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Managing for Resilience? Examining Management Implications of Resilience in Southwestern National Forests

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Abstract

The United States Forest Service 2012 Planning Rule prioritizes making lands resilient to climate change. Although researchers have investigated the history of "resilience" and its multiple interpretations, few have examined perceptions or experiences of resource staff tasked with implementing resilience. We interviewed Forest Service staff in the Southwestern Region to evaluate how managers and planners interpret resilience as an agency strategy, execution of resilience in management, and climate change's impact on perception of resilience. Interviewees identified resilience as a main driver of agency response to land management but, when applying the concept, experienced barriers including ambiguity; scale; management specificity versus broad, adaptive landscape approach; and lack of metrics or examples. Interviewees found restoring ecosystem function to promote resilience while planning for future changed landscapes difficult. They desired landscape-scale collaboration to understand how to operationalize the resilience directive. Our findings revealed obstacles and opportunities for resilience in a managerial context.

Keywords: resilience, US Forest Service, forest policy, forest planning, Southwest

Sustaining ecological health, integrity, and diversity to meet the needs of present and future generations is the top priority of the US Forest Service (USFS). "Resilience" is a leading pillar of recent USFS land-management planning regulations, namely the 2012 Planning Rule (36 CFR §219). This national policy directs forests to develop plans and incorporate resilience to climate change into management strategies.

Resilience is a systems' ability to persist, adapt, and transform with changing conditions and ecosystem disturbance (Folke 2016). Significant research has chronicled the conceptual evolution of resilience; the term is ambiguous in ecological literature and holds questionable utility (Carpenter et al. 2001, Walker and Salt 2006, Brand and Jax 2007, Bone et al. 2016, Folke 2016). Research in forest ecosystems has explored operational indicators and metrics to quantify ecological resilience (Millar et al. 2007, Larson et al. 2013, Seidl et al. 2016, Stephens et al. 2016, van Mantgem et al. 2018, Halofsky et al. 2018, Keane et al. 2018). For example, GTR-310 (Reynolds et al. 2013) emphasizes restoring characteristic composition, structure, and function to improve resilience of frequent-fire forests. Waltz et al. (2014) express a need for more effort on operationalizing resilience by defining metrics of forest resiliency. In a recent content analysis, Bone et al. (2016) focused on the growing presence of the term resilience in USFS planning, budgeting, and public relations documents.

Management and Policy Implications

New directives and recent policy instruct federal land managers to use the concept of resilience. Our research explored how resilience policy has shaped management actions on federal lands. We identified gaps in understanding the policies and directives that mandate personnel to manage for resilience. Our research is directly applicable to staff in the US Forest Service and cooperators working to amend and implement forest plans under the 2012 Planning Rule. It is further pertinent to land-management organizations using resilience as a stewardship objective. Findings from our research suggest that the Forest Service collaborate with internal departments, external cooperators, and stakeholders to coproduce resilience metrics and goals. Metrics of resilience need to be defined within a context. At these broad policy scales, an example would be resilience to uncharacteristically large disturbances expected with climate change. We conclude with a series of observations and recommendations for how managers and planners might ensure policy direction leads to clear actions and suggest where to concentrate future studies examining resilience.

However, little research has looked at how managers and planners define and interpret this term that they encounter and are directed to use in USFS documents (Timberlake and Schultz 2017).

A valuable area for further research is understanding how National Forest System managers and planners interpret, plan for, and implement resilience. The primary disturbance agent prompting management efforts toward resilience is fire (Reynolds et al. 2013). Therefore, the Southwestern Region of the Forest Service (Region 3), a fire-prone forest ecosystem dominated by ponderosa pine and dry mixed-conifer forests at higher elevations, provides a strong case study to examine USFS perspectives of resilience, how the term is operationalized, and challenges faced with trying to incorporate resilience into forest plans as directed by the 2012 Planning Rule.

A Brief History of Forest Policy and Planning

In 1976, Congress passed The National Forest Management Act (NFMA) requiring each National Forest to develop and uphold a land-management plan (forest plan), guided by subsequent and separate planning rules. USFS staff are mandated to follow requirements provided in the planning rule; failure to do so is subject to litigation. NFMA mandates plan revision as new scientific information and opportunities are learned, as well as accounts for shifts in national direction. The 2012 Planning Rule is the first planning rule approved and upheld in court since 1982 and the most extensive federal forest policy change in over 30 years (Schultz et al. 2013).

