Chapter 15: A Desired Future Condition for Sierra Nevada Forests

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Introduction

An unexpected outcome of U.S. Forest Service General Technical Report PSW-GTR 220, "An Ecosystem Management Strategy for Sierran Mixed-Conifer Forests" (North et al. 2009), was how it generated discussion about a desired future condition for Sierra Nevada forests. The paper did not convey leading-edge research results or provide an exhaustive literature review. Rather it was an effort to take findings generally accepted amongst scientists, and synthesize them into a conceptual model for how Sierra Nevada forests might be managed. When the GTR has been used in implementing projects, the conceptual model often generates discussion about a desired endpoint toward which management and treatments could move a forest. Initially that discussion can seem removed from the project at hand, but agreement on a desired future condition is a foundation for building collaboration.

Yet in discussions of desired future conditions for Sierra Nevada forests there remain some challenges that are more fundamental than clarifying GTR 220 concepts or providing more detailed science summaries. During field visits to project sites, discussions with managers and through dialogue with stakeholders, three areas keep being brought up. Collectively they are issues that may require basic changes in how Sierra Nevada forests are managed: changes in the way forests are perceived and measured, the scale and economics of how forests are managed, and an institutional change in management that internalizes science and course correction.

Summary of Findings

1. **Silviculture should consider broadening the measures and scales by which forests are assessed** beyond the current focus on averages and stands.
2. For practical, ecological, and economic reasons, **forest projects should be scaled up to treat an entire fireshed, and then, where safety allows, convert the fireshed's future management to maintenance through managed wildfire and prescribed fire.** Rough calculations suggest fuels should be reduced on 437,000 ac of Forest Service land each year to mimic historical fire regimes.
3. **Question-driven, science-based monitoring should be integrated into management** to address uncertainties arising from climate change and new forest practices.

The Limitations of Stand-Level Averages

Silviculture remains the heart of forest management because it has provided powerful and useful tools for understanding how forest growth responds to manipulation and disturbance. An essential tool in current silviculture applications is the Forest Vegetation Simulator (FVS), a model based on hundreds of studies in many

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different forest types, which has proved invaluable for forest planning and scenario testing for different management practices. Yet silviculture and models of forest dynamics are strongly imprinted with treating forests as a collection of stands, "a spatially continuous group of trees and associated vegetation having similar structures and growing under similar soil and climatic conditions" (Oliver and Larson 1996). The concept of the stand can be traced back to European management efforts to parse forests into relatively homogenous units that could be efficiently managed for more predictable commodity production (Puettmann et al. 2009). The stand concept tends to set a scale at which most forest attributes are then evaluated. Some attributes such as bark beetle damage are well correlated with stand-level measures such as the Stand Density Index (SDI) (chapter 2). However, clearly some of the processes that strongly shape forest ecosystems such as fire, climate, and edaphic conditions, to name only a few, operate across multiple scales. When those processes shape habitat, microclimate, or ecosystem functions at scales other than the stand, managing and measuring forests as a collection of stands is unlikely to be congruent with those processes or accurately assessed with stand-level metrics (fig. 15-1). Just within the topics raised in this collection of papers, authors have suggested that stand-level assessments may not accurately capture how forests respond to fire and climate change, what forest conditions provide habitat for marten, fisher and California spotted owl, or how we measure canopy structure and its influence on microclimate and fine-scale wildlife habitat.

Marc Meyer

Figure 15-1—A mixed-conifer forest with complex structure created by frequent fire in the Illilouette Basin, Yosemite National Park. Identifying "stands" and describing them with averages would probably not accurately represent the forest's variability across different scales.

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A second problem with management focused at the stand level is that it can lead toward an emphasis on averages. The stand concept is an effort to express forest landscape variability by differences between units (i.e., stands) that have been delineated as areas with relatively homogenous conditions. Quantifying the average of the forest conditions best captures attributes of each unit, because within the stand, those conditions should be similar. Heterogeneity is then expressed as the variability between stands within a landscape. In practice, silviculturists often create fine-scale variability within stands by responding to existing forests conditions and accordingly adjusting their treatment. However, with metrics and descriptions of seral development and ecological response that are scaled to the stand, it has been difficult to communicate to stakeholders how that finer-scale variability is sometimes created. This has hindered support for some management practices by suggesting greater uniformity than may actually be present in treated forests. Field visits can help overcome this problem but do not change the fact that currently the language and metrics of silviculture often fall short of capturing the heterogeneity and complexity of forest ecosystems.

