Resilience in Land Management Planning: Policy Mandates, Approaches, and Resources
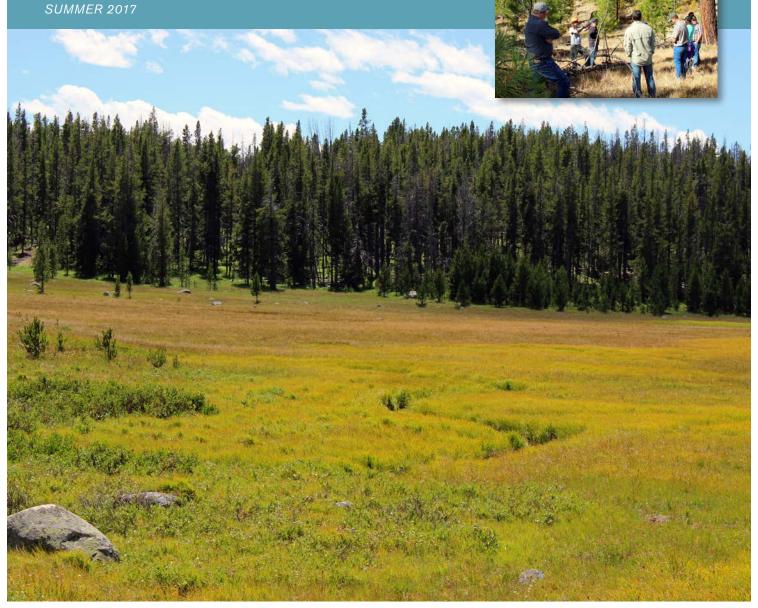
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SUMMER 2017

UNIVERSITY OF OREGON

Ecosystem Workforce Program

JOINT FIRE SCIENCE PROGRAM

Colorado State University

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Executive summary

Climate change adaptation presents a challenge for federal land management agencies in the United States. Increasingly, these agencies are turning to the concept of resilience to guide planning for an uncertain future. Resilience refers to the ability of a system to withstand disturbances and maintain its general structure and function. However, the concept can be challenging to operationalize, and a range of types of resilience and definitions for the concept exist. Nonetheless, the concept of resilience can aid in planning by emphasizing uncertainty, nonlinearity, adaptability, and consideration of cross-scale linkages. It also requires accepting the inevitability of ecological disturbances, including wildland fires. This working paper aims to provide background and context to support individuals and groups working to implement resilience in various land management planning contexts and we summarize various frameworks for planning for resilience.

Three common types of resilience exist. Engineering resilience is a function of the speed and ease with which a system returns to its equilibrium state following a disturbance. Ecological or social resilience is defined as "the ability of an ecological system or social system to withstand disturbance while still maintaining necessary functions." Social-ecological resilience is defined as "[the] capacity of an integrated social-ecological system to adapt to disturbance" (Bone et al. 2016). To date, ecological resilience has been the form used most often in federal agency planning.

Various agency policies mandate or encourage the use of resilience in planning. For example, various strategic documents from the U.S. Forest Service emphasize resilience as a key element of climate change adaptation. The concept makes up a component of ecological integrity, a central element of the U.S. Forest Service's land management planning regulations promulgated in 2012. Accordingly, many planning units working on revising their land management plans are using the concept. The concept also plays a central role in the National Cohesive Wildland Fire Management Strategy. Other agencies such as the Natural Resources Conservation Service, the Bureau of Land Management, and the National Park Service are all embracing the concept in adaptation efforts and approaches to responding to disturbances. U.S. Forest Service researchers have developed two cyclical approaches to planning for resilience. The Resilience Alliance has produced a workbook that offers a useful approach to planning for social-ecological resilience, and various other resources, approaches, and data sources are available for a range of contexts, including human communities and specific places.

Based on our review of these mandates and resources, we propose suggestions for how to plan for resilience. Partnerships drawing on scientists, managers across different agencies, and local communities play an important role in planning and executing resilience actions. Breaking up resilience planning into specific steps or phases makes the challenge less daunting and more understandable. These step-by-step processes are cyclical and iterative. It is important to monitor the system and revisit earlier assumptions to modify management activities accordingly. These processes should seek to define the system in question, identify stressors, and use climate projections to understand future conditions. Subsequent working papers will provide more specific recommendations about how to incorporate resilience into land management planning frameworks.

Introduction

Purpose and document structure

This document is a resource for land managers and stakeholders who are responsible for managing for resilience under the influences of climate change and other environmental and social dynamics. This document is the first in a series; it focuses on definitions, policy requirements, resources, and existing debate pertaining to resilience. Subsequent working papers will provide more specific suggestions for incorporating resilience into planning processes. The concept of resilience plays a central role in adaptation efforts among the federal land management agencies in the United States (e.g., U.S. Forest Service 2011a; National Park Service 2010). These agencies face a challenge in adapting their lands to maintain ecological integrity and provide valuable goods and services. Resilience refers to the ability of a system to withstand disturbances and maintain its general structure and function (Millar, Stephenson, and Stephens 2007). However, the concept can be challenging to operationalize in land management planning. Despite the growing prominence of resilience in scientific research and in policies, many scientists and managers find that the concept means different things in different contexts (Bone et al. 2016). This working paper aims to provide background and context to support individuals and groups working to implement resilience in various land management planning contexts. The document is organized as follows:

- **Section 1** provides a description of what resilience is and why it is important.

- **Section 2** describes policy mandates requiring resilience in land management.
- **Section 3** summarizes processes and approaches to planning for resilience.
- **Section 4** presents concluding remarks, identifies key themes, and makes recommendations for managers.

What is resilience?

The concept of resilience describes how systems respond to disturbances or perturbations. The emergence of resilience represents a shift in management priorities away from the steady-state and output-oriented planning approaches that dominated much of the 20th Century. Table 1 (below) provides a comparison of resilience and steady-state approaches across several key dimensions. C.S. Holling first introduced the concept of ecological resilience in 1973, defining it as "a measure of the persistence of systems and of their ability to absorb change and disturbance and still maintain the same relationships between populations or state variables" (Holling 1973, 14). The meaning of resilience has evolved over time. Recent literature has identified three types of resilience commonly used in land management contexts:

1. **Engineering resilience** is a function of the speed and ease with which a system returns to its equilibrium state following a disturbance. For example, under an engineering resilience approach, a focus might be on enhancing forest regeneration following a wildfire.

Table 1   Key Characteristics of Steady-state Planning and Planning for Resilience
(Source: Holling and Meffe 1996; Walker and Salt 2006)

Steady-state planning	Resilience planning
Calculability and predictability	Unpredictability, characterized by "surprises"
Disturbance as an unwelcome force that should be minimized or eliminated	Disturbance as both inevitable and potentially beneficial
Focus on efficient maximization of a small number of outputs	Focus on retaining system variability, including redundancies
Change assumed to be linear and reversible	Change may include presence of thresholds and "tipping points"
Assumption of stasis and singular "climax" states	Assumption of dynamism and presence of multiple equilibria

2. **Ecological <u>or</u> social resilience**, defined as "the ability of an ecological system or social system to withstand disturbance while still maintaining necessary functions" (Bone et al. 2016, 432). For example, an ecological resilience perspective focuses on maintaining or restoring ecosystem characteristics so that the ecosystem can withstand disturbances, such as fire, and retain its essential structure, composition, and function. Social resilience is a more contentious term, but the concept might refer to a community being able to adapt to an economic shock while still retaining the core characteristics that define the community (Olsson et al. 2015).

