Chapter 1.3—Synopsis of Emergent Approaches

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This synopsis presents three integrated themes that emerged from synthesizing information about biological resources. These themes become particularly important when managing forests to promote resilience at large landscape scales and long timeframes. This synopsis summarizes ideas in the longer chapter 1.2, "Integrative Approaches: Promoting Socioecological Resilience," by using a concise style in which definitions, citations, and elaboration of some key points are included in endnotes.

The emergent theme for promoting resilience is working with and adapting to dynamic ecological processes at broader scales. From this broad perspective, two integral concepts emerge: (1) restoring fire as an ecological process, and (2) reducing fire hazard while sustaining wildlife habitat and restoring riparian ecosystems. Implementing and testing these concepts may require establishing the proposed demonstration landscapes.

Management practices based upon these concepts would also be improved by considering potential effects on economic, social, and cultural components. Questions that are particularly important for integrating socioecological components include how to select appropriate scales for planning in particular areas (see Cheng and Daniels [2003] and chapter 9.1, "Broader Context for Social, Economic, and Cultural Components"); how to design forest treatments in ways that benefit local communities (see chapter 9.4, "Strategies for Job Creation Through Forest Management," and 9.5, "Managing Forest Products for Community Benefit"); and how to consider local and traditional ecological knowledge and promote participation in monitoring programs (see chapter 9.6, "Collaboration in National Forest Management").

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Managing Forests for Resilience

Increasing forest resilience[7] in the Sierra Nevada will require management strategies that work with and adapt to dynamic ecological processes at broader scales. Current practices often concentrate on containing fire, sustaining large trees, and preserving wildlife habitat, in an attempt to maintain stasis with stand-level management. This approach is fundamentally at odds with dynamics in fire-dependent forests and will constrain rather than facilitate an adaptive response to climate change. Management actions might be better guided by evaluating how well they restore heterogeneous forest conditions that are congruent with how site productivity and historical fire intensity affected local growth and mortality.[8]

Many ecosystems processes[9] are complex and difficult to measure, compelling resource managers and scientists to use surrogate assessments, such as structural condition or indicator species presence. Forest management in the Sierra Nevada has often applied indicators derived from other forest ecosystems, particularly the Pacific Northwest, such as old-growth forest characteristics and spotted owl viability.[10]

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[7] Definitions of resilience have evolved as the concept has been adopted and more widely employed in ecology (e.g., Folke et al. 2004; Holling 1973, 2010; Walker et al. 2004; see chapter 1.0, "Introduction," for this synthesis).

[8] Recent research (Falk et al. 2006a) has stressed that restoration efforts should first assess whether structure, composition, or process measurements may provide the most efficient, albeit indirect, measure of ecosystem condition. A pattern in ecosystems with frequent disturbance regimes (e.g., fluvial plains, fire-dependent forests) is that measurements of disturbance processes are often the most effective metrics of restoration (Falk et al. 2006b).

[9] Ecological processes can be both biotic (e.g., competition, growth, nutrient cycling, etc.) and abiotic (e.g., fire, erosion, flooding, etc.). A general definition is "the physical, chemical and biological actions or events that link organisms and their environment." In many Sierra Nevada forests, the processes that appear to most strongly influence forest structure and composition are fire and site productivity (Lydersen and North 2012). Managing forests so that the conditions produced are congruent with these two processes is likely to maintain and restore other ecosystem processes that are much more difficult to assess.

[10] Management practices in the Pacific Northwest such as clearcutting have truncated forest seral stages, largely eliminating the long disturbance-free period of old forest conditions. This reduced the amount of forest containing large structures and deep, multilayered canopies, putting those conditions and the species associated with them at risk. Management practices in the Sierra Nevada also reduced the number of large trees in many areas, raising concerns for sensitive species associated with these stand attributes. Practices in the Sierra Nevada, however, often did not remove all large, old structures or completely reset forest seral stage. Perhaps a more pervasive management impact has been largely eliminating low-intensity fire, putting frequent change and the forest heterogeneity it produced at risk. The seral stage most imperiled in Sierra Nevada forests is that created by frequent, low-intensity fire.