Since 1982, understanding of land-management planning has evolved considerably. Advancements in conservation biology and ecology, as well as shifting societal values, prompted the need for a revised rule (36 CFR §219). The 2012 Planning Rule (2012 Rule) emphasizes eight key management needs consistent with the USFS mission. The first need states: "emphasize restoration of natural resources to make our NFS lands more resilient to climate change, protect water resources, and improve forest health" (36 CFR §219, 21164). Given the rule requires National Forests to consider resilience when developing forest plans, particularly resilience to climate change, the directive has led the term to appear throughout forest plans (Bone et al. 2016). The forests of the Southwestern Region are at various stages of revising plans using the 2012 Rule[1].

Resilience: What Is It?

With the focus of resilience in the 2012 Rule, it is advantageous to understand the development of the term in ecological literature. Holling (1973) defined it as "a measure of the persistence of systems and their ability to absorb change and disturbance and still maintain the same relationships between populations or state variables" (p. 14). The concept has since undergone several developments and is conceptualized as follows:

Engineering resilience is the rate at which a system returns to equilibrium following a disturbance (Holling 1996). Often referenced as systems that bounce back, this perspective frames resilient ecosystems as linear, static systems (Gunderson 2000). If a disturbance occurred, an ecosystem would be considered less resilient if it crossed a threshold transitioning into a new state. This definition is minimally used by the USFS (Bone et al. 2016).

Ecological resilience is "the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks" (Walker et al. 2004, p. 2). This conceptualization suggests resilient systems can exist in multiple states without compromising characteristics and system properties that define the community. Managing for ecological resilience focuses on maintaining or restoring key functions (Millar et al. 2007, Bone et al. 2016).

Social–ecological resilience emphasizes the link between social (e.g., economic, political, cultural) and ecological systems (SES) (Gunderson and Holling 2002, Folke 2006, Bone et al. 2016). An SES approach recognizes how communities, cultures, and economies both shape and depend on the ecosystem (Cumming et al. 2012). To be resilient is to support capacity for reorganization and adaptation, striking a balance between sustaining and developing amidst change (Folke et al. 2010, Folke 2016). A social–ecological resilience perspective is distinguished from previous conceptualizations because elements of a system are examined across temporal and spatial scales (Bone et al. 2016). It can be useful to establish resilience *of* what [system state, variable] *to* what [disturbance] to operationalize resilience (Carpenter et al. 2001).

Why Resilience?

USFS documents emphasize the *ecological resilience* framework, with an aim to restore or improve ecosystem structure and function after disturbance (Bone et al. 2016, Falk 2016). In the Western US, fire seasons have grown longer, and fire size, severity, and frequency have increased. Scientists claim that restoring fire regimes in frequent-fire-adapted ecosystems will build resilience (Millar et al. 2007, Fulé 2008, Hurteau et al. 2014, Stephens et al. 2016). Restoration in these ecosystems includes mechanical fuels reduction, prescribed fire, and/or the management of natural ignitions (Falk et al. 2019). Reference conditions and the historic range of variation are used to evaluate resilience because they demonstrate forests' evolutionary ecology (Reynolds et al. 2013).

In the Southwest, historically open forests dominated by large, fire-adapted trees have experienced human-caused interruptions of their natural fire regimes (Covington and Moore 1994, Swetnam and Baisan 1996). Today these forests are drastically altered in structure, composition, and disturbance regimes compared with presettlement conditions leading to increasingly large, high-severity fire (Covington and Moore 1994, Fulé et al. 1997, Allen et al. 2002, Hurteau et al. 2014). High-severity fire can have significant damaging effects on hydrologic functioning, habitat quality, carbon storage, and soil erosion, to name a few, resulting in decreased recovery potential (Hurteau et al. 2014, Falk et al. 2019). Departure from fire as a keystone process has resulted in less ecologically resilient systems (Larson et al. 2013, Waltz et al. 2014, Stephens et al. 2016, Halofsky et al. 2018, Keane et al. 2018).

