Executive Summary

Objective

This synthesis distills important findings from recent studies to help inform managers, stakeholders, and others interested in promoting socioecological resilience in the Sierra Nevada and southern Cascade Range. As national forests are undertaking revision of land and resource management plans, there is an important opportunity to review existing science while charting directions for ecosystem management. Information was synthesized and structured to examine concepts and issues that cut across science disciplines, address relevant challenges holistically, and identify gaps in previous research. The synthesis considers both terrestrial and aquatic systems, and discusses interconnections between social and ecological components and processes.

Focal Area

The forested mountains of the Sierra Nevada, the southern Cascade Range, and the Modoc Plateau (fig. 1) are the focus of this report. Some specific ecological examples may not be applicable to drier landscapes in the eastern rain shadows of the mountains, which are more representative of the Great Basin. However, the appendix includes references to recent and relevant integrative science reports, including a 2013 synthesis to support land management in southern Nevada.[1]

Socioecological Resilience and the Planning Rule

An overarching question guided the development of the synthesis:

> Based on recent scientific advances, what management strategies are likely to promote resilience of socioecological systems and sustain values-at-risk in the synthesis area over the short and long term given expected stressors?

A socioecological system is a dynamic association of biophysical and social factors that regularly interact and continuously adapt to regulate flows of critical resources, such as biodiversity, water, nutrients, energy, materials, infrastructure, and knowledge. This framework also addresses two key ideas in the 2012 Forest Planning Rule:

- Pursuing "opportunities for landscape scale restoration," and
- Emphasizing "wildland fire and opportunities to restore fire-adapted ecosystems."

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[1] Chambers, J.C.; Brooks, M.L.; Pendleton, B.K.; Raish, C.B., eds. 2013. The southern Nevada agency partnership science and research synthesis: science to support land management in southern Nevada. Gen. Tech. Rep. RMRS-GTR-303. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 207 p.

