



DEVELOPING STRATEGIES TO SUPPORT SOCIAL-ECOLOGICAL RESILIENCE IN FLAMMABLE LANDSCAPES: A STRUCTURED APPROACH FOR NATURAL RESOURCE MANAGERS AND OTHER STAKEHOLDERS

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Miller, Carol; Higuera, Philip E.; McWethy, David B.; Metcalf, Alexander L.; Metcalf, Elizabeth C.; Black, Anne E.; Clarke, Lily; Hodge, Haley. 2021. **Developing strategies to support social-ecological resilience in flammable landscapes: A structured approach for natural resource managers and other stakeholders.** Res. Note RMRS-RN-92. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 41 p. <https://doi.org/10.2737/RMRS-RN-92>.

Abstract

Land management and fire management goals are increasingly framed in terms of resilience, in part due to the combined impacts of climate change, land-use change, and legacies of land management. Implicit in this framing is the recognition that resilience to wildfire involves both ecological and social dimensions. Discussions surrounding resilience often do not explicitly articulate what resources should or must be resilient to wildfire, and seldom do they make explicit for whom resilience is important. Land managers need to understand and identify which resources their communities want to be resilient to wildfire before they can outline specific actions that could be taken to support resilience for those resources. We detail an approach for bringing together land and resource managers, community institutions, and other stakeholders—those people for whom resilience is important—to achieve these objectives. We describe a series of exercises used for a workshop but present them here in a more generic form that could be adapted to a variety of landscapes, audiences, and formats.

Keywords: collaboration, community engagement, environmental evaluation, mutual learning, translational ecology, wildfire management

Acknowledgments

This publication and the activities described herein were supported with funding from Joint Fire Science Program award 16-3-01-24. We are grateful to the workshop participants, who generously and collegially shared their time, expertise, and creative ideas.

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INTRODUCTION

Land managers in the western United States are faced with the daunting challenge of managing wildland fire in an increasingly fire-prone world (Moritz et al. 2014). The rise in fire activity is partially the result of the higher frequency of fire-conducive climate conditions over recent decades (Dennison et al. 2014; Higuera and Abatzoglou 2021; Jolly et al. 2015; Westerling 2016). The challenges presented by human-caused climate change (Abatzoglou and Williams 2016) overlie significant changes in fuels in many forests that reflect the cumulative impacts of the last century of land use and land-management policies (Schoennagel et al. 2004, 2017). An additional layer of complexity comes from growing population densities in the wildland-urban interface (Bar-Massada et al. 2014; Mietkiewicz et al. 2020; Radeloff et al. 2018) and the increasing use and value of Federal lands for personal benefit such as tourism and recreation (White et al. 2016).

Combined, these changes are increasingly and negatively impacting human lives and livelihoods, lending even more urgency to the need to understand and support social and ecological resilience to wildfires. Resilience is defined here as “the capacity of a system to absorb disturbance and reorganize while undergoing change so as to *still retain essentially the same function, structure, and feedbacks*” (emphasis added; Walker et al. 2004). This definition emphasizes the ability of a system to recover after a disturbance and maintain desired functions. Resilience also implies a threshold beyond which the system state is changed. The concept of resilience is inherently useful in the context of fire management because it helps quantify the likelihood of shifts in desired properties and characteristics of systems, particularly in response to dynamic processes such as fire, which change rapidly and result in novel outcomes (Schoennagel et al. 2017; Young et al. 2019). Evaluating characteristics of resilience in different systems is important because the amount of resources—human and capital—needed to maintain systems within a desired state varies greatly depending on current system stability and character within a particular biophysical and social context. For example, land managers with limited resources may place higher priority on mitigating the impacts of wildfire in systems where management actions are likely to maintain or support desired conditions. This approach may be especially relevant for systems with low resilience compared to systems with high resilience where management actions may not be needed.

The concept of resilience has been increasingly integrated into land-management and fire-management goals. For example, two principal goals of the National Cohesive Wildland Fire Management Strategy (USDOJ and USDA 2014) are to (1) restore and maintain landscapes across all jurisdictions so that they are resilient to fire-related disturbances, and (2) create fire-adapted communities that can withstand wildfire without loss of life and property. Implicit in this framing is that resilience includes both the ecological and social components of landscapes with which humans interact (Falk et al. 2019; Gunderson 2000; Keane et al. 2018). However, ambiguities surrounding the use of social-ecological resilience as a concept can make its application and implementation difficult in land management arenas (Bone et al. 2016; Folke 2016). For example, fuels management can mitigate loss of life and property, but a community encompasses far more than its human population and an inventory of values-at-risk. Additionally, notions of resilience have been criticized by practitioners and scholars alike for failing to acknowledge power dynamics implicit in the asking and answering of such questions as “Resilience of what?” and “For whom?” (Carpenter et al. 2001). In other words, determining how to support resilience requires first identifying and prioritizing values worthy of investment and protection, as well as recognizing that these values represent the interests and biases of those who participate in this process.

Recently, the authors of this report worked with other social and ecological scientists to develop a conceptual framework of resilience that helps overcome some of these challenges. The intent was to integrate ecological and social dimensions of resilience (Higuera et al. 2019) while also explicitly accounting for the ability of communities and land management agencies to foster change (McWethy et al. 2019). This framework identifies and separates two important dimensions of resilience: (1) the inherent (i.e., *value-free*) properties

that maintain structure, function, or states of a social-ecological system, and (2) the human perceptions of desirable or valued (i.e., *value-explicit*) components of that system. In distinguishing between value-free dimensions and human-derived, value-explicit dimensions of resilience, the framework becomes useful for exposing when system resilience and human values are misaligned. For example, although cheatgrass (*Bromus tectorum*)-invaded systems in the West are highly resilient to wildfire and unlikely to change, people may not highly value or desire these systems. Conversely, maintaining dry coniferous forests may be highly desired, but in certain regions the system's limited resilience may provide little opportunity to do so (Stevens-Rumann et al. 2018). Furthermore, the framework facilitates an understanding of the specific social-ecological context of a landscape, so that appropriate and ultimately effective management actions can be developed (McWethy et al. 2019).

Motivated by this framework, we developed an easily accessible approach for groups to (1) clearly identify what resources their communities want to be resilient, (2) outline specific actions and behaviors that can be taken to support social-ecological resilience of these resources, and (3) identify key constraints and limitations to enhancing social-ecological resilience for their specific landscape(s). Here, we detail this approach as a specific series of workshop exercises (fig. 1) that bring together public land managers, resource managers, community institutions, and other stakeholders to achieve these objectives. These exercises were piloted during a workshop in April 2019 but are presented here in a more generic form that can be adapted to various audiences and formats (e.g., face-to-face or virtual). Using our specific workshop approach as an example, we share results from each of the exercises and lessons learned.

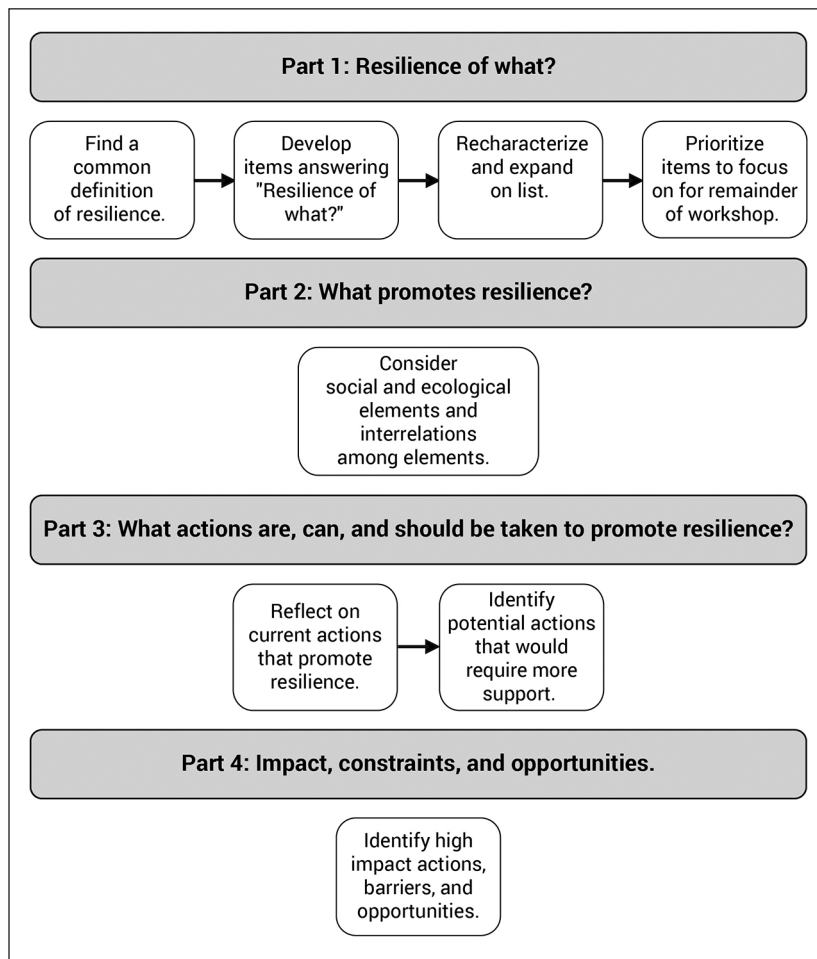


Figure 1—Overview of a sequential series of reflective exercises that can be used by land and resource managers, community institutions, and other stakeholders to generate actionable ways to enhance social-ecological resilience to wildfire for a multitude of contexts. Each of the unshaded rectangles corresponds to one of the eight exercises designed for a case-study workshop .

DEMYSTIFYING RESILIENCE: REFLECTIVE EXERCISES FOR MANAGERS AND STAKEHOLDERS

We developed eight sequential exercises for a wide range of professionals in land management agencies (e.g., U.S. Department of Agriculture, Forest Service; U.S. Department of the Interior, National Park Service; State agencies) and community leaders (e.g., nongovernmental agencies, elected officials, public health institutions). Recognizing that each participant has a unique background, with varied experiences, education and training, and values, we designed the exercises for use in a group setting or workshop format to leverage these diverse perspectives and the synergistic brainstorming that often accompanies group dialogue.