Managers and scientists still have much to learn about frequent-fire forests in the Sierra Nevada by looking to active-fire regime landscapes within its borders (e.g., Illilouette Basin in Yosemite National Park, Sugarloaf Basin of Sequoia and Kings Canyon National Parks, Beaver Creek Pinery in the Ishi Wilderness) (Collins et al. 2007, 2008; Collins and Stephens 2010; Taylor 2010) and to the south (i.e., Sierra San Pedro Mártir in Mexico) (Stephens 2004, Stephens and Fry 2005, Stephens and Gill 2005, Stephens et al. 2007). The research that has come from these areas is probably more directly applicable to Sierra Nevada forest dynamics than is some of the information from the infrequent disturbance and relatively mesic conditions of Pacific Northwest forests west of the Cascade Range.

Indicators from other regions, such as old forests in the Pacific Northwest, which have profoundly different disturbance regimes and climate, are unlikely to be congruent with the reference heterogeneity and dynamism of Sierra Nevada forests. Because current old growth and spotted owl nesting habitat will change, proactive management can plan for creating these conditions in future forest landscapes.

An emphasis on these indicators has often focused management at the stand scale, which can then get bogged down in identifying optimal forest structure on an acre-by-acre basis. Terrestrial treatments at fine scales may also be insufficient for addressing watershed and aquatic ecosystem processes on a scale effective for restoration. When desired habitat is managed at the scale of individual parcels, it can lose sight of the major ecological processes (e.g., growth, mortality, disturbance) that will continue to shape the larger landscape. These dynamics can render forest plans with static structural and habitat goals obsolete by the time they complete public and administrative review.[11] The new planning rule directs national forests to embrace and accommodate ecosystem change.[12]

Research suggests that a prudent approach may be to increase forest landscape heterogeneity at multiple scales with management practices that promote the structure and composition that might have been produced by historical, frequent fire disturbance.[13] Sierra Nevada managers have been experimenting with principles from PSW-GTR-220 (North et al. 2009), such as using existing stand conditions and topography as a template to vary treatments while meeting fire hazard reduction, wildlife habitat, and forest restoration objectives. This approach is consistent with recent research showing that topography, site productivity, and fire history interact to influence burn intensity and forest heterogeneity.[14] Many modern forests are relatively homogenous, with much higher stem density and canopy cover than

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[11] Wildfire, beetle mortality, and drought stress often change forest condition, but change in wildlife habitat designations do not always follow suit. For example, managers cannot decommission or retire PACs once they are established if there has not been "significant" change to the habitat, even if the PAC becomes unoccupied by owls. There is currently no threshold that defines "significant" change, leaving it unclear whether the designation should remain after moderate changes to habitat conditions that are common in dynamic ecosystems.

[12] Final Planning Rule, Section 219.8 (Sustainability): "The plan must provide for social, economic, and ecological sustainability within Forest Service authority and consistent with the inherent capability of the plan area, as follows… iv) System drivers, including dominant ecological processes, disturbance regimes, and stressors, such as natural succession, wildland fire, invasive species, and climate change; and the ability of terrestrial and aquatic ecosystems on the plan area to adapt to change."

[13] See North et al. (2009) and North (2012).

[14] See Lydersen and North (2012).

existed under an active fire regime.[15] Unless treated, these conditions will limit forest resilience to drought and climate change. Management activities that reduce stem density and move forests toward the range of conditions that would result from natural interactions between frequent fire and varying site productivity are likely to improve landscape resilience to both acute (e.g., high-severity wildfire, drought, etc.) and chronic disturbances (e.g., understory burning, climate change, bark beetles, air pollution, etc.).[16]

Management Implications

- Forests managed to be congruent with what potential fire behavior and site productivity would produce will be more in sync with the two dominant processes—growth and mortality—that fundamentally shape Sierra Nevada forests.[17]
- Practices suggested in PSW-GTR-220 and discussed in PSW-GTR-237 may help create these conditions and increase the landscape heterogeneity needed for resilient terrestrial and aquatic ecosystems.

Restoring Fire as an Ecological Process

Restoration of fire as an ecological process is the most efficient means of promoting forest resilience and rejuvenating aquatic habitat in much of the Sierra Nevada.