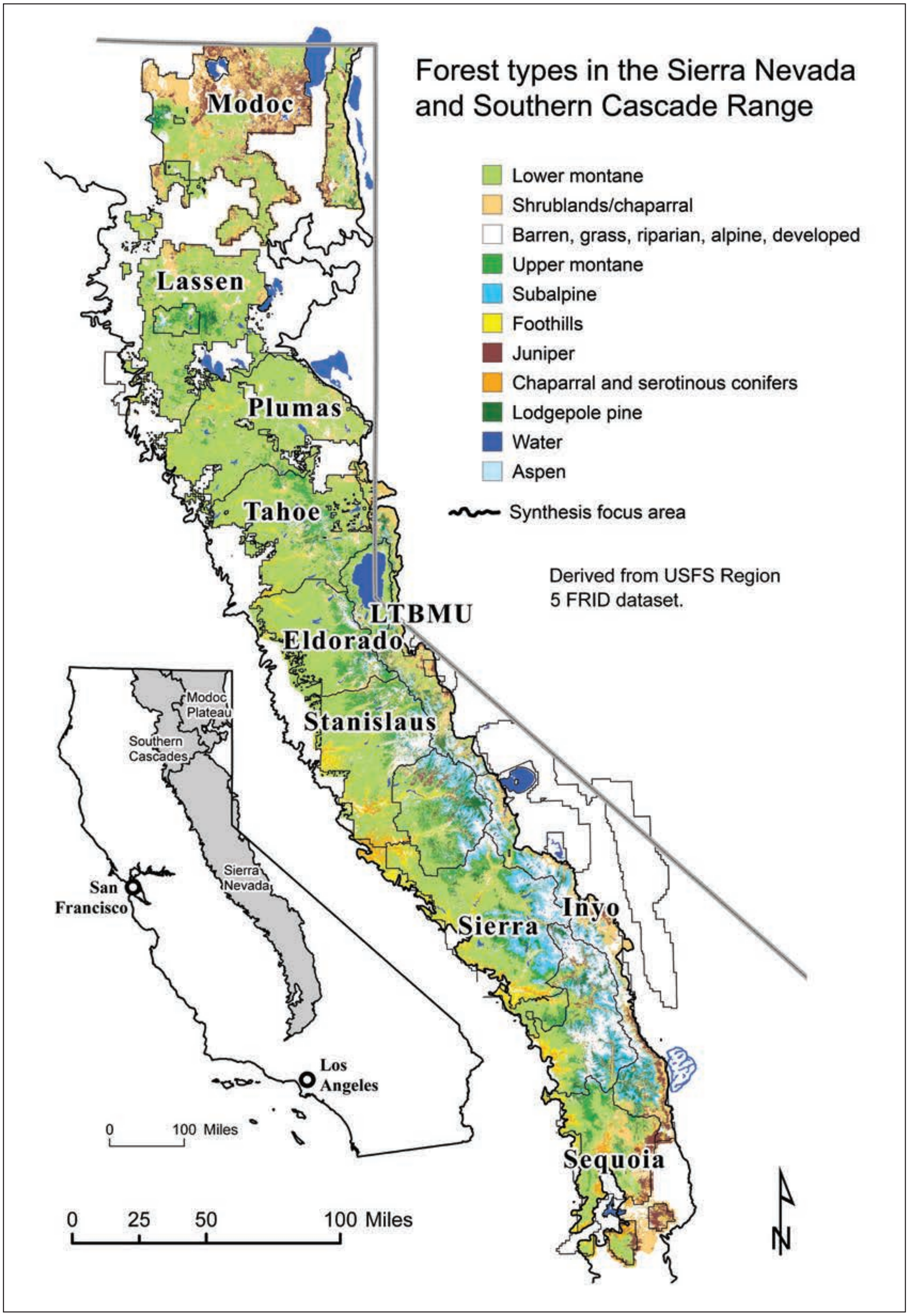

Figure 1—Focal areas of the ecological portions of this synthesis are the conifer-dominated forests in the mountains of the Sierra Nevada, southern Cascade Range, and Modoc Plateau. LTBMU = Lake Tahoe Basin Management Unit.

Stressors

Examples of widespread stressors to socioecological resilience include, but are not limited to:

- Changing climate, associated with warming temperatures and shifts in precipitation from snow to rain.
- Fire deficit and fuels build-up across nearly 3 million acres in the Sierra Nevada.
- Air pollution, including nitrogenous compounds, ozone, mercury, and black carbon.
- Terrestrial and aquatic pathogens and invasive species.
- Demographic, economic, and social changes, including demand for ecological services within the region and from areas farther removed.

These stressors are expected to push systems toward novel conditions that require forward thinking about reference conditions and evaluation of synergistic effects. An example that illustrates the effects of interacting stressors is the decline of endemic amphibians in high-elevation lake ecosystems, which have been affected by stocked fish species and chytrid fungus, and may also be threatened by air pollution and climate change. A terrestrial example is white pine blister rust, an introduced disease that interacts with changes in tree density and forest composition, climate change, and management actions such as tree planting. Monitoring, modeling, field experiments, and proactive adaptive management will be needed to evaluate long-term system response to stressors and interventions.

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A key point of this synthesis, and many other works that have preceded it, is the primary role of fire in shaping the forest's structure, composition, and ecological processes before the 20th century. Since that time, there has been a substantial increase in fuels and a shift in the fire regime toward less frequent, more severe burns in the mixed-conifer and yellow pine forest types that predominate across much of the synthesis area. Despite efforts to suppress it, fire will continue to serve as a catalyst that changes the landscape during periods of rapid climate change.

Integrative Strategies to Promote Socioecological Resilience

Three major themes are identified that are essential for socioecological resilience: integrating considerations of social well-being, promoting more natural ecological disturbance regimes, and adopting an adaptive management framework that promotes social learning.

1. **Integrating social and ecological considerations—**
   - Identifying important socioecological values and promoting societal well-being: In treatment design, consideration of larger societal well-being, including impacts on local communities and economies, can help identify opportunities to facilitate joint social and ecological benefits. Ecosystem services such as biodiversity and habitat, waterflows, forest products, traditional cultural resources and associated livelihoods, and a sense of place are important in promoting resilience. More integrated and applied research is needed to better understand many of these values and potential tradeoffs among different management approaches.
   - Reducing vulnerabilities to major disruptions: Although patches of high-severity fire can be locally important for rejuvenating systems, very large, severe, and dangerous wildfires have short- and long-term social, economic, and ecological impacts (fig. 2), including impacts to human health; degradation of soil, water, and habitat quality; and losses of wood products and stored carbon.
   - Building upon existing community capacity and cultivating trust: The capacity to mitigate and adapt to these risks depends on strategies that address various scales, complex layers of socioeconomic and sociocultural values and concerns, and institutional boundaries and constraints. The importance of cultivating trust and engaging diverse stakeholders in

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Brian Smithers

Figure 2—The Rim Fire on the Stanislaus National Forest and in Yosemite National Park became the premier example of an uncharacteristically large fire burning under severe conditions in the synthesis area in August and September 2013. It produced a number of immediate effects including evacuations, loss of property, poor air quality, and impacts to infrastructure that went beyond the synthesis area.