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A recent critique of silviculture suggested it inherently promotes uniformity and discourages variability (Puettmann et al. 2009). Silviculture, however, has been tremendously adaptable, as public priorities for a forest's ecosystem services have changed over time. Its tools can be modified (chapter 9) and new avenues of research can adapt silviculture practices to a broader range of spatial and temporal scales. This could include developing tools and metrics that measure heterogeneity at scales relevant to ecological processes of interest.

Economics and Treatment Scale

General Technical Report 220 did not address economics, yet costs often determine whether a project is even viable. It's difficult to synthesize information about the potential economic impacts of revising forest management practices. The costs of any particular forest project are highly idiosyncratic depending on many factors such as current wood market prices, diesel costs, hauling distances, and processing infrastructure. However, current trends in economic conditions are not favorable. Many projects require service contracts to remove the noncommercial, small-diameter trees, and available revenue for these costs are decreasing as Forest Service budgets shrink. Out of necessity many national forests in the Sierra Nevada limit projects to areas where the economics are favorable or locations where funds for service contracts can be secured. There are good reasons for rethinking this approach through changing the scale of projects and specifically planning for and linking together areas that can generate revenue with restricted or sensitive areas requiring minimal treatment and revenue support.

How much Sierra Nevada forest would the Forest Service need to treat each year to mimic historical patterns of fuel reduction when there was an active (pre-1850) fire regime? Acreage that may have historically burned each year was estimated using a Geographic Approach to Planning (GAP) analysis that identified the acreage and agency ownership of different forest types in the Sierra Nevada (Davis and Stoms 1996) and sources summarizing historical fire regime studies (Stephens et al. 2007, Van de Water and Safford 2011, FEIS 2011). Of the Forest Service's 4.8 million forested acres (1.9 million ha) (Plumas National Forest south through Sequoia National Forest, including Inyo National Forest), approximately 488,000 ac (197 000 ha) may have burned each year before the arrival of Europeans. From 1986 to 2010, on average 51,000 ac/yr (20 600 ha/yr) are burned by wildfire (with great annual variability) (Bilyea 2011), leaving 437,000 ac/yr (177 000 ha/yr) that would need to be treated to mimic historical fuel reduction levels. Over the last 8 years, the Forest Service has averaged 28,600 ac/yr (11 600 ha/yr) of mechanical fuels reduction and 8,300 ac/yr (3360 ha/yr) of prescribed burning (Sherlock 2011) for a total of 36,900 ac/yr (14 930 ha/yr) treated or about 8.4 percent of the 437,000 ac. Despite the best efforts of managers, the current rate of treatment will leave most of the forest in high density, high fuel load conditions susceptible to an altered disturbance regime. Even if projects are not slowed by legal or administrative challenges, the Forest Service's current pace and scale of treatments in the Sierra Nevada is an order of magnitude less than what is needed to keep up with accumulating fuels from forest growth.

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Another problem with current fuels treatment practices is that most sensitive areas with special value such as threatened and endangered species habitat or riparian conservation areas (Van de Water and North 2010, 2011) are excluded from projects or have minimal treatment. These areas often have high stem densities, moisture stress, and heavy fuels accumulations, decreasing their resilience to wildfire and drought. Yet these areas often are the last to be treated because of increased risk of litigation and high cost, because lighter treatments usually do not include removing trees with commercial value. Without some change in current practices, many of the areas with greatest ecological and habitat value will be prone to high overstory mortality and loss of large live trees.

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An additional economic consideration is that in many forests the only potential for generating revenue will be in the first management entry, when some intermediate-size trees with commercial value may be thinned. Future treatments for maintenance of fuels reduction will probably have expenses that exceed any revenue. At current budget levels, it seems unlikely that such extensive and expensive treatment can be accomplished for second and future fuels reduction entries.