Wildfire is a greater stress on ecosystem stability when coupled with a changing climate (Westerling et al. 2006, Hurteau et al. 2014, Falk et al. 2019). Longer wildfire duration and greater size, severity, and frequency are exacerbated by rising seasonal temperatures and earlier spring snowmelt (Westerling et al. 2006). These trends may catalyze ecosystem reorganization (e.g., type conversion) in Southwestern forests, along with the growing risk to homes, natural resources, and other countless values (Hurteau et al. 2014, Coop et al. 2016, Falk 2016, Stevens-Rumann and Morgan 2016, Davis et al. 2019). The efficacy of using reference conditions on the basis of future ecological uncertainty has been questioned, and restoring processes alone may not be sufficient to restore resilience (Millar et al. 2007, Fulé 2008).

Challenges of Using Resilience

Despite the USFS's increasing use of the term, research reveals employing resilience is concerning because it is a vague, ambiguous concept (Brand and Jax 2007, Bone et al. 2016, Falk 2016). The variety of definitions can dilute the meaning and use of the term (Brand and Jax 2007). To meet land-management objectives, operationalization of resilience is dependent upon conceptual clarity (Bone et al. 2016).

Developing and quantifying metrics of resilience is not an easy task. Resilience as a system property cannot be reduced to a single objective indicator (Allen et al. 2011, Folke 2016). Other challenges arise with policy directing managers to manage for resilience under current and future conditions (Lin and Petersen 2013, Timberlake and Schultz 2017), as "it is clearly not possible to achieve this objective under both current and future climate, with species in their current locations" (Falk 2016, p. 155). Stephens et al. (2016) illustrate that land-management agencies oversimplify resilience accomplishments rather than actual improvement in forest resilience as a result of these difficulties.

Although there is no shortage about conceptual theory of resilience and debate on the term's role in natural-resource management (Gunderson 2000, Carpenter et al. 2001, Walker and Salt 2006, Brand and Jax 2007, Millar et al. 2007, Bone et al. 2016, Folke 2016), interpretations of this complex concept have been understudied and remain an important research need (Timberlake and Schultz 2017). To address this need, our research examines how directives for resilience in the 2012 Rule are interpreted and executed by plan implementers. This research offers insight into the USFS's efforts to use resilience by addressing the following research questions:

1) How is resilience defined and interpreted under the 2012 Rule? What similarities and differences, if any, exist among USFS planners and resource managers' perceptions of resilience?
2) In what ways are USFS staff planning for and/or implementing resilience as directed by the 2012 Rule?
3) How are projections and/or observations of climate change impacting perceptions of resilience among USFS staff?

Methods

This study focused on the USFS Southwestern Region, which includes National Forests located in Arizona and New Mexico. This site was selected because the Southwest has focused management efforts toward resilience, and authors of this paper are familiar with the region offering credibility to gain participant access and trust. To address the research questions, we conducted interviews with 26 USFS staff members. We used purposive and snowball sampling to identify USFS staff based on their knowledge of and involvement in interpreting the 2012 Rule to implement directives of resilience. Given our focus was on implementation, our sample drew from Forest and Ranger District administrative units, where plan implementation occurs. These criteria led us to USFS planners and managers[2]. There was some overlap among these populations (see ID groups below).

Interviews lasted 30–60 minutes and followed a semistructured format. In line with protocol approved by our university's Institutional Review Board, interviews were recorded and transcribed. To maintain confidentiality, staff positions and forests are not linked. An ID was assigned to each participant type: FP = Forest Planner ($n = 6$), RM = Resource Manager ($n = 9$), FPRM = Forest Planner and Resource Manager ($n = 6$), RMP = Resource Manager on plan revision team ($n = 5$).

Transcripts were coded to identify trends and emergent themes aligned with our research questions. Subheadings used in our Results section were our top-level codes (Creswell 2014). We determined themes based upon repetition, unusual terms, and evidence of conflict (Bernard 2006). Findings were organized and reorganized through inductive analysis. This iterative process of querying the data provides stronger certainty of results by generating familiarity with the data (Bernard 2006). We report our results and provide illustrative quotes from interviews to demonstrate examples of summarized data. We concluded interviews upon reaching data saturation on our primary research questions, or when no new themes were raised (Creswell 2014).