Jonathan Long

Figure 3—Tending practices, including frequent use of fire, that Native Americans have applied to California black oaks demonstrates ways to meet needs of humans and wildlife while sustaining productive forests that are resilient to wildfire.

decisionmaking processes has been demonstrated. Incorporating traditional and local ecological knowledge and facilitating social learning are important strategies for promoting resilience to stressors that may also build upon existing community capacity. For example, collaboration with tribal communities has revealed how traditional burning practices can promote ecological and social benefits (fig. 3).

2. **Restoring reference disturbance regimes and heterogeneity at multiple scales—**
    - Research indicates that strategic placement of treatments to reduce hazardous fuel accumulations and to restore fire as an ecosystem process within large landscape areas can reduce the risk for undesirable social and ecological outcomes associated with uncharacteristically large, severe fires, including impacts to wildlife species of concern.
    - Targeting and designing treatments based upon reference disturbance regimes and ecological trajectories can reduce impacts from severe wildfires in areas where interventions may be contentious, including forested riparian areas, wildlife core areas, postfire landscapes, and upper montane forests; however, more research is needed, especially on long-term effects of interventions in these systems.
    - In terrestrial systems, application of fire in concert with silvicultural treatments can reestablish fire regimes and heterogeneity at multiple scales (fig. 4). Using combinations of indicators that relate to key processes at various scales (for example, fire return interval and patch size of high-severity fires at broad scales, and heterogeneity of stand structure and fuels at finer scales) can help to evaluate restoration progress.