One possible approach to revising management practices within these economic constraints is to consider scaling up the size of treatments with an objective, where possible, of treating entire firesheds and then converting their future management to maintenance through managed wildfire and prescribed fire. This approach would increase the scale of treatments and provide an opportunity to bundle revenue-generating areas with lightly treated areas that are revenue sinks. For example, across a fireshed, revenue from heavier thinning on upper slopes designed to restore low-density large pine conditions, might be used to support hand thinning or prescribed burning that maintains high canopy cover in the parallel track of forest that's in the drainage bottom. Once treatments are completed, the burnshed could largely be maintained by allowing it to burn under wildfire or prescribed fire conditions determined by local managers. This approach probably cannot be used in areas with high home density because of liability from escaped fire. It would, however, restore fire and its ecological benefits (Stephens et al., in press) to many forests currently degraded by fire exclusion and reduce future maintenance costs. The larger scale of treatments and the practical need to spread them out over several years would make for a steady, more predictable flow of wood for local mills and potential biomass plants. Biomass use of small-diameter fuels holds promise for improving the economics of fuels treatments. The lack of consistent biomass supply can limit development of processing infrastructure; however, large-scale, long-term treatment planning can overcome some of these limitations (Hampton et al. 2011). Even with some firesheds being turned over to maintenance by fire, there would still be a substantial need for thinning other firesheds ensuring a continuing supply of wood for local communities.

This approach may be criticized as impractical, but at least it could stimulate discussions between stakeholders and forest managers about current and future economic constraints on management options. Without proactively addressing some of these conditions, the status quo will relegate many ecologically important areas to continued degradation from fire exclusion.

Monitoring

Science should become an integral part of forest management, and monitoring may be the best means of achieving this inclusion. Monitoring is an important course correction tool particularly as new silvicultural practices are implemented. It is essential not only for understanding management impacts on focal wildlife species but also for assessing ecosystem response under changing climatic conditions. It is likely that some new management practices will not achieve their objectives and will need adjustment. Furthermore, we have limited information about how best to increase forest resilience under warming conditions, and some trial and error is inevitable. Monitoring is a candid admission that all forest management is experimental and needs to adapt to uncertain outcomes, changing conditions, and new information.

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Monitoring Policy

There is now a window of opportunity, prompted by the Washington office of the Forest Service, to make meaningful improvements in monitoring. The interest in establishing an integrated Inventory Monitoring and Assessment Strategy and Implementation Plan is driven by several agency initiatives, including the new planning rule, the climate change scorecard, the watershed condition framework, the ecological integrity index, and a focus on ecosystem restoration. Integrating the inventory, monitoring, and assessment components of these ongoing activities will improve the consistency and scalability of information and analyses, and hopefully enable the Forest Service to capture cost efficiencies.

Monitoring Implementation

What should be monitored and how will managers know how effective their restoration efforts are? The type of monitoring can determine how informative the data are. Passive and mandated monitoring often produces trend observations, whereas question-driven monitoring guided by a conceptual model can test à priori predictions (Lindenmayer and Likens 2010). The Society for Ecological Restoration has suggested restoration should be assessed in three general areas: species diversity, ecological processes, and vegetation structure (Ruiz-Jaen and Aide 2005a, 2005b). Monitoring changes in vegetation is fairly common, but assessing changes in species diversity and ecological processes is often viewed as difficult and expensive. One approach for species is to target taxa that are more likely to be affected by management practices and examine how generalist and specialist species respond (Clavel et al. 2011 [e.g., Meyer et al. 2007a, 2007b]). Some ecological processes are not difficult to assess using changes in vegetation growth (e.g., tree mortality and growth response assessed with increment core samples). National forest system ecologists familiar with research methods could help design protocol and have study designs peer reviewed.

Monitoring at the landscape level may not be as daunting as it seems if testable hypotheses are well defined. A large-scale restoration project in northern Arizona used regularly spaced permanent plots to assess where forest structure and coarse woody debris approximated presettlement conditions (Roccaforte et al. 2010). One suggestion (DeLuca et al. 2010) has been that monitoring might occur even on limited federal budgets through using a combination of collaborative partnerships, volunteers, prioritized sampling designs (e.g., statistical sampling strategies that focus on a limited number of intensively monitored sites), and emerging remote sensing technologies. It is important to develop a well-structured monitoring approach that is founded on the most basic and crucial questions. Initial efforts should probably be modest and build success and trust towards a more thorough program over time.

Monitoring only has value if its information is incorporated using an adaptive management approach (Nichols and Williams 2006). Yet adaptive management has often become an agency mantra without a well-defined set of implementation measures (Allen et al. 2011; Williams 2011a, 2011b). The feedback between learning and decisionmaking needs to be incorporated into management procedures so that learning and adjustment actually occurs. Bormann et al. (2007) suggest that "adaptive management is less about current decisions than about mutual learning that might lead to better future decisions. Mutual learning calls for managers to consider learning as a core business and for the science community to improve their performance in civic science and their delivery of integrated, science-based evidence and tools."

