emergency managers, farmers, timber company representatives, etc.) (Abrams et al. 2015; Cundill and Rodela 2012; Johannesen et al 2019).

Scholars often distinguish three levels of social learning—single-, double-, and triple-loop—when conceiving of the ways that humans interact to collaboratively address complex environmental problems (Cheng et al. 2011; Pahl-Wostl 2009). Single-loop learning is primarily concerned with effective problem solving or the impact of new interventions on an existing goal (e.g., do new incentives for structure hardening make residents more supportive of fuels reduction on neighboring lands?). Double-loop learning begins to question the assumptions, rules, or norms of existing systems by asking about the causal relationships between interventions and outcomes in the pursuit of their improvement (e.g., should communities be able to pursue using Infrastructure Bill funding for structure hardening incentives?). Finally, triple-loop learning engages the context that shapes assumptions or rules defining societal systems and explores transformation of those assumptions to better reflect the reality of achieving goals across diverse conditions or in lieu of uncertainty (e.g., how could flexibility in promoting local or regional structure hardening initiatives help increase local responsibility across diverse social conditions?) (Blackmore et al. 2007; Medema et al. 2014).

By establishing an expanded, more systematic corpus of potential fire adaptations based on existing practice and

science, and providing processes that guide informed local choice about potential sequences of those practices based on diverse local context, the pathways tool has the potential to collect information and promote multiple types of learning among collaborators at actionable scales. Likewise, the tool has the potential to broaden users' potential considerations of what fire adaptation can look like by providing a more extensive list of practices or options to pursue rather than the narrow, one-size-fits-all approaches that can limit fire science and policy. The fire specific theoretical perspectives that underly the pathways tool (i.e., the Interactive Approach to Adaptive Capacity and the Fire Adapted Communities Framework), and that synthesize broader social science lessons about wildfire, have always focused on providing guides or processes that help explain action or allow insights to emerge from the field through processes of dialogue and learning (i.e., inductive reasoning). Those approaches acknowledge that local people and professionals need to develop shared ownership over the adaptation actions that eventually become normative parts of their continued interaction (see also Eriksen and Prior 2011; Paveglio et al. 2018; Reid et al. 2018; Wilkinson 1991). The pathways tool merely helps operationalize portions of the above processes in a systematic way. It provides a set of empirically oriented considerations, processes, and organizational categories that help streamline the complex process of considering place-specific choices about fire adaptation and facilitating the self-reflection necessary to learn from attempts to advance fire management in real-world situations. At the same time, each stage of the pathways tool is designed to elicit community-specific information organized via uniform categories or choices that could eventually serve as variables or outputs of scientific analysis (e.g., community definition or articulation, initial archetype selection, identification of practices that need additional resources or funding, etc.). Thus, the tool also provides opportunities to collect information and derive lessons about adaptation choices that could help improve, transform, or reimagine broader approaches (i.e., programmatic, policy, and scientific) to fire adaptation.

Take for instance a single community engaging with the pathways tool. The tool provides community members with a structured menu of adaptation practices and a process for prioritizing tailored, customizable fire adaptation efforts that are more likely to be effective given their community context. That outcome and other practical uses outlined in the final stage of the tool (e.g., prioritization of grant writing efforts) represent important sources of single-loop learning. At the same time, users' consideration of fire adaptation actions beyond the somewhat narrow programmatic focus on fuels reduction in the United States or those suggested for other archetypes could help lead to additional local action, expanded partnerships with other collaborators (i.e., double-loop learning), or renegotiation of what types of collective actions might be considered viable progress toward fire adaptation by state and national governments (i.e., triple-loop learning). Such recognition or expansion of the ways that communities might contribute to broader wildfire management (e.g., development of local workforce capacity, establishment of long-term housing for recovery, establishment of conservation easements) may help normalize longstanding calls to develop a broader range of actions that engender collaborative action among local governments and citizens, making them invested partners in ongoing fire management efforts (Davis et al. 2021; McCaffrey 2015; Paveglio and Edgeley 2020). Finding ways

to document interest in, progress on, or capacity for diverse wildfire adaptation initiatives across community conditions also has been a longstanding need articulated by researchers exploring or categorizing diverse community conditions (e.g., the archetypes) (Brenkert-Smith et al. 2017; Nielsen Pincus et al. 2015; Paveglio 2023). Documenting differential needs or potential contributions of diverse communities toward fire adaptation are an important interim step in encouraging a broader application of fire adaptation practices across landscapes—and potentially opening up more sustainable monitoring protocols, policies, or funding to better institutionalize their application across a range of communities.