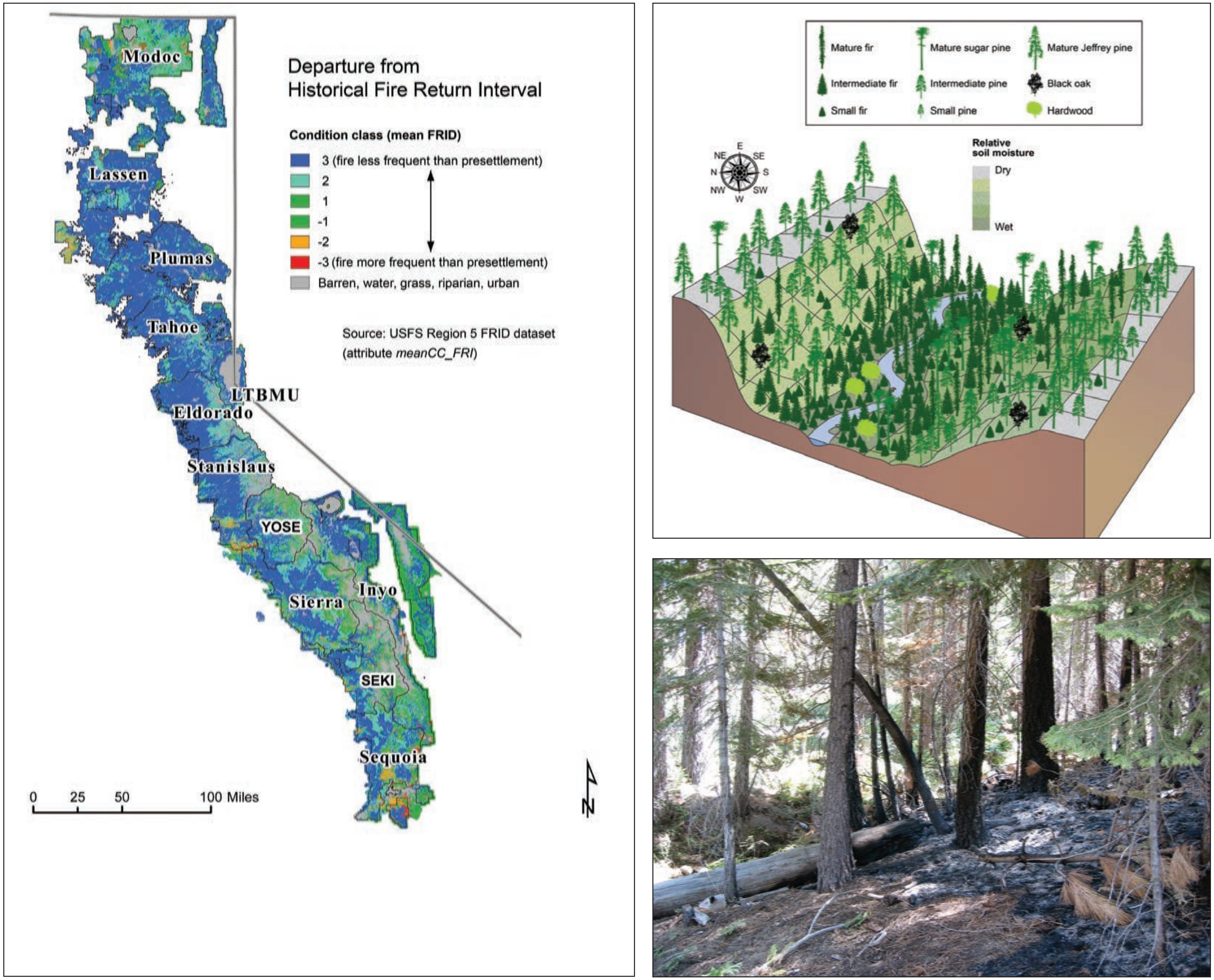

Figure 4—Heterogeneity can be promoted at different scales based upon fire regimes (left), topography (top right), and fuels (bottom right). LTBMU = Lake Tahoe Basin Management Unit. YOSE = Yosemite National Park. SEKI = Sequoia-Kings Canyon National Parks. Map by Ross Gerrard.

- In aquatic systems, restoration efforts aim to support native food webs and promote dynamic but resilient systems that benefit from reference disturbance regimes, including both fire and flooding.

3. Applying strategic treatment at a landscape scale with adaptive management—

- Using large (40 000- to 80 000-ha [100,000- to 200,000-ac]) experimental areas: Most existing experimental areas (fig. 5) are too small to evaluate dynamics of wildlife with large home ranges. Within larger experimental areas, modeling tools (already developed for fisher and in progress for owl habitat) and existing datasets (southern Sierra Nevada fisher occupancy and owl demographic studies) could be used to evaluate effects of both treatments and wildfires on wildlife species with large home ranges.
- Evaluating active treatments for riparian and wildlife zones: Science generally supports the need to treat some riparian and core wildlife zones to restore fire regimes and resiliency. Continuing research is needed to evaluate what levels of treatment yield net benefits or neutral impacts to wildlife species and aquatic resources.
- Applying a phased approach to treatment, combining the use of wildfire, prescribed fire, and silviculture: Designing treatment strategies to promote desired values across large landscapes, while targeting fuels reduction treatments into specific portions of those landscapes, can be more efficient and allow more areas to be moved out of fire suppression into a fire maintenance regime. These approaches facilitate the reestablishment of fire as an ecological process. Under this approach, there would still be a substantial need for mechanical thinning in other areas, which would ensure a continuing supply of wood and economic returns to facilitate restorative treatments. A strategic approach (already underway in some areas) would include three phases:

    1. Strategic defensive fuels reduction.
    2. Restorative treatments in a fraction of the landscape (there is a need to evaluate the extent of such treatments using models in an adaptive management framework).
    3. Maintenance of previously treated areas and extension of treatment across the landscape using managed wildfire, with additional understory burning and mechanical treatments as needed, and with adaptation as wildfires and climate change alter conditions and risks.