The exercises are divided into four distinct parts that build on one another (fig. 1). Part 1 introduces basic concepts of resilience and provides an opportunity to practice resilience thinking. It then tasks participants with identifying the specific system elements in their landscape for which resilience to wildfire is a high priority (e.g., rare plant assemblage, water quality, recreation and tourism opportunities). In part 2, participants turn their attention to thinking about what actions, approaches, or behaviors promote or create resilience for each element identified in part 1. The goal is to build a collective awareness of all processes that confer resilience to wildfire for specific system elements. In part 3, participants suggest concrete management actions and identify those most likely to promote social-ecological resilience to wildfires with the specific prioritized system elements in mind. Part 4 prioritizes actions based on perceived feasibility and expected impact.

Part 1: Resilience of What?

The goal of part 1 is to identify those elements of a social-ecological system which stakeholders wish to be resilient to wildfire. The steps in part 1 seek to empower stakeholders to choose answers for themselves and embrace the subjective nature of concepts related to resilience. Four exercises are used to accomplish this goal.

Exercise 1: Find Common Definitions and Understanding

The purpose of exercise 1 is to find common definitions and understanding of the concept of linked social and ecological resilience. We expect workshop participants to have different understandings of the concept of resilience and to differ in familiarity with related concepts in systems thinking. To help participants start thinking deliberately about social-ecological resilience, we suggest first presenting some foundational background on resilience. For example, in our workshop we walked through the resilience framework of Higuera et al. (2019). This framework emphasizes the concept of linked social and ecological resilience whereby the “value free” likelihood of a system state change is portrayed as orthogonal to the “value explicit” acceptability (or unacceptability) of such a state change for stakeholders (fig. 2). The quadrants formed by this two-dimensional space represent four archetypes of system states, defined by both an objective, value-free assessment and a subjective, value-explicit evaluation. The four archetypes (quadrants) characterize how well social preferences align with system constraints and realities, and each is associated with distinct, generalized strategies for managing for social-ecological resilience (Higuera et al. 2019).

In this exercise, participants practice applying the resilience framework from Higuera et al. (2019) while drawing from their own experiences, both professional and personal. The exercise involves thinking of a familiar landscape, writing a short description of the system characteristics of that landscape on a self-adhesive “sticky” notecard, and then placing that notecard on a poster-sized copy of the two-dimensional framework (fig. 3a). The y-axis of that framework represents acceptability (for stakeholders) of a state change in the system and the x-axis represents probability of a state change occurring under current or projected future conditions. Participants are then asked to explain to the group the rationale for the placement on the poster, furthering the practice of system thinking.

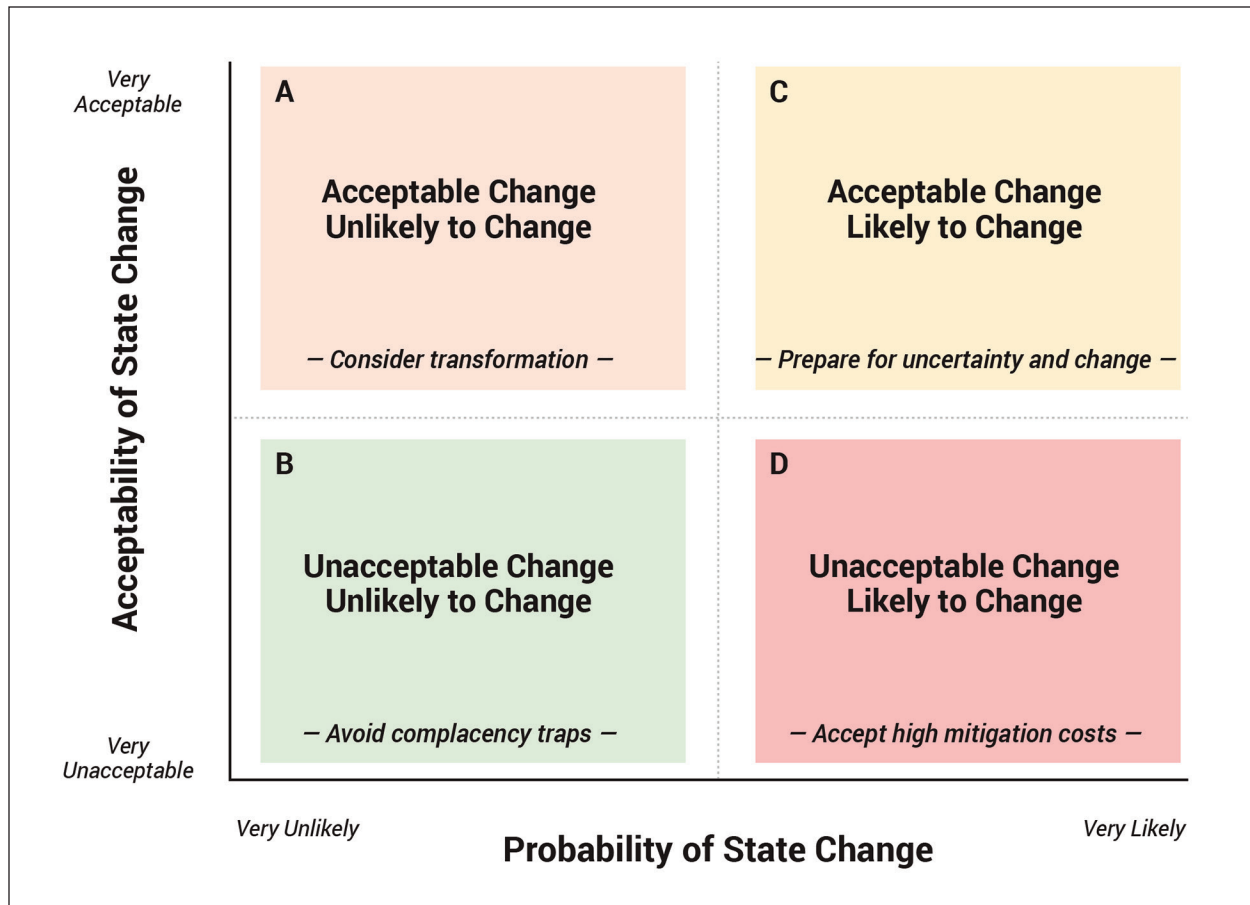


Figure 2—The value-free–value-explicit framework and archetypical scenarios used in exercise 1. The conditions are characterized by the probability (x-axis) and acceptability (y-axis) of a state change after a disturbance such as wildfire. The probability of a state change is inversely correlated with resilience. The acceptability of a state change is based on a social evaluation of whether stakeholders prefer to shift to an alternative condition and is inversely correlated to the desirability of the current condition. The panels' shading indicates a threat level with respect to the probability and acceptability of state change (increasing from green, yellow, orange, to red). Finally, the location of a system in any quadrant reflects a snapshot in time and should be routinely reassessed as the system changes over time. Figure redrawn from Higuera et al. (2019) and used with permission.

Our workshop participants provided examples to populate all four quadrants of the two-dimensional resilience framework. Several systems were placed at boundaries between quadrants, indicating difficulty in assessing likelihood of change in the system or uncertainty or disagreement about stakeholder interest in maintaining the current state of the system. Highly heterogeneous systems added to these difficulties. For example, a system was described for the Flathead National Forest, Montana, at the boundary between quadrants B and D (fig. 3b) because it contained both subalpine and lower elevation forests, which have different propensities for a state change after wildfire. Assessing the likelihood of change was also difficult without a specified timeframe. For example, declining whitebark pine (*Pinus albicaulis*) populations in the Mission Mountains Wilderness in Montana may portend an impending state change, but how rapid or persistent it would be is unclear. Landscapes placed at the midpoint along the y-axis reflected the complexity of social acceptability. Certain aspects of a state change might be acceptable, while others might be unacceptable. For example, in southern Utah, a state change away from conifer-encroached aspen (*Populus tremuloides*) forest toward aspen dominance may be acceptable or even desirable for aesthetics and to reduce flammability, but the large fires (and accompanying smoke) that would be required to initiate the state change might be undesirable. Perhaps counterintuitively, the complexity of these discussions helps highlight how

a)



b)

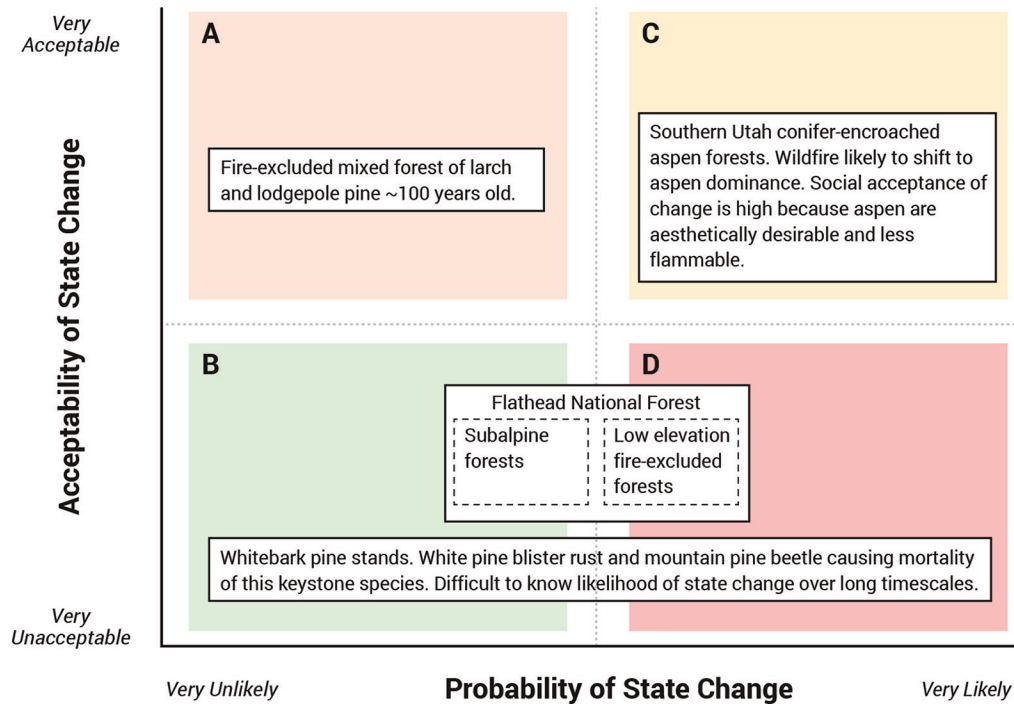


Figure 3—Examples from part 1, exercise 1: (a) notecards containing brief descriptions of a social-ecological system placed on the poster-sized copy of the two-dimensional framework by workshop participants during exercise 1, and (b) selected examples of the systems described and rewritten for illustrative purposes.

participants approach the question of resilience from different scales or perspectives; a key point of this exercise is to highlight these different perspectives—rather than focusing on placing these situations in a “correct” quadrant.