3. **Social-ecological resilience**, defined as "[the] capacity of an integrated social-ecological system to adapt to disturbance" (Bone et al. 2016, 432). Land management activities guided by social-ecological resilience would consider the connections and feedbacks between social and ecological systems, and the extent to which these systems can prepare for, adapt to, and reorganize following disturbances while retaining fundamental system characteristics (Bone et al. 2016).

A recent study found that ecological resilience was the form most often employed in U.S. Forest Service policy documents and public communications (Bone et al. 2016).

There are several metaphors that help explain resilience. For example, various scholars describe the concept in terms of a system persisting in a "basin of attraction" (Holling 1973; Folke et al. 2005). Similarly, others use the idea of a "ball" in a "cup" to capture how a resilient system remains within a particular state (Gunderson 2000). These metaphors demonstrate how systems tend to gravitate to particular states but may shift to other states once thresholds are crossed (e.g., a ball is pushed up and out of one basin and into another). In Textbox 1 (below), we have included a range of different definitions of resilience included in peer-reviewed literature and other documents.

Textbox 1: Definitions of resilience

- "Ability to rebound after perturbation" (Millar and Stephenson 2015, 823).
- "The capacity of ecosystems to return to desired conditions after disturbance" (Millar, Stephenson, and Stephens 2007, 2145).
- "A measure of the persistence of systems and of their ability to absorb change and disturbance and still maintain the same relationships between populations or state variables" (Holling 1973, 14).
- "The ability to anticipate, prepare for, and adapt to changing conditions and withstand, respond to, and recover rapidly from disruptions" (EO 13653, 66824).
- "Resist damage and recover quickly from disturbances (such as wildland fires) and human activities" (Wildland Fire Leadership Council 2014, 91).
- "The ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organization, and the capacity to adapt to stress and change" (National Park Service 2010, 13).
- "Promote the return to normal conditions after a disturbance" (Swanston and Janowiak 2016, 31).
- "The magnitude of change or disturbance that a system can experience without shifting into an alternate state that has different structural and functional properties and supplies different bundles of the ecosystem services that benefit people" (Resilience Alliance 2010, 5).
- "The ability to survive a given change" (Cascade Forest Conservancy 2017, 4).
- "Resilience at a regional scale: the capacity of an ecosystem to maintain function and biodiversity despite pressures brought on by climate change" (Cascade Forest Conservancy 2017, 4).
- "The ability to recover from natural disasters and economic stressors that result from climate-related disturbances to natural resources and socioeconomic conditions" (Cook et al. 2014, 1).

In land management, resilience may apply in several different contexts. Planning documents may focus on disturbances; for instance, documents may emphasize what type of fire behavior and response to fire characterize a resilient system. These documents may, alternatively, focus on attributes that make a particular ecosystem resilient; in this case, managers might focus on the structure and composition that are consistent with a system likely to be resilient to fire.

Resilience is not the only approach that may guide climate change adaptation efforts. In their 2007 paper, Millar and co-authors suggest that forest managers pursue a flexible mix of adaptation strategies, including resistance, resilience, and response. Resistance describes efforts to "forestall impacts and protect highly valued resources;" this might be a desired approach in cold-water aquatic refugia, for example, where managers might want to limit any disturbance or change for a period of time (Millar, Stephenson, and Stephens 2007, 2145). Response strategies, also referred to as transition strategies, involve endeavors to "facilitate transition of ecosystems from current to new conditions," and these conditions may be novel enough to fall outside the realm of resilience (Millar, Stephenson, and Stephens 2007, 2145). Sometimes, managers may also use a strategy of realignment, which "uses restoration techniques to enable ecosystem processes and functions (including conditions that may or may not have existed in the past) to persist through a changing climate" (Peterson et al. 2011, 2); this definition includes aspects of both resilience and transition. While these concepts are often described separately, some researchers note that resilience often serves as an umbrella term that includes both resistance actions that seek to ensure that certain characteristics persist despite climate change and response actions that seek to transition ecosystems to make them more suitable for future conditions (Fisichelli, Schuurman, and Hoffman 2015). While resilience plays a central role in adaptation planning, it is often used in conjunction with other approaches.

Ecological restoration management activities are often seen as means for developing resilient landscapes (Timpane-Padgham, Beechie, and Klinger 2017). Land management agencies are actively funding restoration activities through various programs, such as the Collaborative Forest Landscape Restoration program and the U.S. Forest Service's Integrated Resource Restoration budget approach (Schultz, Jedd, and Beam 2012; Schultz et al. 2017). Restoration that supports the continued function and structure of ecosystems is important for ensuring resilience in the face of various agents of change (Hanberry et al. 2015).
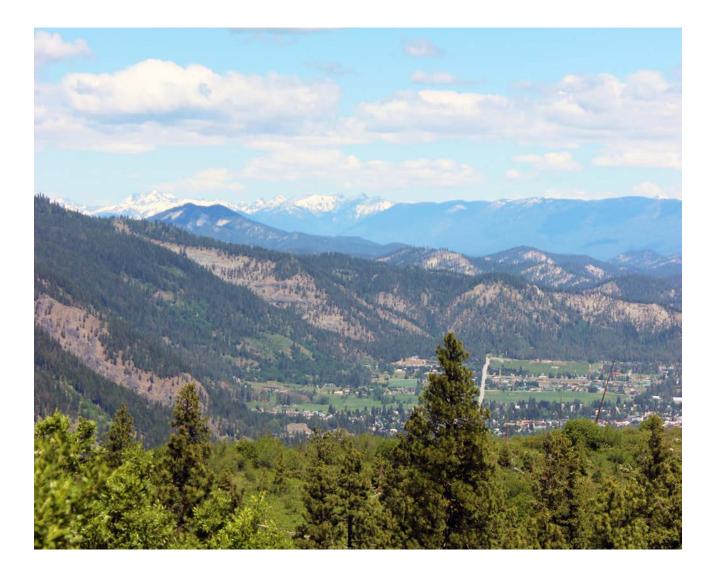
Why is resilience important?

The resilience approach to land management emphasizes uncertainty, nonlinearity, adaptability, and consideration of cross-scale linkages. This perspective also considers the feedback loops that link human and natural elements of these systems (Walker and Salt 2006). As its definition suggests, resilience explicitly requires managing for and accepting the inevitability of disturbances affecting systems. Ecological disturbance is an umbrella term that refers to biotic or abiotic events that result in changes to ecosystem structure or function. Examples of disturbances include natural processes such as wildfires, droughts, insect outbreaks, windstorms, hurricanes, and flood events. Disturbances also include human factors such as clearing vegetation, harvesting timber, and introducing fire intentionally or unintentionally. Resilience thinking incorporates both individual disturbances as well as the interactions between multiple disturbances. Dealing with compounded disturbances is an especially challenging aspect of climate change, which has the potential to exacerbate the effects of many existing disturbances. However, while impacts are certain to occur, the specific timing and location of impacts are extremely uncertain. Given these realities, resilience concepts help managers think about what they are trying to maintain over the long term in the face of multiple interacting disturbances in a time of great change and uncertainty.

Challenges and criticisms of resilience

Despite the prominence of resilience, there are challenges associated with employing resilience in a managerial context. First, it is generally implied that resilience is "good," but this may not always be the case; undesirable systems and attributes may in fact be resilient in the sense that they retain their core system characteristics even in the face of perturbation. The concept of ecological integrity, which considers resilience, natural range of variation, and native biodiversity, may be a better term to use when conveying the desirability of a resilient system (Wurtzebach and Schultz 2016).