Results

Definitions and Interpretations of Resilience

Interviewees emphasized resilience as a primary management objective. As one FPRM noted, "In recent years, resilience has become a hallmark of all our planning efforts." Participants involved with planning highlighted that the term is incorporated into plan revisions as directed in the 2012 Rule. Interviewees commonly described resilience as an overused buzzword and expressed apprehension using the term because it holds ambiguous connotations. For example, an RMP said, "Is resilience just another word we are throwing around to put a new outfit on the same stuff we've been doing? I really am struggling with that."

The majority of interviewees defined resilience as the ability for a system to recover structure and function. As an FPRM attested, "If you were to ask this question a few years ago, I would say resilience is the ability of a system to come back to a preexisting set of dynamics. Now, it's not necessarily that you get back to those familiar things, successional sequences and so forth, but [...] back to a level of function that allows that system to re-align." Some also said resilience involves restoring the ecosystem to its historic range of variability following a disturbance. Most definitions aligned with the ecological resilience (Walker et al. 2004) conceptualization as illustrated in the following quotes:

- "The ability to regain or recover from disturbance structurally, compositionally and functionally" (FP).
- "Ecosystems that come back to structural condition [...] Maintaining all of the pieces to have a fully functioning ecosystem" (RMP).
- "I operate off of a concept of functional restoration, which will increase our resiliency and our resistance" (RM).
- "The ability of an ecosystem to take a disturbance without collapsing and not permanently lose its structure and function" (FP).

A few described engineering resilience or social–ecological resilience. For example, one FP said resilience means, "making management decisions and designing projects not just for what the existing conditions are but what we expect future conditions to be as well," capturing the timescale component of social–ecological resilience. No responses focused on the resilience of human communities embedded in forest ecosystems.

Although there was collective agreement over the definition, when we asked participants about operationalizing resilience, there was a diversity of opinions. Resilience *of* what (Carpenter et al. 2001) held various meanings across participants. One RM explained that resource managers are "biased towards their resource sustainability." We also found managers framed resilience around their specialty:

- "My perspective on resilience has to do with the capability of the soil, because that's my key resource [...] resilience in this context is ensuring that soil returns to a state from which you can still derive some ecosystem services" (RM).
- "In terms of resiliency for wildlife, one of the things that we are looking for is this whole concept of habitat connectivity" (RM).
- "For fire, [resilience] is an ecosystem or forest type that falls underneath its historic regime" (FPRM).

Planners also recognized that resilience *of* what varies across projects, resulting in difficulties when using resilience to meet goals for whole ecosystems across projects. As an FPRM claimed, "Resilience is very challenging because each program area has their own goals, but we are all working towards the ultimate end goal. We have to find common middle ground to satisfy program area needs, but also the greater forest needs."

Perspectives on the 2012 Planning Rule and Resilience Implementation

Planners referenced the 2012 Rule as the directive prompting them to include resilience in forest plans. They expressed drive to disseminate resilience in forest plans but have experienced challenges in doing so. One FP said, "Managing for resiliency on the landscape is one of the big objectives of the 2012 Rule. I'll be honest with you, we are still wrestling with what managing for resiliency on the landscape looks like … how do we codify that in actual plan direction?" Planners also mentioned The National Cohesive Wildland Fire Management Strategy (USDA Forest Service et al. 2014) and GTR-310 (Reynolds et al. 2013) as documents that prompted resilience discourse in Region 3.

Overall, planners welcomed the 2012 Rule's flexible nature because it allows greater license in determining what is done on the ground. They felt this new autonomous approach diverged from the nature of the 1982 Rule, under which directives did not support as much room for adjustment. Planners highly valued flexibility, yet they claimed the adaptable style of the 2012 Rule has led to a lack of specificity posing innate challenges for including resilience prescriptions in forest plans. For example, one FP grappled with the tension of being obligated to incorporate key concepts in the plan without strict guidelines:

> [Planning rules] are purposefully written to give a lot of latitude and decision-making ground to each individual forest. On one hand, we have the flexibility to do what makes sense for our forests. On the other hand, it means when you're out there, there aren't a lot of examples of how other people are doing this. That can be really hard to wrangle big ideas, like resiliency, into actual plan guidance.