Exercise 2: Answer the Question “Resilience of What?”

Defining what resilience means in any system requires community members and stakeholders to first define what elements of a system are desired by humans to be resilient (i.e., the value-explicit dimension of the resilience framework), and only after that, to identify how resilient these elements are or may be to wildfires (i.e., the value-free dimension). The goal of exercise 2 is to identify critical elements or components of a social-ecological system that participants desire to be resilient to wildfire. Participants are asked to think about and discuss the elements that they care about, or that they are charged with caring about in their professional position. A few examples—such as postfire tree regeneration, wildlife habitat, and livelihoods—may be provided for illustration. Participants should be encouraged to think broadly and not to limit items included in this list at this stage. We recommend doing this exercise in small groups (e.g., four to six people). After a brief discussion within each of these groups to stimulate thought, each participant is asked to list three to five items, each on its own sticky notecard, and post these on a board or wall. Enough time should be allotted to encourage participants to move and reorganize these individual items into broader categories.

In our workshop, we set up this exercise by presenting a set of suggested elements of a system that people might want to be resilient to fire, and we illustrated them in the context of the resilience framework (fig. 4). Ultimately, over 60 items were posted, reflecting a diversity of biophysical and social elements of the system. Items included abstract attributes such as “public trust” and more tangible attributes such as “vegetation.” To provide some organization, we ultimately grouped these items into general categories: Agency Capacity; Community Character and Capacity; Economics; Ecosystems; Infrastructure; Life and Health; and Recreation (fig. 5). Importantly, the workshop participants collaborated on the grouping of items into categories, and the names of the categories themselves.

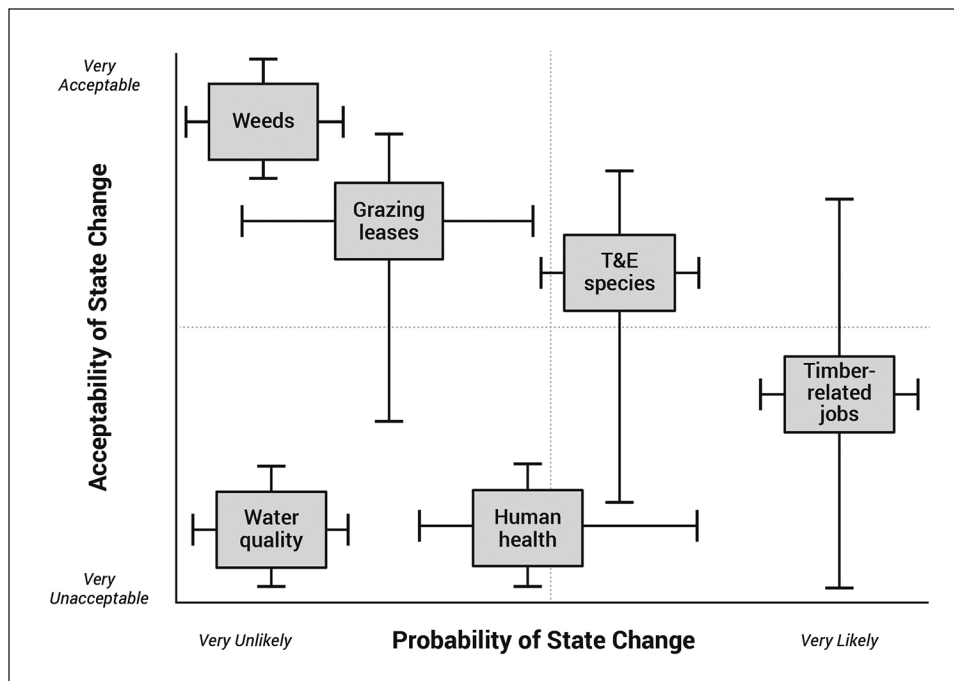


Figure 4—Examples of elements of a hypothetical social-ecological system set in the context of the resilience framework that were used to introduce exercise 2. The horizontal error bars represent lack of precision in estimating probability of a state change, and the vertical error bars represent the diversity among stakeholders and the range of their subjective evaluations. “T & E species” indicates threatened and endangered species. Figure redrawn from Higuera et al. (2019) and used with permission.



Figure 5—Notecards generated by workshop participants during exercise 2 and arranged under broad categories.

Exercise 3: Refine and Revise “Resilience of What?” List

The goal of exercise 3 is to develop a final, expanded list of “Resilience of What” items, and particularly to check whether any key items are missing. To achieve this expanded list, the group is invited to reflect and refine, revise, or recharacterize any of the items. To prompt this expanded thinking, participants can be asked to think of items that colleagues and collaborators from other units, departments, or organizations might add to the list. At the end of this exercise, all participants should feel satisfied that the list captures all elements of a system that they want to be resilient to wildfire.

Exercise 4: Prioritize “Resilience of What?” Items

The final exercise in part 1 is designed to reduce the exhaustive list of items created during the first two exercises. The aim is to identify the most important items on which to focus the remainder of the workshop, aiming for a tractable number of items (e.g., ≤ 10). This prioritization can be achieved through a simple voting process wherein each participant has a certain number of votes to distribute among any number of the items. The exhaustive list of items from the previous exercise and the items which get prioritized in this exercise will vary according to the group involved and the perspectives that each participant brings.

In our workshop, this exercise fell at the end of the first day. We allowed 10 votes per participant. Thirty-six of the items received at least one vote (exhibit 1). The single item receiving the most votes ($n=14$) was “recreation opportunities and access,” followed by “infrastructure (electronic communication, water, powerlines, houses)” ($n=11$). Rather than choosing the 10 highest priority individual items to focus on for the remaining exercises, the group chose to use the broad categories that had emerged from exercise 2. After compressing and editing the categories and category names, we arrived at 7 categories that best encompassed the 36 individual items that had received at least 1 vote. When grouped by the seven general categories, Life and Health received the most collective votes ($n=38$), followed by Agency Capacity ($n=26$), Ecosystems ($n=22$), Recreation ($n=17$), Community Character and Capacity ($n=16$), Economics ($n=15$), and Infrastructure ($n=13$). These results reflect the makeup of our workshop, and we expect results to vary across different participant groups.

Exhibit 1—Items generated during exercise 2 arranged by general category. Number of votes indicates relative importance collectively assigned by the workshop participants.

Category	Item	Votes
Agency Capacity	Relationships between entities (agency, individual)	8
	Public trust	6
	Interagency trust and support	6
	Workforce wellness	5
	Confidence in leadership in community	1
Community Character and Capacity	Sense of place	6
	Quality of life	5
	Cultural impacts	2
	Aesthetics	2
	Community philanthropy	1
	Adequate insurance networks	0
	Wilderness	0
	Historic sites	0
Economics	Business impact (economic)	7
	Tourism and recreation economy	5
	Forest products, resource extraction	1
	Tourism, outfitters, hotels and resorts	1
	Business community	1
	Small business	0
	Nongovernmental organizations, support services (e.g., Red Cross)	0
	Ranching (infrastructure)	0
Ecosystems	Biodiversity	7
	Soil, water	6
	Vegetation	2
	Dead wood habitat consistency	2
	Wildlife and fisheries	2
	Lack of invasive species	2
	Desired ecotypes	1
	Threatened and endangered species	0
	Lynx habitat	0
	Water flow (quantity)	0

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Exhibit 1 (continued)—Items generated during exercise 2 arranged by general category. Number of votes indicates relative importance collectively assigned by the workshop participants.

Category	Item	Votes
Infrastructure	Infrastructure (electronic communication, water, powerlines, houses)	11
	Personal property	1
	Infrastructure (fences)	1
	Infrastructure (hospitals, bridges, road network, cell tower)	0
	Information, utility, infrastructure, communication systems	0
	Utilities	0
	Houses	0
	Public buildings	0
	Roads open	0
	Railroad	0
	Public administration (hospitals, schools, fire department)	0
	Public gathering places (pool, recreation center, library)	0
Life and Health	Public health	9
	Firefighter health and safety	7
	Air quality	6
	Water supply (agriculture, municipal, fish)	5
	Human lives	3
	Water quality	3
	Human safety (firefighters)	2
	Core trauma stress response	2
	Human safety (landowners)	1
	Lack of stress and anxiety	0
	Family safety (health and safety issues)	0
	Food supply	0
	Visual resource management	0
Recreation	Recreation opportunities and access	14
	Wilderness trail access	3
	Trails	0
	Hunting	0
	Trailhead	0

Part 2: What Promotes Resilience?

The goal of part 2 is to identify what promotes or creates resilience for the prioritized items from part 1. We designed one exercise, intended to be repeated for each of the priority items from exercise 4 in part 1.

Exercise 5: Answer the Question “What Promotes Resilience?”

Working in small groups, participants are asked to focus on the set of items prioritized in exercise 4 and identify what promotes resilience of those items. Participants should be encouraged to consider both social and ecological elements, and to think of interrelations among those elements. For example, nonflammable building designs that make infrastructure resistant to fire may simultaneously protect elements such as life or health, as well as minimize fire impacts to the local economy, thereby serving to enhance the other characteristics of a community. A flipchart can be used to capture the list generated. There should be ample opportunity for discussion, clarification, and revisions to the lists. Varying degrees of specificity among the lists can be expected.