Another challenge is that the concept of resilience can be ambiguous and used in fundamentally different ways, even within a single agency; this can make it difficult to apply the concept in a consistent manner (Bone et al. 2016). The ambiguity associated with resilience enables the concept to work as a "boundary concept," used differently among different communities of thought and practice (Cohen 2012). This ambiguity can make both operationalizing and measuring resilience a challenge (Timberlake and Schultz 2017; Newton 2016). Finally, some social scientists have critiqued the concept, saying that it is more appropriate when applied to natural systems than to social systems (Olsson et al. 2015).

Resilience Policy Mandates

Although the concept of resilience was, for many years, found primarily in academic scholarship, it has begun to be incorporated into policy and planning documents in recent years. Here we review federal policies, guidance, and case law on resilience and related concepts. Note that many of these policies are subject to change; what follows is current as of the time of writing of this document.

Agency policies

In this section, we consider how federal land management agencies address resilience planning. While this document primarily aims to be a resource for forest managers, including those associated with the U.S. Forest Service, many of its lessons are applicable to managers working for or with other agencies, including the Bureau of Land Management, the National Park Service, and the U.S. Fish and Wildlife Service.

U.S. Forest Service strategic documents

The U.S. Forest Service, a land management agency within the Department of Agriculture, manages 193 million acres of national forests and grasslands distributed across approximately 170 planning units. The agency's national office leads the U.S. Forest Service's climate change-related efforts by setting priorities, promulgating regulations, and releasing guidance. Lands managed by the U.S. Forest Service are arranged into nine regions, which integrate and organize management operations across planning units (national forests and national grasslands). Each planning unit carries out management activities and develops land management plans. In

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Textbox 2: Examples of the use of resilience in recent national forest plans

- "The composition, structure, and function of vegetative conditions [for a pinyon-juniper woodland] are resilient to the frequency, extent and severity of disturbances (such as insects, diseases, and fire), and climate variability" (Cibola National Forest 2016, 40).

- "Terrestrial habitats as measured by vegetation structure, density, and species composition are resilient to damaging insects and pathogens" (Chugach National Forest 2015, 19).

- "Culverts and other passage improvements are to be designed to restore and maintain hydrologic and aquatic habitat function and stream channel resiliency to a range of flows through natural channel design and other acceptable treatment measures" (Colville National Forest 2016, 46).

- "The Forest resources and operational management are resilient to the influences of a changing climate. Management activities reduce the susceptibility of resources to multiple threats, including drought, invasive species, disease, and wildfire. The immediate and long-term resilience of the Forest will be changed by:
  - Responding to changes in visitor behavior and mitigating any seasonal increases in use;
  - Enhancing landscape connectivity by maintaining natural migration corridors between lowland and upland forests to allow species to move up-slope into cooler environments as climate warms;
  - Maintaining piles of natural woody debris and promote wetlands and ponds in areas of high amphibian diversity to supplement habitats that retain cool, moist conditions; and
  - Rapidly detecting and eradicating invasive species introductions and new locations, especially following disturbances from hurricane events in high-elevation communities" (El Yunque National Forest 2016, 46).

addition to the National Forest System, the agency has a research branch that conducts scientific research relevant to land management, including research pertaining to climate change and resilience. Since 2008, the U.S. Forest Service has developed strategic efforts to address climate change across different dimensions, which generally incorporate resilience as a guiding concept for adaptation.

Strategic Framework

Released in 2008, the U.S. Forest Service's Strategic Framework for Responding to Climate Change outlines seven broad goals for how the agency responds to climate change. One goal, Adaptation, seeks to "enhance the capacity of forests and grasslands to adapt to the environmental stresses of climate change and maintain ecosystem services" (U.S. Forest Service 2008, 9). "Maintaining ecosystem resilience" is a key component of this goal (U.S. Forest Service 2008, 9). Management activities focused on ecosystem restoration and reducing disturbance risk aim to support resilience. Though not stated explicitly, other goals in the document, such as forming alliances, developing policy, and producing scientific information, also support resilience (U.S. Forest Service 2008). For example, partnerships with scientists help to identify and develop scientific information that can inform resilience planning.

Roadmap and Scorecard

The U.S. Forest Service's National Roadmap for Responding to Climate Change builds on the Strategic Framework to lay out a structured approach to addressing climate change. This framework suggests that the agency respond to climate change through a cycle of stages: *Assess*, *Engage*, and *Manage*. Thus, when addressing climate change, forests must *assess* "risk/vulnerability, policy, knowledge gaps, [and] management outcomes" (U.S. Forest Service 2011a, 4). They must also *engage* through "education, science-management partnerships, and alliances" (p. 4). Then, forests *manage* for "resilience, in ecosystems as well as in human communities, through adaptation, mitigation, and sustainable consumption" (U.S. Forest Service 2011a, 4). The document compares resilience to resistance and

transition strategies. Resistance strategies focus on "short-term protection of high-value resources, such as a human community or an endangered species," whereas resilience strategies apply on larger temporal and spatial scales (p. 18). Transition strategies are those that are longer-term than resilience and consider "a trajectory beyond the historical conditions" for ecosystems (p. 18).

FY 2015-2020 Strategic Plan

The U.S. Forest Service's FY 2015-2020 Strategic Plan, another high-level strategic document, outlines several broad goals for the agency. In the plan, the U.S. Forest Service indicates that it intends to "Foster resilient adaptive ecosystems to mitigate climate change" as a strategic objective under the goal of sustaining the nation's forests and grasslands. Actions associated with this goal focus on restoration of key ecosystem functions, such as water filtering and purification. Restoration activities will make ecosystems resilient to disturbances and will support ecosystem services and multiple uses, thus contributing to "vibrant, resilient communities" (U.S. Forest Service 2015b, 10). This consideration of communities suggests a dual focus on both ecological resilience and social-ecological resilience. In carrying out resilience-oriented restoration activities, the agency intends to collaborate with a range of actors, including federal and state agencies, American Indian tribes, and private landowners. Monitoring and adaptive management support these efforts (U.S. Forest Service 2015b).

2010 RPA Assessment Report

The U.S. Forest Service's Future of America's Forests and Rangelands reports on the agency's 2010 resource assessment conducted in accordance with the Forest and Rangeland Renewable Resources Planning Act of 1974 (Public Law 93-378, 88 Stat 475, as amended). This document also identifies restoration activities that yield resilient ecosystems as a key component of the agency's sustainability strategy. The RPA Assessment offers a wealth of broad-scale information on various topics that may help land managers plan for resilience, including development pressures, water yield, wildlife species, and climate projections.

U.S. Forest Service 2012 Planning Rule

In 2012, the U.S. Forest Service promulgated regulations known as "the 2012 planning rule," dictating how individual planning units should carry out their land management planning activities as required by the National Forest Management Act of 1976 (NFMA) (36 C.F.R. §219). Prior to the 2012 rule, forests had been conducting their forest plan revisions in accordance with regulations from 1982 that lacked guidance on contemporary planning challenges, such as climate change adaptation. The 2012 planning rule outlines a three-phase, iterative approach to forest planning, beginning with an assessment phase where planning units collect available information and data in order to inform planning. Then, planning units engage in developing or revising their forest plans. Following plan development, planning units must monitor conditions (36 C.F.R. §219.5). As of early 2017, about 25 forests are currently engaging in forest plan revision guided by the 2012 planning rule, with many more scheduled to begin forest plan revision over the next decade.