Consider instead a community wildfire coordinator or Fire Safe Council facing the challenging task of prioritizing fire adaptation projects across a region. By initiating a pathways tool process in area communities (self-administered or otherwise), the coordinator or council might more quickly and efficiently articulate a range of mitigation actions that local people in various communities will help support, initiate, or collaborate on given their community-specific strengths (i.e., single-loop learning). Concurrently, exposure to, adaptation of, or learning about application of diverse practices across the spectrum of archetype communities spanning the region also has the potential to increase the knowledge and capacities of the coordinator/council. This is because the pathways tool can help develop a flexible framework, variable sets of best practices, and a "management logic" that helps professionals conceive of strategic ways to achieve social change across conditions or in the sequence of actions that help build capacity for lasting behavioral change among evolving human populations (i.e., double-loop learning). Finally, continued feedback from professionals and residents using the tool can establish a systematic way to experiment with the most effective means for empowering ongoing fire adaptation strategies and understand variation in adaptation successes or struggles across diverse populations (i.e., triple-loop learning).

We are encouraging community members to share results from their use of the pathways tool with others who may share similar local context and with nearby communities in an effort to identify broader collaborations. However, the choices articulated by users at each step of the pathways process could also constitute viable sources of information for monitoring differential progress toward the achievement of FACs through a science of practice (see Paveglio et al. 2018 or Williams 2017). For instance, the final prioritization of fire adaptation practices arrived at by a community at the end of the pathways tool, if completed by numerous communities across archetypes or in the same region, could help more systematically evaluate which types of programs are being adopted as viable pathway components for improved fire adaptation, which adaptation approaches might need additional resources (e.g., financial, prescribed burn training, etc.) or capacity building efforts (e.g., decision tools, workforce programs) to increase implementation, or indicate which mitigation approaches are unlikely to gain traction across select populations (i.e., double-loop learning). Likewise, documenting prioritized pathway practices selected by large enough samples of communities could provide a viable system for gauging trends or evolving foci for sustainable FAC adaptation across social conditions or regions, including expansion of emergent adaptation practices or exploration of the community-specific factors that allowed new practices to emerge (i.e., triple-loop learning). In short, a science of practice that

could result from information collection using the pathways tool would explore the actions, abilities, and processes necessary to encourage positive social change (what some call capacity building). Those efforts are both distinct and complementary to an increasing emphasis on simulating, forecasting, or assigning potential wildfire risk across larger regions, states, or countries.

Although the pathways tool might constitute the means for more deliberate monitoring of differential progress toward adaptative capacity, additional conceptualization and agency/program integration will likely be required to institute any such efforts in ways that contribute to wildfire science and policy that are increasingly interested in "big data." We already discussed above how the pathways tool might be useful in the updating or creating of CWPPs, which have long recognized as a social learning process that can empower community members to help influence the direction or foci of fire adaptation across regions (see Jakes and Strutevant 2013; Palsa et al. 2022; Williams et al. 2012 for discussions). Use of the pathways tool as part of the CWPP process is one mechanism for ensuring more comprehensive collection of process-based monitoring information found in the tool. Other avenues for integrating tool use into existing wildfire adaptation programs or initiatives might include its use as a stakeholder analysis preceding the proposal or design of fuels reduction treatments (see Paveglio and Edgeley 2023 as an example), identification of diverse communities, and thus differential priorities for fire adaptation initiatives across landscapes, including those incentivized by CFLRP (see Davis et al. 2021 and Kooistra et al. 2022a for supporting discussions) or as a way to better understand targeted investment across priority landscapes that are central to the USDA Forest Service Wildfire Crisis Strategy (USDA 2022). Because the pathways tool is designed to identifying a broader range of practices communities can pursue while contributing to fire adaptation, it may also help legitimize or expand practices currently accepted in wildfire adaptation grant programs designed to support community wildfire risk reduction in their localities. Examples of grants or programs that might expand or legitimize additional practices included in their grants include Community Wildfire Defense Grants, state cost-share matches, and FEMA preparedness grants (FEMA 2023; USDA Forest Service 2023a).