Participants commonly expressed a key difficulty of incorporating resilience into policy is meeting landscape objectives with site-specific focus. Creating clear resilience directives in the forest plan was strained by desires to be prescriptive, yet efficient when implemented on the ground. An RMP summarized the difficulty of striking this balance: "The challenge is to identify some sort of process that is both informative and somewhat easy to collect, so it's not so intensive that you're measuring and sampling hundreds of different characteristics out in the field." Similarly, another RM described two difficulties with resilience directives:

> "Number one, addressing the diversity that exists at a broad spatial scale. And then number two, managing in a sufficiently site-specific way that you can respond to that diversity that exists across the landscape. Doing that in a single decision document, or single analysis, is pretty new and pretty daunting."

Managers struggled with translating resilience policy into action. Most were uncertain of what resilience is in practice. As one RMP claimed, "I know the textbook dictionary definition … but what does [resilience] actually mean in terms of land management?" Another RM agreed, "We talk the talk, but I don't know that we are walking the walk. I don't know that we're not either, because how do you measure resilience?"

Fire and fuels specialists had less difficulty providing examples of managing for resilience. Interviewees commonly expressed, "[Resilience is] pretty clear-cut … [in] the frequent-fire forest types, we know that if we can manage towards more characteristic forest structure, density, composition, and reinitiate some natural functions, then we feel like they are going to be very resilient" (RM). Fire/fuels specialists also frequently cited fuel reduction or the Four Forests Restoration

Initiative (Four Forest Restoration Initiative, n.d.), a Collaborative Forest Landscape Restoration Program (Collaborative Forest Landscape Restoration Program, n.d.) project, as illustrations of operationalizing resilience. Nonfire specialists commonly listed examples of projects restoring fire to the landscape indicating that resilience implementation appears more straightforward for a project reintroducing fire. One RM suggested, if "you reintroduce fire into an ecosystem in which fire suppression has occurred for a long period of time, it may be a little bit easier to implement resilience that way. In other areas it's going to be a lot more challenging."

Interviewees also revealed that navigating competing resource desires and limited capacity were factors complicating resilience implementation. For example, an RMP expressed how focus on fire has been damaging to other resource areas trying to implement resilience: "The region has had some pretty huge fires with both positive and negative effects. A lot of the negatives affect the other resources and it has really done damage to our relationship. It's always been almost combative. That gets in the way of trying to integrate resilience into our management." Other RMs questioned how resilience directives would be prioritized to different resource areas and the risks of doing so, such as fire overshadowing other resource needs. Some interviewees said limited staff capacity and funding were additional barriers to implementing resilience.

Management for Resilience in a Changing Climate

Most interviewees identified resilience as a primary component of managing for climate change, demonstrating salience of the directive to manage for resilience to climate change under the 2012 Rule. One RMP said, "I don't think you can talk about resilience without talking about climate change." However, many stated that managing for resilience to climate change was a challenging paradox, given the focus on historical reference conditions as a restoration baseline. For example, an RMP illustrated, "Planning for climate change is a conundrum […] we are tasked with trying to restore reference conditions knowing that future conditions are going to be greatly different." Interviewees commonly agreed with this sentiment, expressing confusion of managing for resilience to climate change. An FPRM explained, "Climate change is definitely going to impact resilience. But it's hard for me to wrap my head around because, when you think of resilience you think of the ability for an ecosystem to recover from a natural disturbance, but if that ecosystem changes with climate change … then I don't know." In other words, is restoring historic processes for resilience also meeting climate-change-resilience goals? Is a forest's adaptive capacity to climate change considered resilience?

Desired Strategies: Metrics, Examples, Partnerships

Several participants felt examples or metrics could help clarify resilience. As one FP said, "I would be really interested in knowing how other forests are interpreting resilience and if they are struggling with the same things that I'm struggling with." Another FPRM attested, "The use of the term is very important. The way to get there is to have folks develop examples of the context of resilience and how that varies across land management scenarios. That would be educational and enlightening for a lot of folks." Many participants also desired metrics to measure resilience.