The 2012 planning rule requires land management plans to develop plan components that meet four categories of requirements: 1) sustainability (36 C.F.R. §219.8); 2) diversity of plant and animal communities (36 C.F.R. §219.9); 3) multiple use (36 C.F.R. §219.10); and, 4) timber requirements based on NFMA (36 C.F.R. §219.11). Sustainability requirements incorporate ecological, social, and economic sustainability. The rule requires forests to develop plans that ensure "ecological integrity" in meeting sustainability and diversity requirements (36 C.F.R. §219.8(a)). The rule defines ecological integrity as:

The quality or condition of an ecosystem when its dominant ecological characteristics (for example, composition, structure, function, connectivity, and species composition and diversity) occur within the natural range of variation [NRV] and can withstand and recover from most perturbations imposed by natural environmental dynamics or human influence. (36 C.F.R. §219.19)

The second component of this definition, capturing the ability of ecosystems to "withstand and recover from most perturbations," describes resilience. Furthermore, the rule defines restoration as activities that "facilitate terrestrial and aquatic ecosystems sustainability, resilience, and health under current and future conditions" (36 C.F.R. §219.19).

The Land Management Planning Handbook, also referred to as "the directives," accompanies the planning rule and provides further direction on resilience. It emphasizes that the natural range of variation serves as a tool to guide the restoration of resilient ecosystems and provides additional guidance on this topic. With regards to species conservation, the handbook states that a viable population is resilient if when "disturbance events or stressors result in the local disappearance of individuals or extirpation from an area, recolonization of suitable habitat may occur in the future to facilitate long-term persistence in the plan area" (U.S. Forest Service 2015a). Recent draft forest plans conducted in line with the 2012 planning rule use resilience to guide responses to climate change and demonstrate how planners have begun to use the term in line with the U.S. Forest Service's 2012 Planning Rule.

National Cohesive Wildland Fire Management Strategy

In 2009, Congress passed the Federal Land Assistance, Management, and Enhancement Act (FLAME Act), which required the Departments of the Interior and Agriculture to collaboratively develop a "cohesive wildfire management strategy." The strategy outlines three guiding nationwide goals: 1) Restore and maintain landscapes; 2) Promote fire-adapted communities; and 3) Provide for safe and effective wildfire response. The strategy explains the first goal, stating, "Landscapes across all jurisdictions are resilient to fire-related disturbances in accordance with management objectives" (Wildland Fire Leadership Council 2014, 3). The strategy identifies regional differences in resilience to fire. For example, in southeastern U.S. ecosystems, fire return intervals are frequent. Fire plays a key role in maintaining ecosystem resilience and supporting wildlife habitat and ecosystem services. Accordingly, the strategy prioritizes the continued implementation of prescribed fire. By contrast, the strategy notes that, largely due to the legacy of fire suppression and past harvesting practices, "the West needs landscape-scale changes in vegetative structure and fuel loadings" to improve resilience (Wildland Fire Leadership Council 2014, 13). In general, increased management of wildfires and

increased use of prescribed fire offer opportunities to increase resilience to fire across a variety of landscapes and locations (Wildland Fire Leadership Council 2014).

The strategy recognizes that, given regional social and ecological differences, definitions of resilience vary according to context. As a result, the strategy offers an approach that classifies a county's ecological landscape based on various factors, including the extent to which the county is urban, its fire regimes, federal ownership, region, and prescribed fire use. The approach yields 11 different categories, for which managers may conceptualize landscape resilience differently. Examples of these landscape classes include "Western Public Lands with Recent Large Fires" and "Cool, Wet Northern Forests." The strategy also classifies communities into eight different clusters, such as "Western Rural" and "Disadvantaged Communities." The intersection between landscape resilience classes and community clusters then offers a tool to understand both social and ecological dimensions of landscapes, thus offering a starting point for conceptualizing resilience. The strategy also presents management options for promoting social-ecological resilience; these include: prescribed fire, managing wildfires for resource objectives, non-fire treatments, home and community action, building codes, and reducing human-caused ignitions (Wildland Fire Leadership Council 2014).

Resilience policies for the Natural Resources Conservation Service

Several resilience policies guide activities for the Natural Resources Conservation Service (NRCS), also part of the U.S. Department of Agriculture. The NRCS provides scientific and funding support to farmers and ranchers to support conservation initiatives. In recent years, the agency has been addressing drought resilience in its efforts, including via the Environmental Quality Incentives Program (EQUIP). Many of these efforts focus on soil and water, as opposed to vegetation types (Natural Resources Conservation Service 2015). The agency has also developed a vulnerability assessment of climate change impacts on agriculture and natural resources (Natural Resources Conservation Service 2014). NRCS and the U.S. Forest Service are working together as part of the Joint Chiefs' Landscape Restoration Partnership that aims for landscape restoration on private and public lands with wildfire threats, watersheds, and wildlife habitat. Many of these projects aim to promote landscape resilience to stressors that include wildfires, storms, and insects. These projects involve partnerships between the federal agencies, universities, and other land managers (Natural Resources Conservation Service 2017).

Department of Interior land management policies addressing resilience

Federal agencies in the Department of Interior (DOI) that conduct significant land management activities include the Bureau of Land Management (BLM), the National Park Service (NPS), the U.S. Fish and Wildlife Service (FWS), and the Bureau of Indian Affairs (BIA). As with the U.S. Forest Service, land management policies guiding these agencies emphasize resilience to disturbances as a response to climate change. For example, the Fish and Wildlife Service's manual indicates that one component of the agency's adaptation strategy is to "Deliver landscape conservation actions that build resilience or support the ability of fish, wildlife, and plants to adapt to climate change" (U.S. Fish and Wildlife Service 2013). Examples from other DOI agencies are included below.

Department of Interior Wildland Fire Resilient Landscapes Program

The President's proposed budget for fiscal year 2015 included the Resilient Landscapes Program, and Congress funded the program at $10 million. This program funded 13 initial pilot projects led by different DOI agencies (see Textbox 3, below). The program prioritized projects in areas with high fire risk and where mitigation activities would have significant impacts. In general, the specific objectives of these projects emphasize resilience to fire through the restoration of natural vegetation but also promote the resilience of sagebrush habitat to support populations of greater sage-grouse. For example, several of the projects intend to use prescribed fire to remove encroaching pinyon pine and juniper trees from sagebrush ecosystems. In addition to its focus on sagebrush habitat, the program includes projects addressing a range of other ecosystem types, including pinyon-juniper, redwoods, and longleaf pine (Office of Wildland Fire, U.S. Department of the Interior 2015).

Textbox 3: Resilient Landscapes cooperatives established in 2015

- Bi-State Sage-Grouse in Nevada and California led by the BLM
- Bruneau-Owyhee in Idaho led by the BLM
- Grant Grove Peninsula in California led by the NPS
- Greater Sheldon-Hart Mountain in Oregon, Nevada, and California led by FWS
- Longleaf Pine – South Atlantic in Georgia, Florida, North and South Carolina, and Virginia led by FWS
- Santa Clara Pueblo in New Mexico led by BIA
- Southern Arizona led by NPS
- Southern Utah led by BLM
- Southwest Colorado led by BLM
- Valles Caldera in New Mexico led by NPS.