In our workshop, we chose to focus on all seven broad categories from part 1 rather than the individual items that received the most votes. We allowed participants to self-select into small groups and choose which of the seven categories to focus on. We conducted three rounds during which two to three separate categories were discussed. Each round lasted 20 minutes. After the three rounds and a total of seven lists were captured on flipcharts, a representative from each of the groups summarized (orally) a description of each list to the entire group. There was an opportunity for discussion, clarification, and revisions to the lists.

In our workshop, participants generated a rich list of items that promote resilience of the seven general categories of components (exhibit 2). The Recreation category had the most items, likely reflecting regional priorities. Many of the items generated were phrased explicitly or implicitly as actions or behaviors that promote resilience (e.g., “connect business operators with during-fire and postfire recreation opportunities”). Listed items varied widely in terms of abstraction and specificity. For example, both “encourage social networks” and the more tangible and specific “funding for community storytelling venues” were listed as items that could promote resilience of community character. Several themes ran through multiple categories. For example, the importance of having healthy relationships among community entities showed up in the categories Community Character and Capacity, Economics, Life and Health, and Recreation.

Exhibit 2—Examples of items that promote resilience to wildfire, generated during exercise 3 and arranged by general category.

Category	Items that help promote resilience
Agency Capacity	Employees who are prepared to be flexible and adaptable and to shift duties as needed Employee preparedness for a wildfire event Agency support for decision making Employee preparedness (mental and emotional) for a fatality Mindfulness of what falls off the plate when responding to fire events Proactive engagement of media Culture of reviewing “lessons learned” after fire events, including a willingness to listen to what worked well and what did not work well Commitment to change and improvement Trust, competence, shared values, and benevolence Transparent accounting for property loss with the public

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Exhibit 2 (continued)—Examples of items that promote resilience to wildfire, generated during exercise 3 and arranged by general category.

Category	Items that help promote resilience
Community Character and Capacity	Common understanding of values at risk, deep values, traditions, history Support for valued aesthetics Protection of key values at risk Support for recreation opportunities Opportunities for communities to “commune” on values and experience through structured conversations Funding to support community storytelling Population that is accustomed to the idea of change Engagement of community leaders ahead of time Engagement of local businesses Encouragement of social networks (e.g., neighborhood organizations) Support mechanisms for postfire grief responses (e.g., podcasts) Empowered communities that can identify what they have and what they need Planning and future thinking Identification of opportunities created by fire which can improve community infrastructure (e.g., rebuild but better) Knowledge of where to turn for funding when needed for recovery (e.g., foundations, donors, Federal government)
Economics	Readily available real-time information on smoke, community impacts, closings, etc. National Weather Service information, in real time, provided to business community Daily cooperator meetings Monthly Breakfast Club meetings with agency heads (National Park Service, Forest Service, State, local) and community leaders to proactively plan for wildfires Redistribution of outfitter and guide permits and concessionaire contracts Grazing allotment relief Use of incident management costs to support local economy (e.g., catering, lodging) Small businesses that match government per diem rates Promotion of postfire recreation opportunities (e.g., mushrooms, vistas, wildflowers, snowmobiles) Access to community foundation money Community economic development coordinator who can help address fire impacts Making it easy to tap into local resources during fire events Small Business Association grant clearinghouse Business insurance Market for small diameter trees to enable fuels treatments, and provide infrastructure and jobs (e.g., biofuels)

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Exhibit 2 (continued)—Examples of items that promote resilience to wildfire, generated during exercise 3 and arranged by general category.

Category	Items that help promote resilience
Ecosystems	- Understanding of social-ecological effects of fire - Reduced fuel loading - Strategic placement of fuels treatments - Identification of species of concern and areas that need either protection from fire or management treatment before the next fire - Scientific information on impacts of fire on soil and water at the landscape level - Increased fire occurrence in fire-maintained systems, both prescribed and wildfire - Planning for mitigating climate change impacts - Planning for mitigating negative impacts of prescribed fire and fuels treatments (e.g., invasive species) - Heterogeneity in landscape structure, including fire refugia - Community Wildfire Protection Plans, risk assessments - Regular Breakfast Club meetings with community leaders - Reduction in or removal of institutional barriers to vegetation and fire management operations (including mechanical fuels treatment and prescribed fire)
Infrastructure	- Fuels treatments around assets which need protection (e.g., communication sites) - Emergency plans that extend beyond a unit boundary, include a map of assets and contingencies, and are shareable with others - Contingency plans which include stakeholders and partners - Integration of early preparedness for valuable assets into strategies - Planned evacuation routes and safety zones - Asset maps depicting vulnerability of each asset - Buried power lines - Decreased dependence on the power grid - Planning and zoning that minimize risk and vulnerability to fire and allow for egress and ingress - Access to communication sites and other infrastructure (e.g., water treatment) during and after fire - Redundancy in systems for cellular connections - Collaboratively funded emergency coordination - Firewise homes - Clear, concrete communication about what is “defensible space” - Social license

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Exhibit 2 (continued)—Examples of items that promote resilience to wildfire, generated during exercise 3 and arranged by general category.

Category	Items that help promote resilience
Life and Health	Connections and communications with community entities through education and outreach Social license for being proactive Community partnerships Smoke management as part of land management plans Understanding of both short- and long-term effects of fire Mental health and wellness support Clean air spaces that are “smoke wise” Watershed protection (supply, quality) Health connections (i.e., to quality of life) Evacuation routes and a standardized public notification system Public and political acceptance of tactics, purpose, etc., of fire management, as they relate to resilience Preidentified community safety zones
Recreation	Beneficial impacts of wildfire on recreation opportunities (e.g., fisheries, hunting, scenery, mushrooms, skiing, wildflowers) Encouraging recreation businesses to anticipate impacts from fire Sharing more stories about change and ecological resilience, which helps confer social resilience Developing relationships beforehand Increasing communication and coordination with displaced small businesses (e.g., outfitters and guides, concessionaires) to help mitigate impacts Adequate baseline workforce capacity for recreation infrastructure and vegetation maintenance Partnerships to help do work (e.g., “friends of” groups) Recreation opportunities that are possible during and after fire events Connecting business operators with during-fire and postfire recreation opportunities Stable Burned Area Emergency Response (BAER) and “disaster” funds that can help mitigate postfire impacts on recreation resources Network of skilled people who can work in postfire landscapes and environments On-demand access to information about recreation locations after fire events, and resources to help redirect people during and after fire events Human Resource systems that can support the increased demand in postfire hiring Awareness and recognition of the impacts of fires on the recreation economy Translating smoke forecasts and smoke management to identify recreation opportunities Addressing losses to fee collection, which recreation capacity is built around Surge workforces and grab-and-go capacity

Part 3: Actions to Promote Resilience

The goal of part 3 is to move from theoretical expressions of what promotes resilience in specific components of a system toward specifying concrete actions that promote resilience. We designed two exercises to identify 1) actions currently or already taken, and 2) actions that could be taken in the future.

Exercise 6: Answer the Question “What Do You Do Currently?”

Participants are asked to individually reflect and make a list of actions currently undertaken in their professional role that directly tie to and affect resilience to wildfire. Because it is likely that the lists generated in part 2 include concrete actions that people are already taking to promote resilience, participants should be encouraged to refer to those lists. Participants may want to rephrase or be more specific and may think of additional actions that promote resilience. Some actions may promote resilience in more than one way (i.e., occur across multiple items); such actions could be highlighted for further discussion to continue to build awareness of how actions and the priority items are intertwined.

In our workshop, this exercise resulted in a sizable list of tangible actions for all seven categories of components (exhibit 3). Most of the actions were closely related to the previous lists of actions that promote resilience from part 2. For example, prioritizing fuels treatments to reduce hazardous fuels around vulnerable assets was an action currently being taken to promote resilience, included in the Infrastructure category of components; this was also listed previously in part 2 (exhibit 2). In addition, several actions were identified that were new to the conversation, including “provide opportunities for scientists, managers, and engaged stakeholders to have dialogues and build relationships through fieldtrips and workshops” (under the Agency Capacity category) and “promote and support a ‘buy local’ campaign” (under Economics). Several actions applied to more than one category. For example a common theme that cut across multiple categories involved cultivating relationships: “engage community leaders ahead of time” (Community Character and Capacity), “hold monthly Breakfast Club meetings with Federal, State, local leaders” (Economics), “hold Breakfast Club meetings with communities” (Ecosystems), “create a liaison-type position to work proactively across entities” (Infrastructure), “establish connections and communications with community entities to educate and develop social license and encourage being proactive” (Life and Health), and “cultivate relationships before the fire” (Recreation).

Exhibit 3—Examples of actions currently being done to promote resilience, generated during exercise 6 and arranged by general category.

Category	Actions currently being done to promote resilience
Agency Capacity	Employ varied ways of public engagement (early and often) Set employee expectations for being flexible and adaptable and shifting duties Provide peer support for decision making Provide training to prepare employees for a wildfire event Proactively engage media by providing them with stories to tell Discuss employee preparedness and response for a potential fatality Share lessons learned post-fire with larger community to show learning is occurring, demonstrate willingness to listen to what worked well or not, and demonstrate commitment to change Provide opportunities for scientists, managers, and engaged stakeholders to have dialogues and build relationships through fieldtrips and workshops Encourage employees to embrace how their engagement with fire management can benefit their resource and provide personal and professional development opportunities

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Exhibit 3 (continued)—Examples of actions currently being done to promote resilience, generated during exercise 6 and arranged by general category.