The benefit of collaboration emerged as a best practice for forest management and to better use resilience. For example, one RMP revealed, "Having stakeholder groups involved from the beginning [of plan revision] and participating in the discussions of how best to tackle resilience challenges is really important." Participants said partnerships provide access to shared databases and help develop tools and new technology. Those involved with planning commonly said collaborating with internal and external partners is also closely tied to developing resilience policy. As an RMP claimed, "Some of the new plan that we've started to draft specifically addresses trying to increase resiliency at the landscape level. The biggest part of [landscape resilience] is working in collaboration across jurisdictions with some of the other agencies, as well as collaborating with the adjacent forests."

Discussion

Summary of Key Findings and Implications for Managers

A primary contribution of this project is examining USFS planner and manager interpretations and strategies for resilience. Findings revealed three consistent areas of implementation and reporting difficulties: Resilience Definitions and Scale, Flexibility versus Specificity, and Resilience to Climate Change.

Resilience Definitions and Scale

Although resilience is a mandated objective, the concept remains challenging to effectively interpret and apply. Resilience is at risk of becoming an empty buzzword because it is vague and overused, with unclear utility. Most participants defined ecological resilience, focusing on improving or recovering forest function after disturbance.

The distinction of framing resilience to site-specific elements is logical; staff are most familiar with their specialty. However, Folke (2016) cautions against emphasizing resilience in one part of the ecosystem or reducing resilience to a single metric, as specified resilience is not easily tiered to inform landscape-level trajectories. Such tailored approaches may narrow options when dealing with novel changes and block a deeper understanding of resilience where other areas have been overshadowed (Bone et al. 2016, Folke 2016). For example, overemphasis on resilience to wildfire may leave a forest at risk to other forms of disturbance such as invasive species (Bone et al. 2016). Our research supports this finding by illustrating that staff had an easier time explaining how to operationalize resilience in a wildfire context than in other areas.

Planners understood resilience at the landscape level, recognizing that the concept varies across project type. Generalized resilience is equally cautionary, as it could further contribute to the concept's ambiguity, compromising its effectiveness (Folke 2016). Inherently, planners are pulled in two directions by ensuring that the resilience directive in the plan is broad to encompass a variety of land-management contexts across scales while determining how detailed to get in each management scenario.

Our findings support past scholars suggesting resilience operates and must be considered at different levels of space and time (Gunderson and Holling 2002, Millar et al. 2007, Falk et al. 2019). Scientists suggest that scaling dimensionalities are critical for understanding how ecosystems respond to disturbance, which governs resilience (Falk et al. 2019). For example, resilience may depend on whether the disturbance occurred in many small patches or over an entire watershed. Did the event influence individuals within a population or entire communities? Temporally, it is important to consider the duration of the disturbance event and possible lingering effects, such as erosion after a fire. Scaling resilience across space, time, and levels of biological organization can identify primary mechanisms that will help ecosystems adjust to changes (Falk 2016). Strategies that address diversity of ecological systems and resources at a landscape scale while supporting site-specific management were favorable to staff and could be included in forest plan amendments.

Flexibility versus Specificity

Although resilience was consistently identified as a key pillar of the USFS, interviewees expressed that it has not reached the point of clear operation. Coupled with challenges embedded in the conceptual unclarity of the term, our results demonstrated that further barriers to implementing resilience were attributed to the high level of autonomy in the 2012 Rule. Participants welcomed latitude in the 2012 Rule, which provides individual forests considerable discretion in how provisions are implemented and modified (Schultz et al. 2013). However, managers expressed desire for concrete direction, metrics, and/or examples of how to operationalize the resilience directive. Interviewees felt that they could incorporate additional knowledge to better understand and develop resilience metrics, and thought that developing partnerships within the USFS, other agencies, researchers, and stakeholders would help use resilience.

Planners debated how to best incorporate resilience into forest plans. As a broad concept, resilience can be used as an all-encompassing tool, open to interpretation and malleability, yet it begs for specificity when operationalized (Brand and Jax 2007). Resilience policies and management approaches must be adaptive to support the dynamic, unpredictable nature of ecosystems (Folke 2016). USFS staff are tasked with achieving the balance between flexibility in a plan intended to guide forest management into the future while providing prescriptive standards to effectively use resilience.

Resilience to Climate Change

Repeated throughout the 2012 Rule is: "Emphasize restoration of natural resources to make our NFS lands more resilient to climate change." Interviewees considered resilience to climate change a salient issue. However, restoring lands to be resilient to climate change presents a difficult management paradox. Participants felt that restoring historic conditions to achieve resilience conflicts with planning for resilience to climate change. Challenges interpreting the mandate for resilience to climate change has limited the development of clear on-the-ground approaches.