(Office of Wildland Fire U.S. Department of the Interior 2015, 13–14)

National Park Service Climate Change Response Program

Similar to the U.S. Forest Service, the National Park Service faces the challenge of continuing to provide for recreation and other human uses in light of climate change. Its climate change strategy shares some elements of the Forest Service's approach but also differs in key ways. Like in the Forest Service, ecosystem resilience guides adaptation planning in the NPS. The NPS also uses several other concepts that complement resilience: redundancy, connectivity, protecting refugia, and restoration. Redundancy describes "maintaining more than one example of an ecosystem or population" (National Park Service 2010, 13). Connectivity refers to the "ability for organisms to move from one area to another;" refugia are "places that are relatively unaffected by climate change" (National Park Service 2010, 13). Adaptation efforts are collaborative in nature with strong communication between stakeholders, decision-makers, and the scientific community. The NPS promotes scenario planning to inform adaptation efforts; this approach allows the agency to explore plausible potential future conditions and plan accordingly (National Park Service 2010). In support of visitor outreach efforts central to NPS's operations, the agency has developed web modules to teach interpretive staff how to interact with the public on climate change (National Park Service 2016).

Approaches to resilience:
Existing guidance, tools, and partnerships

In conjunction with mandates and policies requiring land management agencies to plan for resilience, various approaches and processes have emerged to guide agency actions in the strategic and project planning contexts. In this section, we address resources, tools, guides, data sources, and approaches that land managers may draw on when planning for resilience.

Adapting through science-management partnerships

Many national forests are engaging in partnerships with research scientists at Research Stations and at local universities. These partnerships are working to develop adaptation approaches using a multiple step process. This approach is outlined in a U.S. Forest Service General Technical Report titled <u>Responding to Climate Change in National Forests: A Guidebook for Developing Adaptation</u>. Specifically, the steps of the process include:

- *Review.* The partnership works together to develop a shared understanding of basic climate science as well as site-specific management challenges, concerns, and knowledge.

- *Rank.* The partnership assesses how sensitive particular resources (e.g., a species or ecosystem type) are to climate change.

- *Resolve.* The partnership develops adaptation strategies, based on resistance, resilience, response, and realignment.

- *Observe.* The partnership monitors results and revises its strategy accordingly.

This guidebook discusses different tools and processes for projecting climate change and its impacts on resources at different temporal and spatial scales. The resource also describes processes for identifying and assessing relevant scientific information (Peterson et al. 2011). Thus, even if managers choose to follow a different process, they may benefit from reading the background information included in this resource.

These science-management partnerships have produced vulnerability assessments, which are "efforts that identify future risks induced by climate change, identify key vulnerable resources, and provide a sound basis for designing adaptation strategies" (Peterson et al. 2011, 14). Vulnerability assessments have been developed for different geographic scales. Some vulnerability assessments focus on individual planning units, such as the Shoshone National Forest (Rice, Tredennick, and Joyce 2012). Others consider several contiguous Forest Service units and also neighboring national parks, such as the efforts by the Northern Cascadia Adaptation Partnership (Raymond, Peterson, and Rochefort 2014). More recently, the U.S. Forest Service has undertaken region-wide partnership and vulnerability assessment efforts for the Northern Region and the Intermountain Region. The Northern Region Adaptation Partnership and the Intermountain Adaptation Partnership have developed vulnerability assessments relevant across different subregions with the goal of informing land management plan revisions.

The U.S. Forest Service's Climate Change Response Framework

The Northern Institute of Applied Climate Science (NIACS) led an effort to develop the Forest Service's Climate Change Response Framework (CCRF) to support land management planning through pilot projects and other efforts. The group published an initial Forest Service General Technical Report in 2012 (Swanston and Janowiak 2012) followed by a second edition of the report in 2016 (Swanston and Janowiak 2016). The overall CCRF process draws on four pillars: partnerships, vulnerability assessments, adaptation resources, and adaptation demonstrations (Swanston and Janowiak 2016).

Ultimately, the CCRF approach emphasizes an iterative and adaptive approach to assessing vulnerability and developing adaptation activities for land management projects. The CCRF offers

Textbox 4: Adaptive Silviculture for Climate Change

Through science-management partnerships across several sites in a diversity of settings, the Adaptive Silviculture for Climate Change (ASCC) project has applied the CCRF to develop long-term experiments that evaluate how silvicultural treatments oriented around resistance, resilience, and transition fare over time in light of climate change. This project applies experimental design across sites that requires replication, monitoring, and adaptive management. Existing and planned sites include the Coram Experimental Forest on the Flathead National Forest in Montana, the Cutfoot Experimental Forest on the Chippewa National Forest in Minnesota, the San Juan National Forest in Colorado, the J.W. Jones Ecological Research Center in Georgia, and Dartmouth College's Second College Grant forest and the Hubbard Brook Experimental Forest in New Hampshire.

The project tests how these different treatments respond to changes in climate and meet management goals with planned evaluations at 5 and 10 years (Nagel et al. 2017). Conclusions from this project may help managers of sites similar to those included in the project. Furthermore, this project demonstrates how developing specific treatments focused on a range of adaptation approaches (e.g., resistance, resilience, and transition, as well as a no action control) may help managers recognize how resilience treatments differ from other approaches, as well as where and when resilience-oriented approaches are most appropriate.

a workbook that land managers can use to incorporate adaptation efforts in project planning. The first step in this approach is to *define* the project, including its location, timeframe, objectives, and other specifics. Following the *define* step, managers then *assess* vulnerabilities to climate for the project, its location, and affected resources, yielding a vulnerability rating. Then, managers *evaluate* the feasibility and appropriateness of management objectives to respond to the climate vulnerabilities identified in the previous step, using a high-medium-low scale. The fourth step of the process has managers *identify* adaptation strategies, approaches, and tactics for the project in question. Strategies are broad in nature; for example, a strategy noted by the Adaptation Workbook is to "reduce the risk and long-term impacts of severe disturbances" (Swanston and Janowiak 2016, 31). Approaches are more specific, such as

to "alter structure or composition to reduce risk or severity of fire" (Swanston and Janowiak 2016, 31). Tactics are specific on-the-ground actions; for example, in line with the above examples of strategies and approaches, a possible tactic would be to "restore fire in oak forests to reduce surface fuel and promote fire- and heat-tolerant species" (Swanston and Janowiak 2016, 31). After the project is implemented using the previous steps, the final step is to *monitor* how effective the project is. Based on monitoring results, managers may restart this process to refine the project approach in line with principles of adaptive management (Swanston and Janowiak 2016). The CCRF process draws on Millar and others' (2007) three fundamental adaptation options: resistance, resilience, and transition. These fundamental adaptation options provide a broad-level structure for working through the hierarchy of strategies, approaches,

and tactics. Given their general nature, adaptation strategies may align with multiple options or all three. For example, the Adaptation Workbook suggests that the strategy to "sustain fundamental ecological functions" may reflect either resistance, resilience, or transition depending on the context. In addition, the CCRF provides a menu of different strategies and tactics relevant to ecosystem types in the Northeast and Upper Midwest (Swanston and Janowiak 2016, 36).

Several examples of implementation of the CCRF approach exist. The framework's website (forest-adaptation.org) includes descriptions of numerous adaptation demonstration projects in a variety of locations, ecological settings, and land ownership contexts. Another application of the CCRF is the Adaptive Silviculture for Climate Change project described in Textbox 4 (see page 13). In addition, using the CCRF, several science-management partnerships have developed vulnerability assessments for ecoregions in the Midwest and the Northeast.