Wildfire is a major catalyst through which the effects of a changing climate will be expressed (fig. 1). Managing fire in contemporary forests riddled with human development has significant risks. Notwithstanding these concerns, restoration of fire as an ecological process is the most efficient means of promoting forest resilience and rejuvenating aquatic habitat in much of the Sierra Nevada. In addition, there are large portions of wildland landscapes (e.g., steep slopes, wilderness, roadless areas, etc.) where mechanical treatment is infeasible. Thinning will be a substantial component of forest treatments; however, it is important to consider how fire might be used

[15] An example: by one estimate (Forest Service Westcore data), tree density on Forest Service land averages 280 stems/ac. In contrast, Lydersen and North (2012) found stem densities ranging from 45 to 134 stems/ac on ridge and lower slope stands, respectively, in old-growth mixed conifer with restored fire regimes. They also found canopy cover ranged from 19 to 49 percent on ridges and midslope stands, respectively. We are not aware of any estimate of average canopy cover for the Sierra Nevada, but observation suggests current conditions are usually much higher and lack spatial variability.

[16] Betancourt (2012) suggested that landscape heterogeneity decreases the probability of synchronous high-intensity disturbance over large scales. In frequent-fire forests, some processes (e.g., seed dispersal and microclimate amelioration) and forest conditions (plant and animals that require undisturbed refugia) may not be resilient to large increases in the patch size of high-severity fire.

[17] There is not a single structural condition that would always be produced by a set fire behavior. Rather, variation in weather and fuel conditions at the time of burn is likely to produce a range of outcomes that would give management general bounds within which to define a desired condition.

Figure 1—2008 wildfire in the Marble Mountain Wilderness that had a range of fire severities creating postburn heterogeneity.

rather than preemptively dismissing it as impractical. To increase the pace and scale of fuels reduction and forest restoration, management may need to enlarge project areas and incorporate fire at broad scales. This effort will involve expanding burn windows, and in some instances, targets for allowable fire-caused tree mortality.

Fire must be controlled in areas near homes, but in much of the forested wildlands, there are opportunities for wider use of fire for fuels reduction and forest restoration. Current rates of fuels reduction, even when wildfire is included regardless of severity, treat less than 20 percent of the area that may have burned historically each year in the Sierra Nevada.[18] Research suggests that outside of the wildland urban interface[19] (WUI) a more practical objective is to reduce adverse

[18] See North et al. (2012).

[19] In the Healthy Forests Restoration Action of 2003, the WUI is defined as up to 1.5 mi from communities at risk or as defined in individual community fire protection plans.

The pace, scale, and restoration benefits of fire would be significantly increased if national forests identified large, contiguous blocks of forest to be treated, and then moved these blocks out of fire suppression to be maintained with prescribed and managed wildfire.

fire effects and intensity rather than occurrence and size.[20] A recent comparison of fire severity and size between Forest Service and Yosemite National Park lands found that the park's policy of allowing most lightning fires to burn relatively unimpeded under a range of fire weather conditions had achieved fire patterns that were closer to desired historical conditions.[21] The pace, scale, and restoration benefits of fire would be significantly increased if national forests identified large, contiguous blocks of forest to be treated, and then moved these blocks out of fire suppression to be maintained with prescribed and managed wildfire (fig. 2).[22] Outside of the WUI, forests could be zoned for a range of wildfire responses consistent with desired effects and made a priority for managed fire use.[23] More creative and flexible ways of working with fire could help achieve restoration objectives. Greater use of wildland fire will require continued interagency coordination (especially between land management and air quality regulatory agencies), strategic monitoring, robust science-management partnerships, and increased support of fire management programs from agency leadership and the general public. Approaches that focus primarily on containing fire through suppression, regardless of burning conditions, sacrifice opportunities for using fire for ecological benefits and promise more dangerous and more destructive fires in the future.

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[20] See Reinhardt et al. (2008).

[21] See Miller et al. (2012).

[22] Recent research (Ager et al. 2012b, 2013) has developed models for optimizing fuels treatment locations across a landscape to facilitate managed wildfire and prescribed fire use, rather than the traditional allocation designed to aid suppression.

[23] Dellasala et al. (2004) suggested a comparable three-zone approach.

Marc Meyers

Figure 2—Variable forest structure produced by a restored fire regime in Sugarloaf Valley, Sequoia-Kings Canyon National Park.