Although efforts such as those described above might better institutionalize the uniform and regular collection of information about FAC progress, it is also important to note that the achievement of uniform, universally consistent data to be used in assessing wildfire adaptation across all conditions is likely neither possible or desirable given the differences in values, perspectives, histories, and relationships that are often changing across communities. Rather, the hope is to be more systematic in deriving lessons or building resident and professional capacity to work with communities who have varying social conditions. It is our hope that the insights organized in the pathways tool, which span many lessons across wildfire social science, might be one mechanism for helping to organize the disparate threads of research and policy foci that have and continue to emerge surrounding best practices for FAC (see Dupey and Smith 2018; Paveglio 2021; or Whitman and Holmgren 2022 for examples or supporting discussion). It can also begin to provide overarching frameworks for systematically considering how to best engage or empower communities to engage with increased funding for wildfire adaptation at federal (e.g., Infrastructure

Bill, National Wildfire Commission) and state levels (e.g., California Regional Forest and Fire Capacity Program, Washington State House Bill 1168) while considering longer-term, sustainable adaptations beyond those investments.

Evolving Pathways for FACs

This article is intended to introduce the processes that comprise the pathways tool and situate its development in longstanding lessons from both wildfire social science and practitioner experience working with communities to promote fire adaptation efforts. We would be the first to admit that the pathways tool is only one step toward a broader "science of practice" surrounding wildfire adaptation. However, we would also argue that step helps cross an important threshold of operationalizing scholarship and practice in ways that could transform the ways we facilitate, monitor, or conceive of FACs. More specifically, the development of the pathways tool provides a self-guided or facilitated process by which to derive practical lessons from qualitative, place-based lessons that the broader field of wildfire management has consistently recognized as necessary (Charnley et al. 2020; Cooper et al. 2020; McCaffrey 2015; Paveglio et al. 2015). Mechanisms for deriving in-depth, place-based lessons about shared understanding, collaborative deliberation, and tailored efforts for local wildfire management such as those implicated by the pathways tool have and continue to be poorly captured by many deductive scientific approaches that are prominent in wildfire management. Instead, more deductive wildfire science often seeks a limited number of important influences they can use to "predict" human action or develop quantifiable and consistent data that can be used to prioritize risk investments. Others focus on strategic interventions meant to modify the future actions of populations who are not performing the actions suggested by external actors or who need to be "educated" to support proposed adaptations (see Ager et al. 2021; Dunn et al. 2020; Iglesias et al. 2023; Xu et al. 2023 for examples and discussion). Such efforts often do not engage people in dialogue, negotiation, or joint inquiry about what they could contribute to a shared need for fire adaptation given their site-specific challenges (i.e., inductive processes). Both inductive and deductive approaches are needed to contextualize a fuller picture of wildfire management challenges and the ways they might actually be implemented in practice. However, they also need to be viewed as very different types of knowledge, and which engage different types of methods or logic to derive lessons. Results from both approaches can help contextualize one another, with inductive approaches providing the context-rich information that helps inform deductive evaluation, and that translate deductive results into practical collective action.

The pathways tool should not be viewed solely as a set of ideas to transform into quantitative scales, benchmarks, or measures that can fit neatly into existing deductive approaches. Nor should it be seen as a mechanism for extracting data from local populations to augment or advance big data assessments of risk susceptibility and potential aid (see Chas-Amil et al. 2022 or USDA Forest Service 2023b for examples of assessments). While those efforts serve select purposes (i.e., understanding coarse patterns of risk, determining equitable funding or policy coverage across regions/states, initial frames of reference about changing fire conditions) the ways they are built or introduced can also inhibit peoples'