An approach to social-ecological resilience: Resilience Alliance Workbook

The Resilience Alliance is a research group that draws on different disciplines to explore social-ecological systems and resilience in a range of settings around the world. In 2010, the Resilience Alliance published a second edition of its <u>Assessing resilience in social-ecological systems: Workbook for practitioners</u>, which offers a structured approach to planning for resilience. Similar to other approaches, the Resilience Alliance approach includes multiple stages that are cyclical and iterative. The workbook emphasizes analyzing integrated social-ecological systems that contain "cultural, political, social, economic, ecological, technological, and other components;" another way of describing this is a "humans-in-nature" perspective (Resilience Alliance 2010, 6). These systems may exist in multiple different states, or collections of variables. State change occurs as a result of feedbacks and reaching thresholds. The

concepts of adaptive cycles and the closely related panarchy cycle also offer insight on the fluctuations of systems. An adaptive cycle describes a four-stage progression of ecosystems, beginning with "rapid growth", followed by "conservation of resources", "release of resources," and "reorganization" (Resilience Alliance 2010, 7). The concept of panarchy describes the relationships between adaptive cycles operating at different scales. The idea of adaptive governance captures new and emerging rules, laws, and approaches to ecosystem management that are meant to be flexible, diverse, and innovative, thus enabling resilience (Resilience Alliance 2010).

With these concepts in mind, users of the workbook then engage with the first step in the process, *"Defining the focal system."* This step involves determining the temporal and spatial scale of the system in question, and identifying key issues and how these issues relate to key aspects of the system. For example, a national forest using the tool could identify the management of a particular ranger district over the next 20 years as the focal system; main issues could include the legacy of a recent beetle outbreak and concerns about future catastrophic wildfire, as well as high levels of recreational use in the area by off-road vehicles. As part of this step, users address the question of *"resilience of what to what?"* by identifying key system components for which to optimize resilience. In addressing this question, the workbook encourages users to consider key uses, ecosystem services, and stakeholders with interests in the system. Users identify relevant disturbances and their associated patterns over time. Types of disturbances include pulse disturbances that are acute and singular in nature, and press disturbances that occur gradually and continuously. The workbook also suggests identifying smaller- and larger-scale systems that may impact the focal system and its resilience. For example, a national forest considering resilience to fire may want to consider how larger-scale budget and funding changes may affect their ability to prepare for fire. The workbook provides worksheets to help users organize and record their ideas in a concrete fashion.

The second step addresses the dynamics and change of the system. This step suggests applying the adaptive cycle concept to analyze the history of the system over time and identify phases of rapid growth or exploitation followed by conservation, release, and reorganization. By identifying these phases, users then identify variables that appear to explain the system's progression through these phases. The workbook gives institutional budgets and carbon storage as examples of possible key variables. This process yields a better understanding of the key drivers of change. Other considerations include whether there are key types of natural or other capital that should be maintained regardless of how much other aspects of the system change, as well as tradeoffs between efficiency and flexibility. The workbook then asks users to consider whether the system exists in multiple stable states identified via several key variables. The user identifies these system states and their changes over time in conjunction with the discussion of the adaptive cycle. Armed with this information on state changes, the user may then describe the nature of transitions and thresholds associated with state changes.

The third step involves considering cross-scale interactions. Applying the concept of panarchy, users identify adaptive cycles at different scales and how they interact. This gives a sense of desirable and undesirable interactions, as well as tradeoffs. As part of this step, users also identify thresholds at different scales and describe their level of certainty in their threshold identification. Users then consider whether they are prioritizing general resilience or specified resilience (this refers to the type of resilience identified in step 1 in response to the "resilience of what to what?" question). Prioritizing specified resilience at the expense of general resilience can be problematic if it hinders the system's ability to be resilient to unexpected disturbances. The workbook describes four dimensions of general resilience: openness, reserves, tightness of feedbacks, and modularity.

The fourth step involves addressing the governance and institutions that affect resilience. Factors to consider include:

- Formal institutions, such as laws and property rights
- Informal institutions, such as social norms
- Social networks.

Using a worksheet, this step has users identify key institutions, the levels at which decisions are made, how rules are enforced, and the power relationships between different stakeholders. In addition, the step involves mapping social networks, including the number of relationships and how centrally focused these networks are.

The fifth step incorporates acting on the information collected in the assessment. It guides users through synthesizing information collected in the assessment and devising actions based on this synthesis. It also suggests general principles that underpin resilience-based stewardship, including supporting diversity of various types, blending feedbacks that stabilize and those that lead to "creative renewal", promoting social learning, and adapting governance to be more flexible and better support resilience. Ultimately, adaptive management should occur based on monitoring and periodic revision of resilience assessments.

NOAA U.S. Climate Resilience Toolkit and the Partnership for Resilience and Preparedness

The National Ocean and Atmospheric Administration's (NOAA) Climate Program Office manages a website (or "toolkit") that collects information on climate resilience from different sources for federal government employees and others. The toolkit suggests a stepwise approach to resilience:

- Step 1 of this approach is to "explore climate threats" via expert teams.

- Then, in Step 2, managers "assess vulnerability and risks" by discussing climate and other stressors and identifying thresholds.

- Step 3 is to "investigate options" by brainstorming solutions.

- In Step 4, managers "prioritize actions" by developing plans that recognize tradeoffs and combine similar actions.

- Finally, Step 5 entails "taking action" by carrying out resilience actions on the ground, monitoring results, and revising accordingly. Furthermore, the toolkit recommends that managers summarize their efforts and share lessons learned with their counterparts. Thus, land management agencies and professional societies may play an integral role in compiling databases of successful resilience projects.

In addition to providing a process, the toolkit collates numerous resources for managers. It maps out locations of climate experts that managers may consult, including state climatologists, USDA Climate Hubs, DOI Climate Science Centers and Landscape Conservation Coops, and NOAA Regional Climate Centers. The toolkit also includes short descriptions of resilience case studies that users may explore on a map or by stressor or topic area. Land managers may be especially interested in the *Ecosystem* topic area, which includes several case studies pertaining to managing lands for resilience to fire, climate change, and other stressors. For example, one case study describes efforts by Denver-area water utilities to promote forest resilience to wildfires in order to maintain a clean water supply.[1] Another helpful resource is the "ForWarn Forest Change Assessment Viewer" that monitors disturbances trends affecting Engelmann spruce in Colorado.[2] Managers may use this toolkit to identify relevant tools to use for their ecosystem topic and stressor. While many of these tools focus on coastal issues, there are tools relevant to forest management decision-making, such as North American Seasonal Fire Assessment and Outlook (National Oceanic and Atmospheric Administration 2017).

The Partnership for Resilience and Preparedness (PREP) has developed an online mapping interface that allows users to observe a range of climate factors, including historical precipitation and projected precipitation. In addition, PREP allows users to view the locations of infrastructure, such as dams. PREP also allows users to produce charts and other insights of a range of factors. This easy-to-use interface may be helpful for scoping out potential climate change impacts (Partnership for Resilience and Preparedness 2017).