Future Research

The goal of our study was to gather preliminary understandings of how plan implementers interpret and apply the directive to manage for resilience. Interviewees included specialists overlapping in a variety of areas, but not all expertise (e.g., social sciences) were captured because of participant availability, willingness to participate, and forest-level involvement. Our findings are a function of, and limited to, our set of interview subjects. However, our research provides findings on relatively new terminology that is not addressed broadly in the literature (Timberlake and Schultz 2017). As an initial exploration in a developing research field, our work can provide a foundation for future work on this topic.

Given that our findings show there are challenges with managing for resilience, analogous research is needed to study contextual nuances of these challenges. For example, future work could examine a broader diversity of disciplines, regions, and/or the influence of demographic characteristics on resilience interpretations. A survey would be a useful way to explore these factors. Although future research considering additional factors may show more detailed findings, the overarching theme that we highlight—USFS staff experience challenges with managing for resilience—provides valuable insight for scholars examining resilience perspectives.

Social–Ecological Resilience Framework and Staff Opportunities

Using the social–ecological resilience framework is one way to assist challenges with managing for resilience. Interviewees commonly used the ecological resilience framework to define resilience, whereas none mentioned social elements of resilience, such as economic considerations. Thus, interviewees' perceptions of resilience are not in step with literature conceptualizing social–ecological resilience. The lack of focus on social–ecological resilience is concerning because managing forests under dynamic variability (e.g., climate change) requires understanding cross-scale interdependencies in both ecological and social systems (Allen and Holling 2010, Allen et al. 2011, Bone et al. 2016, Falk 2016, Folke 2016). For example, structures in the wildland–urban interface may make restoring natural fire regimes socially and economically challenging.

Social–ecological resilience differs from ecological resilience, where management approaches are focused on restoring ecosystem components (Bone et al. 2016). Instead, social–ecological resilience emphasizes adaptive capacity of recovering and reorganizing through disturbance, as well as the persistence of function, structure, and feedbacks (Walker et al. 2006, Folke 2016). Research also distinguishes the consideration of scale in social–ecological resilience (Bone et al. 2016). Ecological resilience does not focus on adaptive capacity or cross-scale dynamics; nor does it consider how social systems are embedded in management and planning (Folke 2006, Bone et al. 2016).

Interviewee focus on ecological resilience begs us to examine what effects might occur from the lack of attention on social–ecological resilience. For instance, our findings demonstrate that staff are finding problems meeting ecological resilience goals in a changing climate. A social–ecological framework can help fill this void in addition to taking into account the social elements of ecosystems, an important aspect that lacked mention by interviewees.

The first useful component of a social–ecological framework is the focus on adaptive capacity over time. In the Southwest, major disturbances make it increasingly unlikely that ecosystems can be maintained in their current or historic form forever (Hurteau et al. 2014, Falk 2016, Davis et al. 2019). The ecological resilience framework does not provide clear direction for adjusting forest management for future conditions in a changing climate because scales of space and time are not incorporated, and neither is the capacity for system reorganization or adaptability. Our results validate there is limited opportunity to use the ecological resilience framework when managing for resilience to climate change. Social–ecological resilience better suits climate-change strategies because it embraces ecosystem capacity for adaptation and the increasing probability of reorganization across scales of space, time, and levels of biological organization.

The other useful element of social–ecological resilience is the emphasis of human systems embedded in ecological systems. Social components are integral to climate change approaches (Gunderson and Holling 2002, Folke 2016). For example, patterns of land use and municipalities depend on forests' carbon sink abilities. As the 2012 Rule emphasizes resilience to climate change, it is reasonable to presume that social elements are included; yet, our findings show that social factors are not what comes to participants' minds when managing for resilience. In its conceptualization, a social–ecological framework elevates the importance of social components into management and planning (Bone et al. 2016).