Category	Actions currently being done to promote resilience
Community Character and Capacity	Continually deliver messaging to expect ecological change Engage community leaders ahead of time Support and encourage social networks (e.g., neighborhood organizations) Address postfire grief response (e.g., phone-in radio and podcast show) Empower communities to identify what they have and what they need Encourage people to think ahead to what future they want Identify opportunities created by fire where we can “rebuild but better” Compile a list of funding sources and donors to support recovery programs Establish community assistance program with grant funding Provide recreation opportunities
Economics	Provide real-time, readily available information regarding weather, smoke, and other things that affect tourism (e.g., fire communication messaging, webcam feeds) Meet daily with cooperators Redistribute outfitter and guide, concessionaire, and other permit holders to mitigate business loss Provide relief allotments for grazing and grass banks Hold monthly Breakfast Club meetings with Federal, State, local leaders proactively before fire season Provide and promote postfire recreation opportunities (e.g., hunting, mushrooms, snowmobiles, vistas) Promote and support a “buy local” campaign Establish community foundation to provide access to money post-disaster Maintain a grant clearinghouse for disaster relief to small businesses Subsidize small diameter timber market to diversify economy while enabling fuels treatments Brainstorm with Chamber of Commerce to identify small businesses in need of grants or assistance Provide a Resource Advisor (READ) to assist community with smoke planning Encourage business owners to carry business interruption insurance Encourage small businesses to offer or match government per diem rates

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Exhibit 3 (continued)—Examples of actions currently being done to promote resilience, generated during exercise 6 and arranged by general category.

Category	Actions currently being done to promote resilience
Ecosystems	Increase understanding of social-ecological effects of fire Reduce fuel loading Strategically place treatments Identify species of concern and areas that need either protection from fire or management treatment before a fire Increase awareness and understanding of new science through workshops, fieldtrips, syntheses, webinars, and online searchable databases and publications Increase fire (wildland and prescribed) in fire-dependent systems Hold Breakfast Club meetings with communities Implement planning to mitigate negative impacts (e.g., invasive plants) of prescribed fire and other treatments Enhance landscape heterogeneity Develop forest plans that are less restrictive and more flexible Complete Community Wildfire Protection Plans, risk assessments Promote awareness of fire ecology research showing that good outcomes happen with natural fire cycle Develop “learning labs” for community engagement sessions Increase scientific knowledge of soil and water impacts at landscape level
Infrastructure	Prioritize hazardous fuels treatment around key assets that need protection (e.g., communication infrastructure) Implement fuels treatments around vulnerable infrastructure Coordinate and communicate contingency plans with stakeholders and partners as early as possible Annually update and share Community Wildfire Protection Plan Identify evacuation routes, safety zones Create and share maps showing vulnerabilities of assets Create a liaison-type position to work proactively across entities (Federal, community, other) focused on “firewise” education Develop program to incentivize hazard mitigation by private landowners adjacent to work occurring on Federal or State lands Provide grant funding for fuels treatment around community infrastructure located on private land Develop Standardized State Transportation Improvement Plan (STIP) and mitigation measures for Right-of-Way Environmental Assessments (agency-wide) Assess the adequacy of bridges for supporting heavy equipment Plan for redundant cellular communication and power systems

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Exhibit 3 (continued)—Examples of actions currently being done to promote resilience, generated during exercise 6 and arranged by general category.

Category	Actions currently being done to promote resilience
	Reduce dependence on the centralized power grid Collaborate to fund emergency coordination Stage generators on-site for decentralized backup power source; implement strategic power outage during active fire growth Conduct on-the-ground postfire damage assessment of homes within 48–72 hours after event
Life and Health	Jointly hire community wildfire preparedness coordinator Write letters of support for Federal Emergency Management Agency (FEMA) grants that have a public health (smoke) component Produce videos explaining what we can do in the landscapes we care about Establish connections and communications with community entities to educate and develop social license and encourage being proactive; provide information to include in home emergency plan Make risk-based fire response decisions Identify community safe zones
Recreation	Develop and share messaging about beneficial effects of fire on the resource and on recreation opportunities Encourage recreation-oriented businesses to anticipate impacts from fire Share more stories about ecological change and resilience Cultivate relationships before the fire Increase communication and coordination with displaced small businesses to help mitigate impacts Increase partnerships to help address baseline workforce capacity for trail maintenance Keep knowledgeable local people in contact with local small businesses Set expectations for the postfire backcountry or wilderness recreation experience Allow return of natural fire intervals that ultimately will improve conditions for trails and backcountry sites Develop a network of skilled people to work in postfire world or environment (i.e., surge workforce) Identify during-incident and postfire recreation opportunities and connect business operators with those opportunities Share skilled personnel with another location as needed Translate smoke forecasts in terms of outdoor recreation recommendations Standardize templates for requesting Burned Area Emergency Response (BAER) and “disaster” funding

7: Answer the Question “What Could You Do?”

The purpose of exercise 7 is to move beyond the status quo to identify a broader range of concrete actions that could promote resilience. At this point in the workshop, participants will have identified actions that they are already engaged in. This next exercise will identify three types of actions: (1) those that can be implemented now within the current job description and available resources; (2) those that could be implemented, but would require additional resources or concurrence and support from a supervisor (e.g., reallocation or reprioritization of resources); and (3) those that require broader system reorganization or change (e.g., change in policy and procedures) and may be outside a participant’s sphere of control. This exercise can be set up by providing three different colors of sticky notes or designating three separate wall spaces to organize notepaper. Participants should be given a few minutes to think individually and encouraged to write at least one action within each of the three types on a sticky note. We suggest inviting participants one at a time to post their sticky notes and explain what they wrote. The exercise can conclude with a group reflection and discussion about what is posted on the wall.

At our workshop, participants collectively generated 20 to 30 actions in each of the 3 types (exhibit 4). Quite a few actions related to the categories Agency Capacity and Recreation were provided by members of our group who were Forest Service employees with recreation management responsibilities. Many of these were concerned with workforce utilization, for example:

- “shift duties to work on fire incidents and help fire personnel have effective community conversations,”
- “shift duties and use my skills as public information officer to help engage community in implementing prescribed fire and other fuels treatments,”
- “develop information system to facilitate sharing of employees with backcountry or wilderness skills who can work in fire-affected areas,”
- “identify a surge workforce for prescribed fire and postfire work,” and
- “collaborate with fuels personnel to make recreation infrastructure more ‘firewise.’”

Many of the actions that are possible now involved some aspect of proactively engaging or communicating with members of the community, for example:

- “have proactive conversations to understand concerns of recreationists about fire,”
- “have proactive conversations to understand needs of small businesses impacted during fire and post-fire,”
- “provide more community education about the benefits of fire, including positive postfire effects on recreation opportunities,”
- “convene regular Breakfast Club with agency partners to build community and foundation of trust,”
- “conduct community discussions around shared values,”
- “have discussions with local businesses on how to adapt to a fire economy,”
- “work with Chamber of Commerce and other entities to build social license in the community,”
- “share information with public and political representatives about social-ecological tradeoffs of fire,” and
- “frequently talk with partners and stakeholders” to help them “anticipate the impacts of more frequent fires.”

Several actions that are related to treating fuels and managing vegetation would require permission, incentives, resources, or broader changes, and included:

- “reduce fuels around critical infrastructure and egress routes (requires resources),”
- “increase capacity for fuels mitigation, preparedness planning, and outreach (requires resources),”
- “work with Federal, State, and private entities to implement fuels treatments that retain wildlife habitat (requires permission, incentive),”
- “increase prescribed fire in fire-dependent systems (requires smoke restrictions to be reduced or changed),” and
- “manage more natural fire for resource objectives (requires incentive).”

Exhibit 4—Examples of potential actions that promote resilience to wildfire, generated during exercise 7 and arranged in descending order of feasibility from left to right.

Actions possible now	Actions that would require permission, incentive, or resources	Actions that would require system change
Have proactive conversations to understand concerns of recreationists about fire	Shift duties to work on fire incidents and help fire personnel have effective community conversations (requires permission)	Identify a surge workforce for prescribed fire and postfire work
Have proactive conversations to understand needs of small businesses impacted during fire and post-fire	Shift duties and use my skills as a public information officer to help engage community in implementing prescribed fire and other fuels treatments (requires permission)	Develop information system to facilitate sharing of employees with backcountry or wilderness skills who can work in fire-affected areas
Provide more community education about the benefits of fire, including positive postfire effects on recreation opportunities	Reduce fuels around critical infrastructure and egress routes (requires resources)	Increase prescribed fire in fire-dependent systems (requires smoke restrictions to be reduced or changed)
Convene regular Breakfast Club with agency partners to build community and foundation of trust	Increase capacity for fuels mitigation, preparedness planning, and outreach (requires resources)	Advance forest products industry to create opportunities for local economic development (e.g., subsidies for biofuels, small diameter wood, commercial thinning)
Conduct community discussions around shared values	Facilitate inclusive process to take “Fire adapted community” planning to next level (requires incentive)	Change agency “attitudes” so we communicate, coordinate, and cooperate to establish priorities without duplication of efforts (i.e., become force multipliers)
Have discussions with local businesses on how to adapt to a fire economy	Communicate success stories about how fire has strengthened the community (requires incentive)	Provide alternative source of funding for maintenance projects when recreation site fees are lost due to wildfire
Work with Chamber of Commerce and other entities to build social license in the community	Engage in mentoring opportunities to increase agency capacity (requires incentive)	Implement a postfire strategy to address impacts to recreation opportunities and resources
Share information with public and political representatives about social-ecological tradeoffs of fire	Increase pace and scale of mitigation activities (requires resources)	Provide affordable and sustainable insurance coverage for businesses
Frequently talk with stakeholders and local businesses and encourage them to anticipate impacts of more frequent fires	Hire people in a timely manner (requires resources)	Address community grief after wildfire
Work with fuels personnel to make recreation infrastructure more “firewise”	Develop a “how to” guide for building social license (requires resources and incentive)	Provide grant funding for fuels mitigation on private lands
Work with individual landowners on forest stewardship projects that reduce fuels and provide wildlife habitat	Manage more natural fire for resource objectives (requires incentive)	Increase capacity for research and development to conduct strategic projects
Participate as public information officer on fires	Support recreation partnerships (requires resources)	Establish mechanism for programmatic spending across multiple years
Encourage fire staff to identify and protect historic or cultural resources that are critical to community character	Create redundancies in communication systems and utility infrastructure (requires resources)	Develop and implement more flexible internal contracting regulations
Reinvent forest planning meetings to stimulate creative collaboration	Work with Federal, State, and private entities to implement fuels treatments that retain wildlife habitat (requires permission, incentive)	Reform grants and agreements process for approval of applications and project proposals to more efficiently funnel funding to communities for fuels mitigation, preparedness planning, and education and outreach opportunities
Hold a science symposium	Write guidance on best management practices for fuels reduction that retain wildlife habitat (requires incentive, resources)	
Influence research agendas to study and collect data from landscapes with recurring fires		