NPS Climate Change Response Strategy: Scenario planning

A key component of the National Park Service's climate change strategy is the use of scenario planning to help envision the future and make decisions. This offers an alternative to the U.S. Forest Service's approach that focuses on vulnerability assessments. This approach helps managers to "explore assumptions, test hypotheses, and ultimately develop robust strategies and actions to manage the uncertainties of climate change," including planning resilience activities (National Park Service 2010, 15). The NPS describes a scenario as "a plausible, internally consistent story about the future that challenges us to consider how we would operate under novel conditions" (National Park Service 2013, 5). In this context, scenario planning involves bringing together participants to undergo a five-step cyclical process:

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[1] For more information on this case study, see:
https://toolkit.climate.gov/case-studies/partnerships-promote-healthy-forests-and-clean-water.

[2] For more information on this case study, see:
https://toolkit.climate.gov/case-studies/monitoring-forest-disturbances-aids-management-decisions

- In the first step, *orientation*, the participants define the scope of the project, set priorities and guidelines, and identify research questions.

- In the second step, *exploration*, participants address "the critical forces, variables, trends, and uncertainties" of the situation (National Park Service 2013, 15). Products of this phase include tables, charts, and other graphics summarizing these factors. This step requires consideration of different scales, how the area in question fits in with local communities, and the land management agency's organizational structure.

- The third step, *synthesis*, involves developing between three and five specific scenarios to use for planning that vary across key driving forces and associated uncertainties. Scenarios may correspond to combinations of high- and low-end estimates of different uncertain variables. For example, managers may develop four scenarios based on a two-by-two matrix of the ranges of two variables. Developing scenarios usually requires some dialogue back-and-forth

between participants and a few iterations. Groups working on scenarios then develop descriptive narratives that describe the future state of the world and how it got there. The guide for scenario development suggests to not use qualifiers in describing scenarios; that is, scenario developers should avoid comparing "good" and "bad" scenarios, as well as using "low, medium, and high" as descriptors.

- Then, Step 4, *application*, involves translating information from the scenarios into management strategies and actions, such as resilience. Scenarios allow managers to identify "no-regrets" strategies, which would do well across all potential future scenarios.

- In Step 5, *monitoring*, managers identify indicators and develop a monitoring strategy that will help identify whether the system is trending towards a particular scenario. In addition, in this step, managers prepare deliverables summarizing and displaying conclusions about uncertainties about the future, corresponding scenarios, and strategies and actions to respond (National Park Service 2013).

Resilience efforts oriented around communities and locations

The growing prominence of resilience concepts across administrative policies has led to various initiatives and efforts intended to promote resilience in specific locations or communities. This section describes the Resilience Dialogues project, the Community and Regional Resilience Institute, and the Resilient Lands and Waters Initiative.

Resilience Dialogues

In 2016, the White House's Office of Science and Technology Policy launched the Resilience Dialogues project, which seeks to connect communities, scientists, and practitioners to promote resilience. The U.S. Global Change Research Program and the American Geophysical Union coordinate the program, and the Kresge Foundation offers funding. In addition, several federal agencies in and including USDA, DOE, DOI, and the EPA are contributing to the effort. The goal of the project is to "help decision makers build a better understanding of their climate risks and identify the locally relevant information, tools, programs, and other resources that can help them in resilience planning" (Office of Science and Technology Policy 2016, 1). Accordingly, the project seeks to help communities identify the important questions that they are struggling with, and approaches to answering these questions. The project is currently in the beta stage with the following communities participating (Resilience Dialogues 2017):

- Antioch, CA
- Bridgeport, CT
- Menominee and Oneida Reservations (WI)
- Navajo Nation (AZ, NM, and UT)
- Boynton Beach, FL
- Hallandale Beach, FL
- Mt. Shasta, CA
- San Francisco Bay Conservation and Development Commission, CA
- East Lansing, MI
- Savannah, GA

The Community And Regional Resilience Institute

The Community And Regional Resilience Institute (CARRI) also offers a series of resources on community resilience. These may be helpful for land managers working directly with local communities on resilience projects. Of particular interest may be the group's report that describes different definitions of community resilience (Community and Regional Resilience Institute 2013). Community resilience generally refers to a community's "capability to anticipate risk, limit impact, and bounce back rapidly through survival, adaptability, evolution, and growth in the face of turbulent change" (Community and Regional Resilience Institute 2013, 10). While land managers often do not consider resilience in terms of community resilience, having awareness of this perspective may be helpful, particularly for managers working in close collaboration with local communities.

The Resilient Lands and Waters Initiative

The Resilient Lands and Waters Initiative developed out of interagency efforts to address resilience that resulted from Obama administration policies. The project seeks to build existing partnerships into more robust networks. The Initiative supports seven partnerships across the country that seek to increase landscape-scale resilience:

- California Headwaters
- California's North-Central Coast and the Russian River Watershed
- Crown of the Continent in Montana and Alberta and British Columbia, Canada
- Great Lakes—Lakes Huron and Erie Coastal Wetlands
- Hawai'i Resilient Lands and Waters Partnership
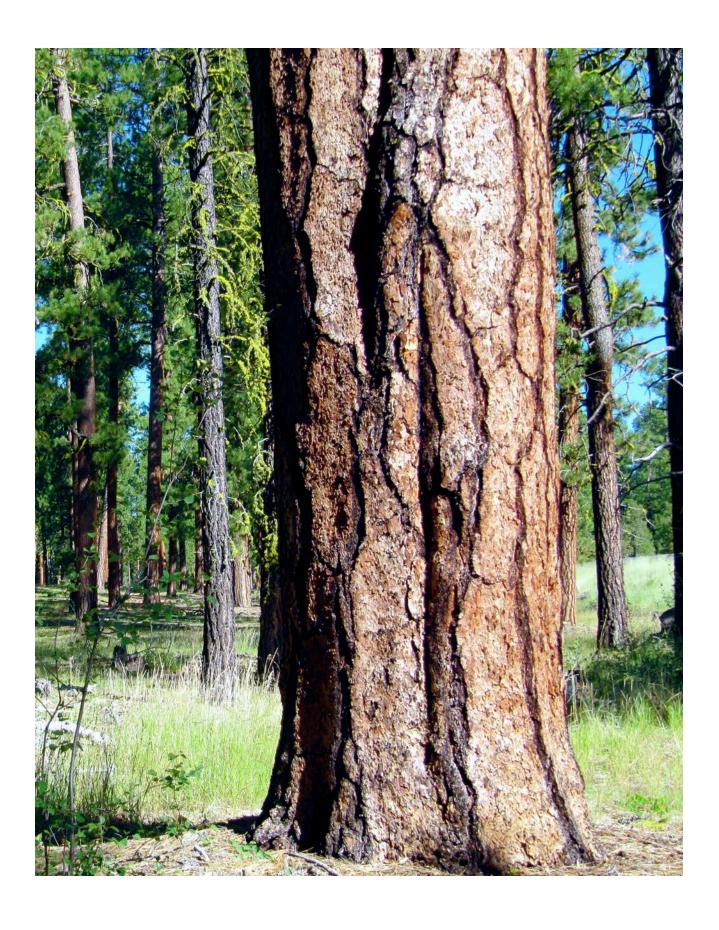- Snohomish River Watershed
- Southwest Florida.

In these initial projects, the diversity and intermixing of mandates, priorities, and knowledge across different entities presented a significant challenge (Resilient Lands and Water Initiative 2016).