Management Implications

- In mid-elevation forests, use of frequent, low- and moderate-intensity fire is the most effective management practice for restoring forest resilience in the advent of climate change. Treatment prescriptions could often be guided by what is needed to restore fire to the area.
- Outside of the WUI, each national forest could zone areas for different fire responses (e.g., let burn and monitor, containment but not suppression, allow surface but not crown fire, etc.) under specified weather percentile conditions.
- More remote firesheds could be identified, fuels treated in strategic locations, and desired conditions maintained by prescribed fire and managed wildfire.

Demonstration Landscapes for Reconciling Fuels Treatment, Wildlife Habitat, and Riparian Restoration

Current practices and regulations make it difficult to manage forested landscapes for broad-scale processes. Forest planning often involves a patchwork of designations; for example, the Sierra Nevada Forest Plan Amendment includes protected activity centers, habitat conservation areas, and riparian conservation areas) within which forest practices are limited. Management decisions under these constraints often becomes triage, with treatments opportunistically targeting forests with the highest fuel loads that do not face operational or stakeholder barriers. Proactive, integrated landscape management will be needed to effectively reduce fire hazard while providing immediate and long-term wildlife habitat and restoring riparian ecosystems. Exploring this may require relaxing some of the constraints, on an experimental basis, in demonstration areas. The intent is to test how habitat for sensitive species can be maintained and improved across a landscape without using spatially explicit protection or buffer areas. To date, management and research have not collaborated and experimented on the scale needed to examine how treatments that promote forest resilience can be reconciled with the provision of sensitive species habitat and riparian restoration. Without taking that step, it may be impossible to effectively manage Sierra Nevada forests at a scale that is consistent with some species habitat use patterns or the ecological processes inherent in these forests. The body of research, much of it recent, supports this approach and provides a solid foundation for moving forward. Demonstration landscapes might be identified where a collaborative team would define a desired condition, and management would be planned and implemented at a broad scale while relaxing constraints on current forest practice designations.

Recent success with several collaborative projects in the Sierra Nevada suggests some institutional structures that may facilitate success. First, effective broad-scale management efforts could be based on a collaborative process.[24] A key to successful collaboration is that participants define a desired condition and identify immediate and long-term objectives.[25] Second, science-based monitoring and its active incorporation in adjusting management practices are essential both for course correction and as a means of building trust and cooperation. A third guideline is the inclusion of rural community concerns and economic factors in decisionmaking. Landscape management requires public support, and for long-term viability, a self-sustaining economic base. Projects that cultivate stakeholder and community involvement, and plan for generating sufficient revenue to support long-term management objectives, could weather shrinking budgets and steadily fund monitoring that better accomplishes broad-scale restoration.

Management actions aimed at restoration of dynamic, broad-scale processes that produce a range of vegetation conditions similar to those under which Sierra Nevada ecosystems evolved should help to conserve coarse-scale terrestrial and aquatic biodiversity.

Although principles in PSW-GTR-220 suggest a general approach (North et al. 2009), optimal management of a landscape for all wildlife species while reducing fire hazards is still in a developmental stage. Current policy focuses on sensitive species and is weighted toward maintaining and creating high canopy cover, old-forest conditions. This fine-filter approach does not adequately consider the habitat needs of a broader range of species and the shifting dynamics in frequent-fire forests. Management actions aimed at restoration of dynamic, broad-scale processes that produce a range of vegetation conditions similar to those under which Sierra Nevada ecosystems evolved should help to conserve coarse-scale terrestrial and aquatic biodiversity. For terrestrial wildlife, this approach would include developing variable habitat conditions for species associated with different seral stages, from primary disturbance conditions (i.e., black-backed woodpecker and postfire habitat-associated species), to early succession (fox sparrow, deer, etc.), through old-forest conditions, and the diversity of prey species upon which top trophic predators depend. For riparian ecosystems, reductions in forest density and judicious fire

[24] Collaborative teams by definition strive for consensus. However, it is not always possible to get 100-percent agreement. Effective and efficient collaboration may hinge on eventually voting on some issues and then moving forward following the majority's intent (Bartlett 2012).

[25] There are several collaborative groups that have made significant progress and can provide practical lessons, including all three collaborative forest landscape restoration programs, the Dinkey Landscape Restoration, the Amador-Calaveras Consensus Group Cornerstone, and the Burney-Hat Creek Basin. Sagehen Experimental Forest has also had tremendous success with its collaborative efforts, including the implementation of demonstration plots to help visualize treatment options.