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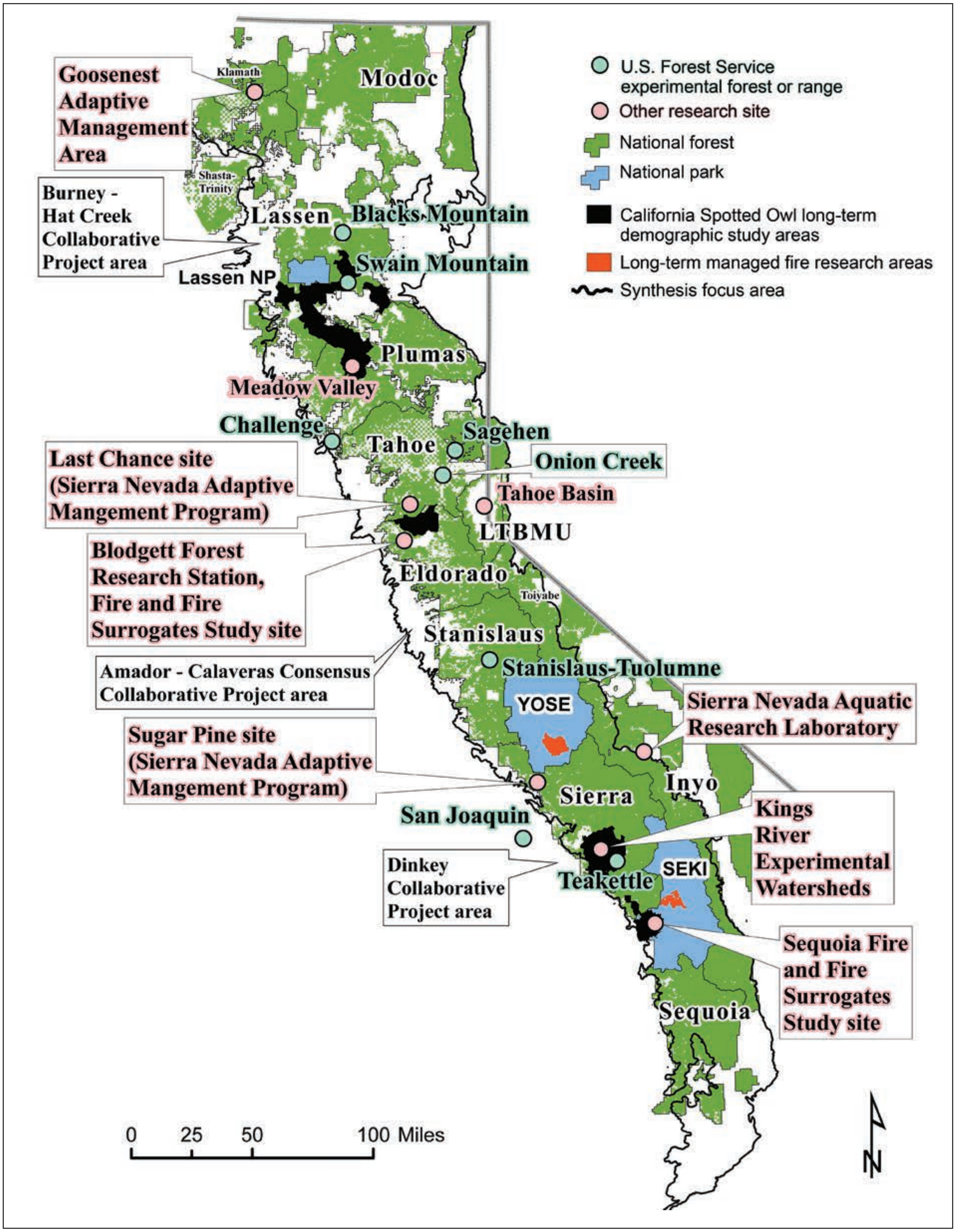

Figure 5—Owl demographic study areas (in black) are much larger than existing experimental forests, so they can facilitate efforts to evaluate landscape-scale effects on wildlife. LTBMU = Lake Tahoe Basin Management Unit. YOSE = Yosemite National Park. SEKI = Sequoia-Kings Canyon National Parks. Map by Ross Gerrard.

Multiple fires with high severity have potential for both short- and long-lasting impacts to ecological trajectories, watersheds and streams, socioeconomic values, and wildlife.