NGO place-based resilience guides

Non-governmental organizations (NGOs) have also developed resilience resources for specific forested areas. For example, the Cascade Forest Conservancy has developed The Wildlife and Climate Resilience Guidebook: A Conservation Plan for the Southern Washington Cascades. This guidebook synthesizes scientific literature, local knowledge, and climate projections to make recommendations about restoration and conservation strategies in the region with a focus on the Gifford Pinchot National Forest in Washington State. The guidebook provides an overview of aquatic, forest, and alpine and meadow ecosystems, with recommendations on how to promote the resilience of these ecosystems, particularly as habitat for wildlife. Recommendations include increasing connectivity and expanding protected areas, such as Wild and Scenic River and Wilderness designations. In addition, the guidebook describes how dimensions of forest management contribute to resilient communities. For instance, they note that

stewardship contracting and other activities create employment and visitor spending supports the local economy. Citizen science projects also foster engagement from the public in forest management (Cascade Forest Conservancy 2017).

Another example of a place-oriented resilience guide is the Mount Shasta Bioregional Ecology Center and the Model Forest Policy Program's Renew Siskiyou: A Road Map to Resilience report. This effort outlines goals including promoting water quantity and quality, forest restoration, public health, and partnership-building. The effort provides a series of steps towards resilience (Cook et al. 2014). These place-based resilience resources may help land managers understand the challenge from a different perspective. Furthermore, they may develop partnerships with NGOs producing these reports. However, these sources may not be peer-reviewed and may not reflect statutory and other policy requirements that many land managers face.

Conclusions and recommendations for managers

Using resilience to guide land management planning is promising in light of anticipated change and complexity but can also be challenging. Resilience may be helpful in light of uncertainty associated with climate change, and numerous policies have emerged requiring federal land management agencies to consider resilience when planning for climate change adaptation. Since there are numerous approaches to resilience, it may be challenging to identify an appropriate approach to resilience planning in a particular setting. It is especially important to consider how resilience fits in with other policy and statutory requirements. It is also important to remember that resilience may not always be the most appropriate framework to use; in some cases, resistance or transformation may be preferred. Below, we present conclusions and recommendations for managers based on our review of policy requirements, resources, and the existing debate on resilience. Subsequent working papers will provide additional recommendations pertaining to incorporating resilience into forest planning processes.

Suggestions for resilience planning processes

Following a well-structured and inclusive process is important to resilience planning. This extends to the question of who participates in resilience planning. Partnerships of various types play an important role in planning and executing resilience actions. Policies specific to the Forest Service, such as the Scorecard and Roadmap, also point to science-management partnerships as opportunities to combine scientific and technical expertise with local knowledge (U.S. Forest Service 2011a; U.S. Forest Service 2011b). Managers within the Forest Service may look to the Forest Service's Research and Development Branch, especially its Research Stations, to identify scientist partners. Managers may also consider working with academics at local universities as well as scientists associated with local, regional, and national NGOs. Land manag-

ers may also want to consider whether local communities are working on resilience planning and explore opportunities to partner with these communities. The use of partnerships for resilience planning extends to non-governmental stakeholders, particularly those groups with strong social and economic connections to the management area. For example, local timber companies may be economically reliant on proximate national forests; these companies may offer capacity to national forests for restoration activities. Similarly, water providers and recreation user groups may be especially interested in forest management decisions.

Breaking up resilience planning into specific steps or phases makes the challenge less daunting and more understandable. Furthermore, this approach may help make the process more transparent and accountable to external stakeholders. The CCRF approach includes several steps: define, assess, evaluate, identify, and monitor. The Resilience Alliance approach and the NPS scenario planning approach also use a series of steps. In general, the initial step in the process allows managers to build relationships with partners and to get the lay of the land. That includes defining the system in question, whether that is an ecosystem, national forest or other planning unit, or a community. Then, managers consider key aspects of the system and stressors that may threaten the system, potentially utilizing scenario planning to consider a range of possible trajectories and outcomes. Based on this information, managers may use subsequent steps to plan resilience activities. Following the development and implementation of resilience activities, monitoring is crucial.

These step-by-step processes are cyclical and iterative. It is important to monitor the system and revisit earlier assumptions to modify management activities accordingly. In other words, planning for resilience resembles adaptive management. Partnerships with researchers, managers, and stakeholders are crucial for adaptive management and cyclical resilience planning alike. It is crucial

to recognize the importance of monitoring from the onset of the project as managers may need to set aside funds for monitoring following the implementation of resilience activities.

Suggestions for substantive elements of resilience planning

We now address some key substantive elements to consider when progressing through resilience planning processes. As many resources indicate, it is crucial to define and understand the system in question early in the resilience planning process. Defining the system requires considering the geographic scale of the system, key ecosystem types, important species, and how social components affect the system dynamics. In many situations, policy requirements shape how the system is defined. For example, in land management planning, planning occurs at the planning unit scale—a national forest or grassland, for example. However, depending on the planning entities' priorities, capacity, and legal requirements, another scale or coordination across scales may be more appropriate. It is also important to consider key features—species, ecosystem types, ecosystem services, structural elements, places—for which resilience is a goal. It is equally important to consider how different stressors and processes affect these features of the system. For example, disturbance regimes are key considerations in many systems. Stressors rooted in the social side of the system, such as economic changes, are also worthy considerations.

Climate change may be a separate stressor or it may affect other stressors. Understanding the future impacts of climate change is challenging because projecting the future is inherently uncer-

tain. With regards to anticipating the impacts of climate change, there are multiple different emissions scenarios based on different trajectories of future greenhouse gas emissions. Furthermore, there are several different global climate models (GCMs), which use emission scenarios to identify specific climatic impacts. These GCMs are relatively coarse in spatial resolution. There are several methods for downscaling these GCMs to provide higher resolution information at local scales; however, there are additional uncertainties introduced by using these methods. In short, projecting future climate is quite challenging; thus, partnerships with climate scientists are important for working through some of these challenges. These climate projections may produce numerous projected values for numerous different climate indicators, such as seasonal and annual temperature or precipitation, or snow-water equivalent. An alternate approach to projecting future climate is the scenario development approach used by NPS. Planning for resilience requires identifying different states of a system and how different variables affect whether a system is in a particular state. Furthermore, it is important to identify thresholds that separate different states. As a result, many variables operate with non-linear dynamics. In carrying out planning activities, considering different future scenarios or a range of projected future conditions may help in the identification of management actions applicable across a range of possible futures. Throughout this process, managers will have to consider how to engage various publics in the planning process to leverage their knowledge and resources, to identify the kinds of information that are most relevant to resilience planning, and to ensure that outcomes are considered to be socially relevant and legitimate.

Textbox 5: Key recommendations

There are several key elements of the *process* for resilience planning

- Partnerships with government and academic scientists, other government entities, and stakeholders help provide capacity and a diversity of perspectives to resilience planning.

- Resilience planning should occur over several steps.

- Monitoring and revisiting assumptions helps managers respond to uncertainty; resilience planning is a form of adaptive management.

When resilience planning, managers should consider several *substantive* elements

- Defining the system in question should occur early in the process. What are key ecosystem types, species, stressors, human uses?

- While defining the system, it is important to consider the geographic scale. Geographic scale may correspond to jurisdictional boundaries (e.g., a national forest) or an ecoregion.

- The timeframe (or temporal scale) also matters.

- What are the relevant stressors? Will climate change affect these stressors? Managers are accustomed to managing for disturbances, such as wildfires and insect outbreaks. However, climate change may impact these disturbances. How can resilience help respond to disturbances?

- Understanding the impacts of future climate change is a complicated process with several different decision points. Partnering with scientists may be important in order to identify the most appropriate climate scenarios to inform resilience planning, and other community and NGO partners may provide important resources and perspectives.

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