Another way that a social–ecological resilience framework can assist in management is through its focus on collaborative learning to operationalize cross-scale, partnership-integrated principles (Gunderson and Holling 2002, Olsson et al. 2004, Folke 2016). One form of collaborative learning is knowledge coproduction, which is "the process of producing usable, or actionable, science through collaboration between scientists and those who use science to make policy and management decisions" (Meadow et al. 2015, p. 179). Knowledge coproduction emphasizes the joining of stakeholders in learning how to interconnect goals and leverage capacity across scales by integrating a variety of expertise, values, and insights. Coproduced projects have resulted in the development of more useful products, tailored to management needs (Djenontin and Meadow 2018).

Knowledge coproduction serves as a structure for staff to iteratively learn about and develop ways to make resilience more pragmatic, as interviewees desired. Given interviewees' desire for knowledge and examples of how resilience has been applied in other forests, coproduction can allow partners to collaboratively confront the intricacy of how to apply, monitor, and evaluate resilience. Coproduction might also provide space for personnel to share apprehensions, such as the overemphasis of resilience to wildfire, a concern expressed by some interviewees. For example, involving multiple stakeholders and diverse specialists could encourage the consideration of overlooked resilience components. Furthermore, coproduced approaches are critical for producing usable climate science, which is helpful given interviewees' challenges with managing for resilience to climate change (Dilling and Lemos 2011, Wall et al. 2017).

Dynamics of social–ecological resilience contribute to social capacity for learning about ecosystem dynamics and allow managers to actively adapt management and policies (Olsson et al. 2004). Systems of governance and institutions that enable comanagement and shared learning processes, such as knowledge coproduction, have the potential to enhance capacity to deal with uncertainty and change (Olsson et al. 2004). Interviewees championed using partnerships to plan for and operationalize resilience, therefore USFS staff may be interested in coproduction approaches to assist social–ecological resilience.

Adjusting current governance to support partnerships for resilience is not a simple task (Folke 2016, Timberlake and Schultz 2017). Coproduction, while appropriate for complex issues involving multiple spatial and temporal scales, can be initially expensive and taxing (Beier et al. 2016). Some vehicles for knowledge sharing are already in place and could serve as useful organizational structures for coproduced knowledge (Kemp et al. 2015). For example, the USFS-funded CLFRP encourages collaborative and science-grounded ecological restoration. Knowledge coproduction is one platform to support the interdisciplinary focus in a social–ecological resilience framework. Although shifting to the social–ecological framework may seem abstract, our intention is to broaden the arena of thinking about resilience. Researchers might expand on our work by exploring how to apply the coproduction of knowledge to resilience.

Conclusion

Scientific research provides grounding for the conceptualization and concerns of resilience in a land-management context (Carpenter 2001, Brand and Jax 2007, Folke et al. 2010, Bone et al. 2016, Falk 2016). Use of resilience is required by 2012 Rule, but the term is difficult to operationalize. Building upon the growing body of research investigating resilience, this paper fills a gap in examining insight directly from USFS managers and planners tasked with incorporating resilience into land management. Considering the term's ambiguous roots and ecological complexities, it is not unexpected that implementing resilience is muddy, hindering opportunities for effective management.

Our findings suggest there is a need to better inform resilience directives to be pragmatic to USFS staff. There is no silver bullet approach to managing for resilience to climate change. Strategies will require engaged partnerships and malleable tactics. The USFS could collaborate with internal departments, external agencies, and stakeholders to coproduce resilience knowledge and metrics. With resilience continuing to permeate USFS management, it is crucial to develop intentional strategies to clarify esoteric connotations of resilience in efforts to enhance meaningful forest stewardship.

Supplementary Materials

Supplementary data are available at Journal of Forestry online.

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End notes

1. In Region 3, Carson, Cibola, Gila, Lincoln, Santa Fe, and Tonto are in the process of revising plans under the 2012 Rule. Kaibab, Apache-Sitgreaves, Coconino, Coronado and Prescott have completed plan revision under 1982 Planning Rule provisions. Forests revised under the 1982 Rule proactively incorporated principles from the 2012 Rule. They are making amendments to update compliance with 2012 Rule but, more importantly, were required to do monitoring provisions that met 2012 Rule requirements. The Coconino, Coronado and Prescott forest plans were approved after this research was conducted.
2. Resource areas included: biology, soil science, silviculture, wildlife, ecology, watershed, climate-change monitoring, and fire and fuels specialists.

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