Part 4: Impact, Constraints, and Opportunities

Exercise 8: High Impact Actions, Barriers, and Opportunities (optional)

The final exercise for the workshop is intended to help identify which of the listed actions from part 3 are the highest priorities. We recommend using a prioritization scheme based on the feasibility and expected impact of the action. This prioritization can be accomplished as a group through discussion, or as individuals who populate an “ease and impact” chart with sticky notes (fig. 6). In the latter case, participants can be prompted to review and reflect on the flipcharts and to identify a few (e.g., three) actions that they think are important and write them on individual sticky notes. These could be actions that they would like to take in the future, or actions that they have already taken. Individual participants could in turn read aloud their actions and place their sticky notes on the chart, explaining their reasoning. For example, an action that is easy to do, but not likely to have much impact, will be placed in the upper left portion of the chart. Actions in the upper right corner of the chart are so-called low-hanging fruit because they are readily accomplished and have high impact. Actions in the lower right corner may have an impact but are less feasible, perhaps requiring longer-term strategy and engagement with multiple actors and organizations.

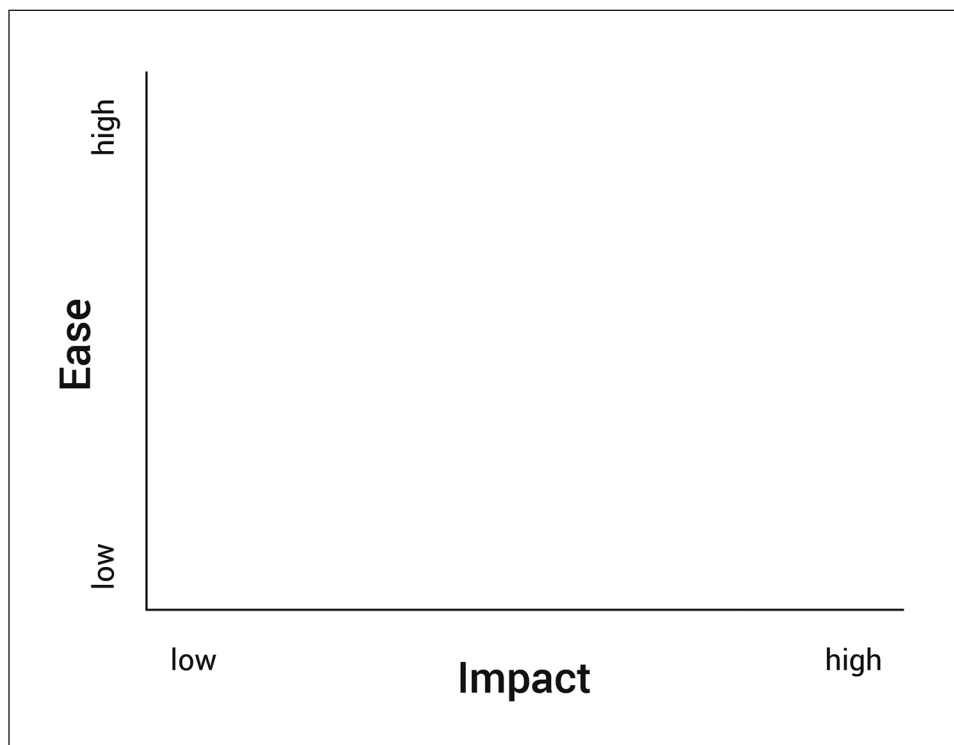


Figure 6—Scheme for use during exercise 8 to prioritize actions identified in exercises 6 and 7.

DISCUSSION

Applying Reflective Exercises

The reflective exercises in this resilience workshop are designed in a sequential fashion to build incrementally toward actionable objectives. Participants are asked to shift between a view of a social-ecological system in its entirety (exercise 1), to a view of specific elements within the system (exercises 2–4), and then ultimately to seeing and identifying a set of interrelations among system elements (exercises 5–7). Firmly establishing the concept of a social-ecological system at the outset helps avoid too narrow a focus on either the ecological or social arena. At the same time, forcing a degree of specificity, as in Exercise 2: Answer the Question Resilience of What?, helps ensure grounded thinking and eventual generation of actionable ideas.

The interactive group setting for these exercises capitalizes on participants' diversity of thought, experience, and knowledge. The first of our exercises, which familiarizes the participants with the concept of a linked social-ecological system, provides an opportunity to discover this diversity (see Ingalls and Stedman 2016). How an individual participant initially conceives of and describes a system, and perceives its stability, will vary. For example, several participants said that they had a mandate to support resilience in systems but lacked a process to identify what their agency or organization values as the most important parts of that system. Working through this exercise provides individuals within an organization an opportunity to articulate and understand what other members of their agency or organization value. Furthermore, because social acceptability of a state change (or conversely, of the status quo) is inherently subjective and varies among individual participants, so too will the view of where the system and its elements reside within the two-dimensional resilience space. For example, maintaining dry forests that are experiencing postfire regeneration failures may be the highest priority for some individuals in specific settings, whereas allowing forest to convert to nonforest may be acceptable to others. In some cases, an entire system may fall squarely within one of the four quadrants of figure 1. In other cases, a system and its individual elements may extend into multiple quadrants.

The elements of a system that an individual desires to be resilient are, by definition, subjective and reflect personal values and beliefs. For instance, a group of people living and working in a timber-dependent community is likely to identify a different set of elements than those who live and work in a community more reliant on nature-based tourism. By making explicit and embracing the diversity of values, these exercises help facilitate communication and power-sharing among participants. Therefore, it is of paramount importance that all voices in the room are heard and captured. If these steps are to inform specific management or policy decisions, a fully collaborative and inclusive process should be followed.

We expect divergent management approaches to emerge from any group of participants, and different opportunities and challenges to be revealed depending on who is in the room. The information generated by these exercises will vary according to the diversity of knowledge and experiences held by the participants. For example, a group of land management professionals is likely to identify a very different set of actionable objectives compared to a group of healthcare professionals or a group of business leaders. Even within the broad profession of natural resource management we would expect different ideas to emerge depending on discipline. For instance, recreation managers are likely to generate different ideas for action than fire managers. As such, outcomes from this workshop will be more valuable when participants are as diverse and representative as possible.

Group composition will also influence the dynamics of group discussions in a workshop setting. The discussions that ensue develop in an idiosyncratic manner, making it impossible to fully anticipate how discussions will unfold. When applying these exercises, workshop facilitators and organizers will almost certainly need to adjust and adapt the exercises to the circumstances. While the core objectives of this process involve guiding participants to (1) identify what components of a system they want to be resilient to wildfire,

(2) outline ideas for how they could promote resilience to wildfire for these components, and (3) evaluate how feasible it would be to support resilience for these components based on current and future conditions, we recommend maintaining flexibility throughout the process.

We designed these exercises for an audience of land managers with responsibility for a variety of resources on different landscapes. The exercises could be suitable in other contexts such as community planning meetings that focus on climate change and wildfire, nonprofit groups that work on rural land issues and fire, and collaborative planning groups that are focused on a specific landscape. Furthermore, these exercises could be adapted to help discover common ground among community groups and residents toward developing a new understanding of what is important to whom, and how to foster resilience of those values to the inevitability of future wildfire.

Case Study: Workshop on Managing for Resilience to Wildfire

Methods

We convened a 2.5-day workshop in April 2019 in Missoula, Montana. Sixteen land management professionals were able to attend and included ecologists, social scientists, silviculturists, planners, agency administrative officers, and community fire outreach organizers. Though most were employees of the USDA Forest Service, representatives attended from other Federal and State agencies, including the Bureau of Land Management and National Park Service (U.S. Department of the Interior) and Washington State Department of Natural Resources, as well as nonprofit organizations and universities. Our initial invitation letter included a general introduction of the project and overview of workshop objectives. After invitations were accepted, and approximately 4 weeks before the workshop, we disseminated an online survey instrument to all attendees to determine the range of knowledge of resilience concepts within the group (Appendix A). We used this information to tailor the workshop agenda (Appendix B).

On the morning of the first day of the workshop, we devoted the first 30 minutes to the overall purpose of the workshop and set the context for the state of fire-prone landscapes, management and policy directives (e.g., National Cohesive Wildland Fire Management Strategy; USDOJ and USDA 2014). We then used approximately 30 minutes for self-introductions and conducted a few icebreaker exercises. We next presented a summary of the information that we collected through the preworkshop online survey of attendees. This step allowed participants to identify common ground, start thinking about resilience, and be aware of the perspectives that were represented and which voices might have been missing.

We spent the remainder of the workshop setting up and conducting the series of reflective exercises. In three instances we deviated from the planned agenda. The first instance occurred in part 1 before exercise 3, when we took 20 minutes to present preliminary results from a community survey conducted during 2018 with the objective of gaining insights about whether and how community members think and talk about resilience to wildfire. Exposing attendees to these community members' perspectives served to prompt workshop participants to think broadly about what needs to be resilient to wildfire and help them consider a comprehensive list of "resilience of what" items (exhibit 1). A second instance where we deviated from the planned agenda was at the end of part 2. After finishing Exercise 5: Answer the Question "What Promotes Resilience?", and before starting part 3, we invited attendees to share personal and professional stories from recent wildfire events. For example, two of our attendees came from the Methow Valley in Washington, and both had experienced and recovered from wildfire disasters in 2014 and 2015. Hearing their real-life stories helped the group make the transition from the abstract and somewhat generic concepts emphasized in the exercises to this point, toward thinking about more concrete and specific actions. The final deviation from the workshop agenda occurred on the last day. Rather than conducting exercise 8 to prioritize the list of actions that had been generated, participants preferred to spend their final efforts on crafting messages for specific audiences about resilience to wildfire.