Uncertainty, Collaboration and Monitoring

Uncertainty about the effects of climate change could bring about a fundamental shift toward adaptive management and active monitoring that has long been proposed; yet rarely implemented. This uncertainty could be viewed as license for unending litigation since no environmental assessment will be able to adequately present all outcomes. Uncertainty, however, can also be an opportunity for a different approach, one where management practices are tried, evaluated, and modified iteratively. Such an approach will require candid acknowledgment of unknowns, public participation, and transparent collaborative planning.

Studies of sustainable resource stewardship suggest that several social, administrative, and economic conditions are needed, with effective management often requiring long-term collaboration that builds trust (Dietz et al. 2003, Ostrom 2009). In forestry, good management hinges on flexible practices that can respond to different onsite conditions. Forest practices restricted with set prescriptions do not allow this flexibility, producing predictable treatments often poorly adapted to different ecosystem conditions. Deliberative collaboration, discussed in chapters 7 and 8, is one means of moving beyond restrictive prescriptions. The pace and cost of these efforts may frustrate some, but under the right conditions they can eventually allow managers greater flexibility.

Monitoring can provide the institutional glue for long-term collaboration.

Monitoring can provide the institutional glue for long-term collaboration. Often, however, monitoring has not had a clear scientific objective and initial efforts fade as funding dwindles. Yet with uncertain forest outcomes, new management practices need longitudinal data and an institutional mechanism for incorporating

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that information into adaptive course correction. Science-based, objective monitoring can build trust. The adage applied to U.S.-Soviet arms treaties, "trust but verify," may be equally apropos to new forest management strategies.

Chapter Summary

> "If we open a quarrel between past and present, we shall find that we have lost the future." (Winston Churchill)

Forestry is an art as well as a science, a creative response to existing forest conditions based on the best silviculture, ecology, and wildlife biology. The challenge has always been how to best provide a forest's multiple ecosystem services with imperfect knowledge of management's effects. Conflicts over the priority of those ecosystem services (e.g., timber, fuels reduction, wildlife habitat) on public forest lands has often resulted in management by restrictive prescription. Yet the best forestry has always required flexibility, innovation, and the latitude to respond to ecological context. How can forest management in the Sierra Nevada regain its art?

Ironically, the uncertainty of global climate change could be a catalyst for restoring flexible management if agencies consider some changes. No one can predict exactly how changing climatic conditions may affect forests. All forest projects will be experimental, requiring assessment at multiple scales and including patterns of variation. Acknowledging this uncertainty, committing to monitoring forest response, then adapting management practices as information accumulates, would institutionalize flexibility. It would also require managers and stakeholders explicitly discuss and develop a desired future condition against which to measure forest conditions. The hope of GTR 220 and this collection of papers is that it can provide a starting point for that discussion.

References

Allen, C.R.; Fontaine, J.J.; Pope, K.L.; Garmestani, A.S. 2011. Adaptive management for a turbulent future. Journal of Environmental Management. 92: 1339–1345.

Bilyeu, A. 2011. Personal communication. Natural resource planning specialist, U.S. Department of Agriculture, Forest Service, Pacific Southwest Region, Fire, Fuels and Aviation Management. 3237 Peacekeeper Way, Suite 101, McClellan, CA 95652.

Bormann, B.T.; Hanes, R.W.; Martin, J.R. 2007. Adaptive management of forest ecosystems: Did some rubber hit the road? BioScience. 57: 186–191.

Clavel, J.; Julliard, R.; Devictor, V. 2011. Worldwide decline of special species: toward a global functional homogenization? Frontiers in Ecology and the Environment. 9: 222–228.

Clements 1916. Plant succession: an analysis of the development of vegetation. Washington, DC: Carnegie Institution of Washington. 654 p.

Davis, F.W.; Stoms, D.M. 1996. Sierran vegetation: a gap analysis. In: Sierra Nevada Ecosystem Project: final report to Congress. Vol. II. Assessments and scientific basis for management options. Wildland Resources Center Report No. 37. Davis, CA: University of California, Centers for Water and Wildlands Resources: 671–690.