Box 1.3-1

An Adaptive Management Proposal to Evaluate Tolerance by Fishers for Disturbance

A reasonable hypothesis to be tested in an adaptive management framework is whether fishers can tolerate fuels treatments up to the levels that may be needed to reduce risk of uncharacteristically severe wildfire at the landscape scale. Fishers have evolved with the effects of fire on their habitat, yet it is uncertain how much disturbance via fire and fuels treatment they may tolerate. Researchers on the Sierra National Forest,[26] however, have surveyed multiple study areas equivalent to the average size of a female fisher home range (approximately 13 km^2 [5 mi^2]) and evaluated the percentage of those areas that were covered by treatments, including a combination of prescribed fire, thinning, salvage logging, and other forms of timber harvest, over 3-year periods (a reasonable estimate of fisher generation time). Evaluation of these data could suggest levels of treatment per year that might be tolerated by fisher, and those levels could be compared to the areas that modeling results suggest need to be treated to reduce the likelihood of unacceptably large, high-intensity fires (10 to 25 percent of a landscape over a 5- to 10-year period) (Ager et al. 2007, 2010; Finney et al. 2007; Schmidt et al. 2008; Syphard et al. 2011). To be cautious, the area treated should account for the relative suitability of habitat patches as well as their contribution to fisher habitat conditions within the local area. For example, impacts to fishers may be too great if treatments target important patch types in a poor quality home-range area; this is in contrast to treatments that target less important habitat patches in a higher quality home-range area. This approach remains a hypothesis to be tested, but the proposed rate and extent of disturbance in fisher habitat may permit the coexistence of fishers with a rate of application of fuels treatments that will also protect their habitat from loss from high-intensity fire. Fishers may tolerate such a rate, especially because the fraction of the landscape needed to reduce wildfire risk may only partially coincide with occupied fisher areas. It is important to caution, however, that this proposal represents the desire to create a starting point for collecting new information that can evaluate its merit. This proposed guideline needs to be tested in an adaptive management framework and to be integrated with other emergent approaches.

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[26] Thompson, C.M.; Purcell, K.L. 2013. Unpublished data from fisher study. On file with: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station, Forestry Sciences Laboratory, 2081 E. Sierra Avenue, Fresno, CA 93710-4639.

use[27] could enhance soil water balance and help restore stream microclimate, nutrient, and sediment processes that support aquatic diversity. The heterogeneity of conditions within Sierra Nevada riparian areas suggests delineating riparian management zones using scalable widths based upon soil moisture, geomorphic settings, and other local landscape characteristics.

As forest management strategies place more emphasis on a coarse-filter approach to biodiversity, sensitive species populations presently at risk still need to be maintained or increased. Monitoring of sensitive species while treatments are implemented would help to evaluate impacts and provide for course corrections (see box 1.3-1 for a suggested approach in fisher habitat). Recently developed fisher and spotted owl habitat models[28] can be used to evaluate different management alternatives and their expected influence on current and future habitat conditions. These analyses would include designing and maintaining habitat connectivity[29] across a dynamically changing landscape.

Practices in demonstration landscapes would be considered experimental and subject to initial evaluation against the best available sensitive species habitat and fire behavior models, and longer term evaluation from monitoring results.

Management Implications: Demonstration Landscapes

- Establish demonstration landscapes with an objective of restoring ecological processes and resilience while maintaining safeguards to minimize the loss of ecosystem services and habitat in the short term.
- When necessary, constraints on management practices from land use designations could be relaxed to achieve landscape resilience objectives. These practices would be considered experimental and subject to initial evaluation against the best available sensitive species habitat and fire behavior models, and longer term evaluation from monitoring results.

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[27] Recent research suggests that riparian forests on many first- and second-order streams in the Sierra Nevada may have had fire regimes comparable to adjacent uplands (van de Water and North 2010, 2011). This reinforces the idea that riparian areas should not be set aside when designing landscape-level treatments.

[28] See Ager et al. (2012a), Gaines et al. (2010), Thompson et al. (2011), and Zielinski et al. (2010).