interest in adapting lessons that fit their local circumstances. Likewise, development of outside assessments using only secondary data or without consultation can alienate local people (including resource managers or emergency services) by promoting solutions derived from afar and through expert-only assignment (see Cash et al. 2006; Daniels and Walker 2001 or Essen et al 2022 for arguments). Rather, the pathways tool might be better thought of as a set of processes that comprise a scientific system of social learning that is complementary, yet distinct from the deductive approaches described above. Efforts by those using the pathways tool help refine strategic choices and gather pattern-oriented lessons that encourage dialogue and shared commitment to a range of fire adaptation practices that can occur in their communities. Those actions have the potential to create legacies that promote broader, transformative practices, and which are rooted in existing science and practice. Likewise, the tool is designed to collect rich information and insights that help support, monitor, or conceive of what FACs might look like in a variety of social conditions. Aggregation of those choices can provide some insights about prevalence or pattern, but they should be progressively contextualized by asking how and why local populations choose to act (or not) the way they do and what that might mean for further empowering professionals and residents in the pursuit of various adaptations that fit their circumstance.

Introduction of the pathways tool also should not give the impression that we are promoting a set of magic formulas for facilitating FACs. It has been our experience that only local people and collaborating officials and professionals can forge sustainable fire adaptation through their ownership of the process. This is because fire adaptation is inherently a learning process shared among people that adapts over time, not a series of programs or the achievement of static targets that will undoubtedly change over time. The pathways tool provides a series of steps, considerations, and existing insights that help advance the effectiveness of those processes. We do hope that the pathways tool initiates a broader dialogue about what a science of practice might look like in terms of wildfire adaptation, how it serves residents, professionals or scholars in conceiving of transformative processes that add up to societal shifts, and the ways the tool can provide common frames of understanding that promote the systematic sharing of lessons learned. It is for that reason that our next steps with the pathways tool are designed around continued "learning from the field," working with residents, professionals, and scholars engaging in the task of implementing fire adaptation across diverse communities. We intend to help facilitate use of the pathways tool in a variety of diverse communities. Practitioner team members will help guide choice-based processes whereas science team members will experiment with potential inputs, strategies, and measures or outcomes of the process to improve both its utility and our understanding of collective action surrounding wildfire. For instance, science team members could work with end users to determine which of the options for selecting a guiding archetype are most effective for different populations or whether additional indicators (e.g., vignettes, visual cues, excerpts from community-derived descriptions of their communities) can help users more efficiently navigate the choice-based components of the pathways tool. We also plan to conduct in-depth case studies of highly prioritized adaptation practices across communities (e.g., introduction of mobile chippers as options to increase

resident mitigations, development and funding of community coordinators in dispersed residential areas) to determine the next steps, opportunities, or strategic barriers that are needed to advance such practices in the site-specific conditions of studied communities. Finally, we hope to work with communities, practitioners, and professionals engaging with specific adaptation practices suggested by the tool to brainstorm potential metrics or indicators of progress and outcomes associated with the pursuit of different practices for wildfire adaptation. Those efforts will include a focus on documenting associated increases in local community and agency capacity that often have not been well captured in current metrics of fire adaptation progress (see Charnley et al. 2023; Davis et al. 2020; Paveglio et al. 2017b; and Paveglio 2021 for supporting discussions).

More immediate than the research described above is the planned introduction of an interactive pathways tool. The interactive version will guide users through tool processes (including tailoring of practices within and across the archetypes) in an online environment. The interactive version of the pathways tool will allow users to create a digital pathways graphic (see figure 2), including their list of associated practices and resources, for easy integration into a variety of processes surrounding wildfire management (e.g., CWPPs, fuels treatment planning meetings, planning and zoning efforts). The online version also has the potential to expand feedback or outcomes generated by users of the tool.

The pathways tool and associated implementation guides are openly available to anyone who wants to download them from the FAC Net website (see Paveglio et al. 2022). We hope that anyone using the tool will engage with its broader design to make it more useful, explore the ways tool components may be better operationalized for data collection, or suggest conditions and practices that help make the process for tailoring wildfire adaptations a better system for learning. This includes drawing from their experience to provide additional case studies, lessons learned, or guides that help populate a more robust or expanded description of practices provided by the tool. After all, the lessons organized and expanded on in the pathways tool build on the experience of countless residents, managers, professionals, and scholars whose collective efforts provide a growing legacy to learn from.

Funding

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