- Facilitating integrated ecosystem management by addressing cross-cutting research gaps: Success in promoting well-being in socioeconomic systems will depend not only on considering the condition of terrestrial, aquatic, and human systems in broad terms, but also on understanding the effects of management actions over long periods, particularly following major change events such as wildfires (including postfire treatments such as salvage logging). Multiple fires with high severity have potential for both short- and long-lasting impacts to ecological trajectories, watersheds and streams, socioeconomic values, and wildlife (fig. 6).

Scott Stephens

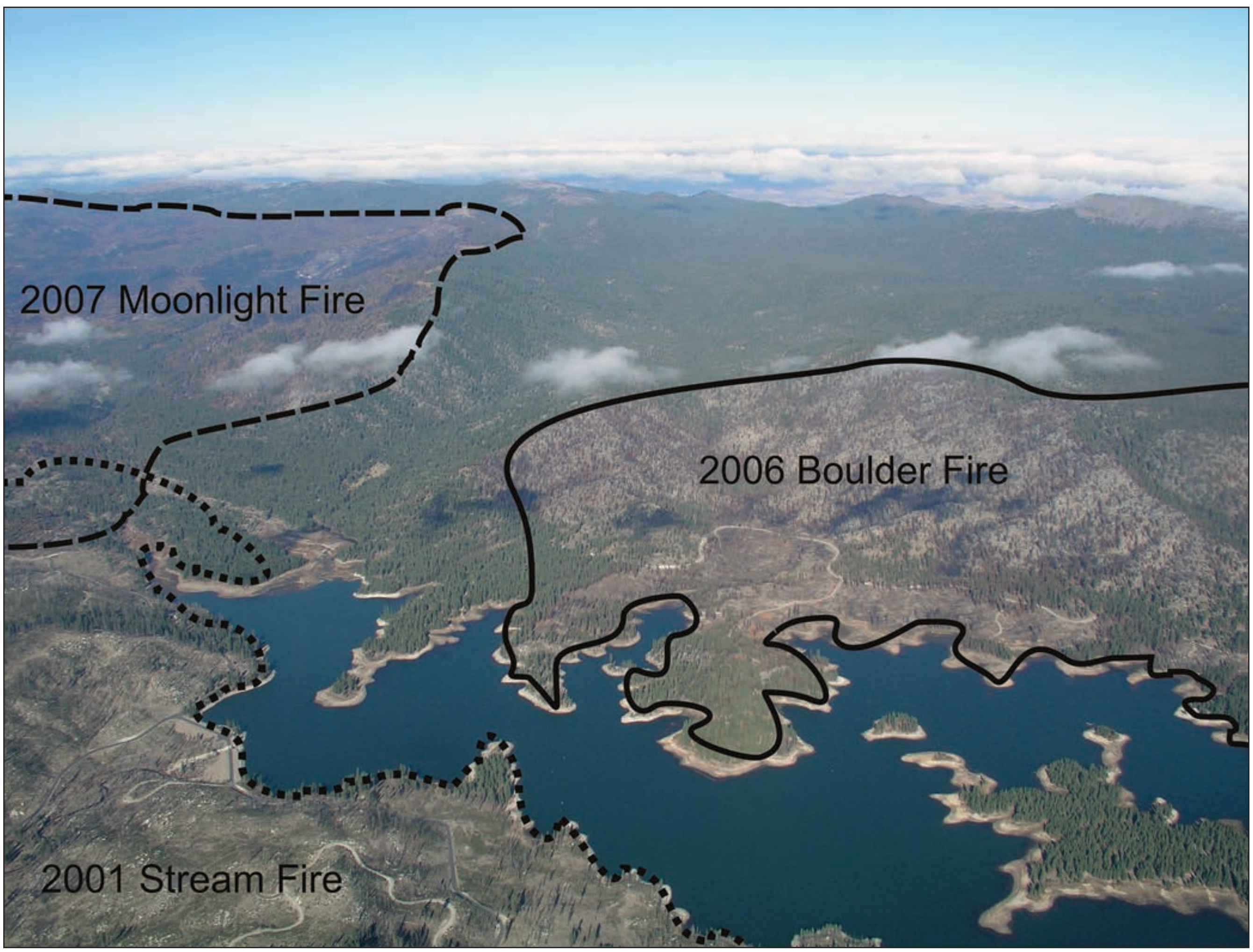

Figure 6—Multiple fires have burned large patches with high severity in the watershed of Antelope Lake. Fire boundaries illustrated by Brandon Collins.