[29] Forest conditions that facilitate landscape connectivity vary between species, making it difficult to plan and manage “corridors” for an array of wildlife. Riparian areas have an important function as corridors, as research suggests that even under an active fire regime, historical riparian forests had higher stem density and canopy cover than upland forests (van de Water and North 2011). To maintain this high-cover corridor and avoid wildfire wicking, riparian forests could become a priority for light fuels treatment (i.e., surface and small ladder fuels). A more sophisticated approach, albeit focused on forest carnivores, is the multiple species habitat connectivity modeling that is nearing completion (collectively for Pacific fisher, marten, wolverine, and Sierra Nevada red fox) (Spencer and Rustigian-Romsos 2012). This effort received input, over several years, from species and connectivity modeling experts. Another more explicit modeling approach of note is the California Essential Habitat Connectivity Project (Spencer et al. 2010), which produced a coarse level of wildlife connectivity statewide.

- Demonstration landscape boundaries could be identified based on fireshed concepts (i.e., 100,000 to 200,000 ac in size) to be consistent with the scale of the dominant process, fire.[30]
- These landscapes might be established in areas with extensive ongoing monitoring or research (e.g., spotted owl demographic study areas, southern Sierra fisher occupancy monitoring area, instrumented watersheds, etc. [see fig. 1 in chapter 1.5]). This strategic placement would significantly reduce costs and "startup" time because long-term baseline data are available at these sites.
- Desirable locations could include places without large WUIs or checkerboard ownership; places near wilderness or National Park Service lands to provide a buffer for species and a comparison landscape with less intensive active management. Once located, strong commitment and innovation would be needed from local Forest Service leadership.
- Create a collaborative team among managers (including the Regional Ecology program), stakeholders, and research scientists to develop a desired condition for the demonstration landscape and a science-based, question-driven monitoring program[31] to inform and modify management with updated information.

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[30] The primary intent is to manage the entire landscape to a condition where it is resilient to ecosystem stress, particularly fire, drought, and large bark beetle infestations. Widespread reintroduction of fire is the best means to build this resilience. All areas in the landscape could be managed collectively to achieve landscape-level resilience, although some areas may not need active treatment. For example, an area that is too steep for mechanical treatment and has low or moderate fuel loads may not currently be a priority for treatment, but it could be included within plans for managed wildfire or an adjacent prescribed fire. Similarly, some areas that are naturally more resilient owing to their moist conditions or shaded aspects (i.e., north- and east-facing slopes and some riparian areas) may also not be priorities for treatment.

[31] The science-based, question-driven monitoring program in Appendix E of the Sierra Nevada Framework could be updated to more fully address the social dimensions of socioecological resilience. Monitoring that evaluates the effects of management decisions on socioecological resilience might (1) reflect relevant ecological, social, and economic processes in a "triple bottom line" framework; (2) use metrics that are quantifiable, reasonably available to managers, and within the scope of management influence; (3) incorporate concerns of scientists, managers, and local experts; and (4) be linked to potential changes in management based upon the results of monitoring.

Monitoring plans could be centered on a coarse-filter approach to evaluate landscape-scale habitat patterns and ecological processes, but could include some fine-filter monitoring to ensure that at-risk species are being conserved. Integrating modeling with monitoring of field conditions could help evaluate how ecosystems are changing at broad scales where experimentation may be impractical. Modeling would be an important component of developing and adjusting an adaptive management strategy. Predictive habitat models could be integrated with silvicultural and fire models. Tradeoffs between treating new areas and maintaining existing areas would need to be considered using models to account for costs of treatment, changing fire conditions, and other factors.

- Planning for desired conditions accounts for long-term, large-scale context. Objectives for smaller areas, such as stands or stream reaches, are identified in the context of the entire landscape and over a long timeframe (e.g., see sidebar in chapter 2.1, "Forest Ecology").
- As a general treatment implementation guide, models in fire (FARSITE/FlamMap), wildlife (fisher and owl habitat trajectory), and forest restoration (PSW-GTR-237 ArcGIS LMU macro) could be used to project and plan future conditions.
- Use prescribed fire and managed wildfire wherever possible to most effectively achieve or maintain ecosystem resilience.
- For long-term sustainability, many projects would need to generate their own revenue and support local economies. Without compromising ecological integrity, economic and social factors need to be explicitly included in planning, monitoring, and management to ensure long-term viability.

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