Findings

The primary goal of the workshop was to help land managers, leaders of nonprofit organizations, and community members more readily understand, define, and apply concepts of resilience to set management goals. Based on the response of participants evaluating the workshop, the process was effective in doing so. Attendees reported that this series of reflective exercises helped clarify the elements of a system that people want to be resilient, and how, when, and where resilience could most effectively be supported for these elements. The process also seemed to diffuse some of the anxiety related to prioritizing elements of a system that are more feasibly supported. Based on feedback from workshop participants, this framework was effective in helping participants map out specific ways in which they could feasibly support social and ecological resilience to wildfire. Furthermore, the workshop validated that much of what they were already doing helped support resilience to wildfires.

Most of the participants were from western Montana and eastern Washington, both areas that rely heavily on the outdoor recreation and tourism economy. Not surprisingly, many of the elements identified in part 1 were related to outdoor recreation (exhibit 1), a theme that carried through the rest of the workshop. The outdoor recreation theme was reflective of the landscapes and the social-ecological systems with which the participants were most familiar. If the participants lived and worked in places that did not have exceptional outdoor recreation opportunities, the list of elements and associated categories might have been different.

We believe that maintaining flexibility throughout our workshop resulted in outcomes that were understood, supported, and generally well received by workshop participants. For example, we set a time limit for participants to complete each exercise, but often expanded or shortened time limits based on how each exercise evolved, paying particular attention to attendees' level of engagement, interest, and energy. When there was broad interest and fruitful discussion, we stuck with a particular exercise longer than planned, adjusting the time dedicated to future exercises along the way. Another example is that when participants wanted to group system elements into categories, we adjusted our plan to accommodate this approach—and subsequently saw value in formalizing this step.

The workshop was a valuable opportunity for the sharing of ideas and lessons learned among practitioners, and the resulting adoption of new practices. For instance, one participant described a monthly “breakfast club” that has helped him build and maintain relationships with a variety of community leaders (exhibits 2, 3). Other attendees picked up this idea of a regular informal meeting and identified it as a new action that could be taken (exhibit 4). Another exchange of ideas was related to agency capacity; a synergy developed during discussions about workforce adaptability, with participants finally identifying creative ways to better utilize staff during and after wildfire events such as establishing a surge workforce for recreation (exhibit 4).

CONCLUSIONS

Promoting resilience to wildfire involves an appreciation for systems thinking and a recognition of the inherently linked components of social-ecological systems. The complexity of social-ecological systems, including the diversity of values therein, demands thoughtfulness and cooperation among actors. The primary goal of the approach outlined here is to help land managers, policymakers, and community members more readily understand, define, and apply concepts of resilience to guide management goals and actions. Participants in our workshop found that this approach helped them better plan for how to achieve these goals—and ultimately, apply concepts of resilience to management actions. The series of exercises that we developed are flexible and can be adapted to a variety of landscapes, audiences, and formats.

Management Implications

Before land managers can outline and implement specific actions to achieve resilience goals, they need to identify and understand what community resources and characteristics community members want to be resilient to wildfire. We detailed a structured approach for bringing together land and resource managers, community institutions, and other stakeholders to help achieve these objectives. An unintended success from this workshop was validation of an approach that facilitated communication and power-sharing among a diverse group of participants. Through a series of sequential group exercises, a group of people can collectively determine what elements they care about within a social-ecological system and ultimately identify concrete management actions most likely to create or promote resilience of those specific elements to wildfire. Land management agencies, Tribal entities, nonprofit organizations, or collaborative stakeholder groups can use this approach to design similar workshops to generate actionable ways to enhance social-ecological resilience to wildfire for a multitude of contexts.

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APPENDIX A

Questionnaire used to collect information from participants prior to the April 2019 workshop.

Click to write the question text

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree	N/A
Resilience is a useful concept for understanding ecological phenomena	☐	☐	☐	☐	☐	☐
Resilience is a useful concept for understanding social-ecological phenomena	☐	☐	☐	☐	☐	☐
Resilience is a useful concept for understanding social phenomena	☐	☐	☐	☐	☐	☐

What attributes of an ecological system confer or diminish resilience to wildfire?

What entities (organizations, agencies, individuals) are responsible for promoting ecological resilience to wildfire?

What attributes of a human community confer or diminish resilience to wildfire?

What entities (organizations, agencies, individuals) are responsible for promoting (human) community resilience to wildfire?

What are the most important ways in which ecological systems affect the resilience of human communities to wildfire?

What are the most important ways in which people affect the resilience of ecological systems to wildfire?

How relevant are each of the following temporal scales when applying the concept of resilience to ecological phenomena in fire-prone landscapes?

	Very relevant	Somewhat relevant	Irrelevant
1 year	☐	☐	☐
5 years	☐	☐	☐
10 years	☐	☐	☐
25 years	☐	☐	☐
100 years	☐	☐	☐
1,000 years	☐	☐	☐
10,000 years	☐	☐	☐
1,000,000 years	☐	☐	☐
Other	☐	☐	☐

How relevant are each of the following temporal scales when applying the concept of resilience to social phenomena in fire-prone landscapes?

	Very relevant	Somewhat relevant	Irrelevant
1 year	☐	☐	☐
5 years	☐	☐	☐
10 years	☐	☐	☐
25 years	☐	☐	☐
100 years	☐	☐	☐
1,000 years	☐	☐	☐
10,000 years	☐	☐	☐
1,000,000 years	☐	☐	☐
Other	☐	☐	☐

How relevant are each of the following temporal scales when applying the concept of resilience to ecological phenomena in fire-prone landscapes?

	Very relevant	Somewhat relevant	Irrelevant
Plant (10 m)	☐	☐	☐
Plot (10^0 - 10^2 m ²)	☐	☐	☐
Site (10^2 - 10^4 m ²)	☐	☐	☐
Landscape/Watershed (10^4 - 10^6 m ²)	☐	☐	☐
Region (10^6 - 10^8 m ²)	☐	☐	☐
Sub-continent (10^8 - 10^{10} m ²)	☐	☐	☐
Continent (10^8 - 10^{10} m ²)	☐	☐	☐
Planet (1.5 - 10^{12} m ²)	☐	☐	☐
Other	☐	☐	☐

How relevant are each of the following spatial scales when applying the concept of resilience to social phenomena in fire-prone landscapes?

	Very relevant	Somewhat relevant	Irrelevant
Person	☐	☐	☐
Household/Property	☐	☐	☐
Neighborhood	☐	☐	☐
Town/City	☐	☐	☐
State/Province	☐	☐	☐
Nation	☐	☐	☐
International region	☐	☐	☐
Globe	☐	☐	☐
Other	☐	☐	☐

How would you describe your primary occupation?

- ☐ Ecologist (please specify further)
- ☐ Social Scientist (please specify further)
- ☐ Manager (please specify further)
- ☐ Not-for-profit employee (please specify further)
- ☐ Other

What is your name? (optional)

Additional comments for the team.

For Managers Only

To what extent are you guided/mandated to support ecological resilience in your position?

To what degree can you fulfill this requirement? Can you provide specific examples?

What constraints prevent you from fulfilling this requirement?

To what extent are you guided/mandated to support social resilience in your position?

To what degree can you fulfill this requirement? Can you provide specific examples?

What constraints prevent you from fulfilling this requirement?

Please list the different ways you interact with communities in your area on fire-related issues.

APPENDIX B

Detailed agenda used for the April, 2019 workshop held in Missoula, Montana.

JFSP Workshop: Social-Ecological Resilience in Fire-Prone Landscapes April 16-18, 2019, Holiday Inn Downtown, Missoula*

*200 South Pattee, Missoula, MT, 59802; (406) 721-8550

Overarching Workshop Goals:

The overarching goal of the workshop is to *identify actions, approaches, and/or behaviors that can enhance social-ecological resilience, and key constraints and limitations to enhancing social-ecological resilience*. We specifically aim to identify ways in which managers can (or cannot) affect the elements in social-ecological systems that confer resilience to wildfires. A key outcome of the workshop is material for a publication, as a USFS-General Technical Report, and/or a refereed journal article. Finally, we are also seeking feedback from workshop participants on the results and findings from our project thus far, which could potentially shape the rest of the project.

General Agenda or Workflow to Reach Workshop Goals:

- 1. Introduce and practice resilience thinking: “Resilience of what?”**
 - Consider that resilience is a combination of system “function” and human desirability
 - Consider whether resilience is in fact what we want! (BioScience paper)
 - Consider the answer to the question “Resilience of what?” before jumping into what to do
- 2. Introduce and practice systems thinking: “What confers resilience?”**
 - Consider how the biophysical things we care about are *interrelated* with the social things we care about
 - Look for key leverage points that affect both the biophysical and social elements
 - Identify where the things we are already doing are really important, and/or identify new areas of focus
 - Identify unique needs of specific items on our group-generated “Resilience of what?” list
- 3. Identify action items to accomplish goals of social-ecological resilience to wildfires**
 - Things you are already doing
 - Things you want to do
 - Resources needed to keep doing what you doing, and do it better
 - Identify what it would take to do the things you want to do

Monday April 15th:

- Some participants arrive and check into the hotel. For out-of-town guests, early arrival is encouraged.
- 1:30 – 3:30 Print final materials; set up at Holiday Inn (posters, test technology)
- 5:30 – 7:00 Informal mixer with team members.

Day 1: Tuesday April 16th:

8:30-9:30: Breakfast on-site, sign in, transition to workshop location

9:30-10:00: [1] Welcome: project summary, workshop overview and goals

Introduce overall project, summarize our work and relevant insights to date, and clearly define workshop goals and plan.

- Introduce team
- Define goals of larger project AND specific goals of this workshop
- Why you're here...
- Meeting facilitator – site orientation
- Have administrative assistant come: \$ logistics
- Questions
 - Specify the systems that we're focusing on in this workshop (e.g., forests, WUI, wildlands, other).

10:00-10:30: [2] Introductions

Personal introductions; ice breaker; favorite shutdown stories

Name, affiliation, position(s) relevant to wildfire; why did you accept our invitation (why are you here)?

10:30-11:00: [3] Pre-workshop survey results

Present results of pre-workshop survey, highlighting areas of common ground and areas of disagreement.

Process: Use combination of posters and ppt.

11:00-11:10: "5-min." BREAK – coffee, snacks

11:10-11:30: [4] Resilience Thinking: present value-full / value-free framework (BioScience paper), and transition into "Resilience of what?" exercise.

Define resilience. Managing for resilience involves a combination of understanding system “function” and human desirability.

11:30-12:00: [5] “Resilience of What?” – Part I

Participants place their landscapes into the value-full/value-free space defined by Fig. 1.

Goals: start to get participants to identify what they want to be resilient; a secondary goal is to “test” the value of the framework with participants.

Guide participants through the exercise of placing landscape they work in (or are familiar with) with into Fig. 1 space.

Process:

- Think of the landscape you work in, or are most familiar with. Write a short description of this on the sticky notes (3x5 or larger) at their table.
- Team member demonstrate: by taking their landscape and placing it on the blank white board or flip charts, locating first on one axis, then the other. **Why are you placing it where you are?**
- Each participant locates on the board/chart and shares the name, rationale for location on chart/board.

12:00-13:00: LUNCH + post-lunch ramble

13:00-14:00: [6] “Resilience of What?” – Part II:

Goal: participants identify critical elements of systems that need to be resilient.

Participants identify elements of their systems that they care about and/or what they have to care about in their professional position. [*If “what confers resilience” items come up, address and put aside for tomorrow.]

Process:

- Completes presentation of BioScience paper: Fig. 2
- Break into groups of 5-6 (3 groups), discuss what you care about and/or what you have to care about in your professional position.
- After a few minutes, have participants write 3-5 ‘things’ one/sticky and put up on one big wall
- Provide some examples of what might go on this list to start (e.g., tree regeneration, “suitable for timber” status, habitat, aesthetics, jobs, historical forest structure and processes). [*Link to pre-workshop survey results as relevant]
- Encourage participants to think broadly: don’t filter responses at this point; feel free to move sticky’s to lump things that are similar or the same;
- Summarize, re-organize to create initial list

14:00-14:45: [7] Key Informant and Community Survey

Goal: Expand discussion by sharing survey initial results. Link to the first list of “resilience of what” items, either reinforcing items on that list OR adding new items to that list (e.g., social factors).

Process:

- Presentation of goals and take-home messages from the Key Informant interviews, the relevant questions on the Community Survey, and key results thus far.
- Note if/how this information is similar/different from the KI and survey participants.
- Discussion (what would your community have come up with?)

14:45-15:00: Break: coffee, stretch legs, get fresh air

15:00-15:45: [8] Refine and revise “Resilience of What”

Goal: An expanded list of “Resilience of What” items.

Engage in a discussion to help participants (re)identify/refine/revise what they care about (i.e., their answer in the “Resilience of what” exercise). Refresh participants on the broad social-biophysical context for this list; check if key items are missing. [*If “what confers resilience” items come up, address and put aside for tomorrow.]

Process:

- Step back. Review first list in light of prior discussion. We will move forward the elements on our list, so,
 - Is anything missing?
 - Need to re-characterize any?
 - Step back, for a moment, from your favorite landscape and consider all of the landscapes within the project area ... does this list cover critical elements?
 - Role-play: you are your FMO, what would they/your partners say?
- *TEAM: Think about what items the team wants to be included in here, from social or ecological perspective; add these items if needed.

15:45-16:30: [9] Prioritize “Resilience of What” items

Goal: identify what participants think is *most important* to be resilient to wildfires, and aim to identify a list of ≤ 10 items to focus on for the remainder of the workshop; *create a list of prioritization criteria* (do not provide criteria beforehand).

Process:

- In groups (~4-5/group), work to identify 5-8 top items/elements that should be resilient to fire (15 mins)
 - Records the items- feel free to use poster paper at table - *and* the criteria used to generate the list; be able to report back to larger group.
 - Project team participates in group
- Groups share their list and thinking
 - Record / document how participants prioritized
 - Project team participates in group
- Create master list

16:30-17:00: [10] Report out to larger group; wrap up day.

Goal: Develop master list of “resilience of what” items, and a list of the criteria used for prioritization

Process:

- Ideal to end day with this exercise, but it’s possible we will not complete it; if so, we can pick up with this to start Day 2.
- Share criteria used for prioritization, by each group, to help the entire group come to a single, prioritized list. *Is the BioScience figure framework useful in this context?
- Wrap up / review what we’ve accomplished today.

18:30-20:00: Dinner

Day 2: Wednesday April 17th:

8:00-9:00: Breakfast on-site, transition to workshop location

9:00-9:30: [1] Check in, review what we’ve done so far

- Review: Introduced and practiced resilience thinking
 - a. Introduced and practiced systems thinking
 - b. Identify/identified a few highest priority items to focus on in upcoming conversations and exercises.
- Check-in: questions, thoughts reg. what we’ve done? Is the framework useful?
- Placement of priority items on x-axis of Fig. 1, and lower ½ of the y-axis.

9:30-9:45: [2] Introduce “What confers resilience” exercise

9:45-11:00: [3] “What confers resilience” exercise

Goal: Identify what confers resilience to the items on “Resilience of What” list

Working in groups focused on a single priority element, identify what process or what determines whether that element is resilient (or not). May take 2 rounds of 3-4 groups to cover the 8-10 highest priority topics.

Process:

3 tables - Identify 3 items at a time, and link items with a table. Spend 20 min. per set of items; document; shuffle and repeat 3 times. *Identify a leader for each item; document list/narrative of “what confers resilience,” to present in report-out.

- Identify item to be discussed at each table. Allow participants to self-select which item they want to work on (20 mins/element)
 - After 10 mins, stop and get quick report out; Team refocuses and provides additional guidance, if needed
 - Consider both social and ecological components; capture your discussion for report out.
 - Think about if/what things are missing from this list, given the experiences of the participants.
 - Expect that there will be varying degrees specificity among items and groups.
- Break, as needed, or synchronized from 10:30-10:45.
 - If synchronized and groups are done, we can give them next set of elements and people can choose which one they want to work on. Team ensures minimum of 3/group.
- Second suite of elements @ 10:45

11:00-12:00: [4] Report out and summarize

Goal: Collect and begin to build collective awareness of all processes that confer resilience. End with 1 flip chart per item, which contains the details of “what confers resilience.”

Process:

- Group leaders present some formalized/organized information back to full;
 - Check with full group to ensure comprehension and clarity
- workshop leaders digitize this information (Google Doc, text, and/or figures)
- Identify which items show up on multiple flip charts: one-to-many items.

12:00-13:30: LUNCH, slide presentation, post-lunch physical ramble

13:30-14:00: [5] Share stories about “resilience to wildfires”

Goal: Hear how this worked in the Methow.

Process:

- Discussion to transition into next exercise – identify any new or repeating themes?

14:00-15:00: [6] “What DO you do” exercise

Goal: Begin to strategize actionable activities by making a list of actions participants can do to affect resilience

******Researchers do parallel activity: identify commonalities among “what confers resilience” items from previous exercise.

Process: Thinking about your own story, take a moment to think of, then list, actions that you in your professional role that directly tie to and affect resilience

- ~ 14:45 Compare this list “resilience of what” items: identify where there is alignment and misalignment. *Utilize results for “obstacles and opportunities” activity. Identify if there are items from our “resilience of what” list that are left unaddressed by these actions.*

15:00-15:15: Break: coffee, stretch legs, get fresh air**15:15-16:30: [7] “What COULD you do/what(else) needs to be done”**

Goal: organize what actions can be done to confer resilience, with respect to feasibility (currently and in the future). Review ... discussion gone from landscapes to elements to processes that confer resilience; prioritized list of key elements each of you deals with in your professional capacity ... now, continuing to think about actionable items

SET UP: Put list of what convey resilience next to list of what’s already being done next to list of what NEEDs to be done.

Process: Stop for a moment, and individually take a few minutes to capture your thoughts: what **could** you do (inside and outside of your PROFESSIONAL capacity) to affect things that confer resilience?

- “Could” → can do it now (within your job description); yes, but need something (incentive, permission); yes, but would require system reorganization.
- Add to list started in “What do you do...” exercise, but keep track of “could do” items separately.

16:30-17:00: [8] Summarize, discuss as needed, and wrap up day.

17:00: Team Huddle [group photo]

18:30-20:00: Dinner

Day 3: Thursday April 18th:

8:00-9:00: Breakfast on-site, transition to workshop location

9:00-9:30: [1] Check in, review what we've done so far [group photo]

What we've done:

- Introduced and practice resilience and systems thinking.
- Identified items that we want to be resilient to wildfire
- Prioritized these items and selected those to focus on for today
- Identified what processes make the items we care about “resilient” to wildfire
- Identified what we are already doing to support these processes
- Considered what we could do to further support these processes

Today plan:

- Identify the barriers that prevent you from going things that confer resilience
- Prioritize actions that confer resilience, by organizing along dimensions of “ease” and “impact.”
- Wrap up: group photo, quick survey

9:30-11:00: [2] “Constraints and opportunities” exercise:

What are the barriers that prevent you from doing the things that confer resilience?

Goal: help prioritize actions that confer resilience, by organizing along axes of “ease” and “impact”; along the way identify constraints.

SET UP: Ease and Impact grid, sticky notes

Process:

- Explain grid and exercise.
- Thinking over the past two days, and reviewing these flipcharts identifying what is and could be doing, identify what 1 (up to 3) activities you would change if you could
- Each person will come up and explain their action, then place it on the grid, explaining their reasoning.

11:00-11:30: [3] Summary and wrap up.

Your pledge: what are you going to change?

Workshop survey what are the next logical steps for implementing what you learned?

Next steps: publication, co-authorship.

11:30-12:00: Lunch

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