DeLuca, T.H.; Aplet, G.H.; Wilmer, B.; Burchfield, J. 2010. The unknown trajectory of forest restoration: a call for ecosystem monitoring. Journal of Forestry. 108: 288–295.

Dietz, T.; Ostrom, E.; Stern, P.C. 2003. The struggle to govern the commons. Science. 302: 1907–1912.

Fire Effects Information System [FEIS]. 2011. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: http://www.fs.fed.us/database/feis. (December 15, 2011).

Hampton, H.M.; Sesnie, S.E.; Bailey, J.D.; Snider, G.B. 2011. Estimating regional wood supply based on stakeholder consensus for forest restoration in northern Arizona. Journal of Forestry. 109: 15–26.

Lindenmayer, D.B.; Likens, G.E. 2010. Effective ecological monitoring. Collingwood, Australia: CSIRO Publishing. 184 p.

Meyer; M.; Kelt, D.; North, M. 2007a. Effects of burning and thinning on lodgepole chipmunks (*Neotamias speciosus*) in the Sierra Nevada, California. Northwestern Naturalist. 88: 61–72.

Meyer, M.; Kelt, D.; North, M. 2007b. Microhabitat associations of northern flying squirrels in burned and thinned stands of the Sierra Nevada. American Midland Naturalist. 157: 202–211.

Nichols, J.D.; Williams, B.K. 2006. Monitoring for conservation. Trends in Ecology and Evolution. 21: 668–673.

North, M.; Stine, P.; O'Hara, K.; Zielinski, W.; Stephens, S. 2009. An ecosystem management strategy for Sierran mixed-conifer forests. 2nd printing, with addendum. Gen. Tech. Rep. PSW-GTR-220. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. 49 p.

Oliver, D.D.; Larson, B.C. 1996. Forest stand dynamics. New York City, NY: John Wiley and Sons, Inc. 520 p.

Ostrom, E. 2009. A general framework for analyzing sustainability of social-ecological systems. Science. 325: 419–422.

Puettmann, K.J.; Coastes, K.D.; Messier, C. 2009. A critique of silviculture: managing for complexity. Washington, DC: Island Press. 189 p.

Roccaforte, J.P.; Fulé, P.Z.; Covington, W.W. 2010. Monitoring landscape-scale ponderosa pine restoration treatment implementation and effectiveness. Restoration Ecology. 18: 820–833.

Ruiz-Jaen, M.C.; Aide, T.M. 2005a. Restoration success: How is it being measured? Restoration Ecology. 13: 569–577.

Ruiz-Jaen, M.C.; Aide, T.M. 2005b. Vegetation structure; species diversity; and ecosystem processes as measures of restoration success. Forest Ecology and Management. 218: 159–173.

Sherlock, J. 2011. Personal communication. Regional silviculturist, U.S. Department of Agriculture, Forest Service, Pacific Southwest Region, 1323 Club Drive, Vallejo, CA 94592.

Sierra Nevada Forest Plan Amendment [SNFPA]. 2004. Sierra Nevada Forest Plan Amendment: final supplemental environmental impact statement. R5-MB-046. Washington DC: U.S. Department of Agriculture, Forest Service, Pacific Southwest Region. 492 p.

Stephens, S.L.; Martin, R.E.; Clinton, N.E. 2007. Prehistoric fire area and emissions from California's forests, woodlands, shrublands, and grasslands. Forest Ecology and Management. 251: 205–216.

Stephens, S.L.; McIver, J.D.; Boerner, R.E.J.; Fettig, C.J.; Fontaine, J.B.; Hartsough, B.R.; Kennedy, P.; Schwilk, D.W. [In press]. Effects of forest fuel reduction treatments in the United States. BioScience.

Van de Water, K.; North, M. 2010. Fire history of coniferous riparian forests in the Sierra Nevada. Forest Ecology and Management. 260: 384–395.

Van de Water, K.; North, M. 2011. Stand structure, fuel loads, and fire behavior in riparian and upland forests, Sierra Nevada Mountains, USA; a comparison of current and reconstructed conditions. Forest Ecology and Management. 262: 215–228.

Van de Water, K.M.; Safford, H.D. 2011. A summary of fire frequency estimates for California vegetation before Euro-American settlement. Fire Ecology. 7: 26–58.

Williams, B.K. 2011a. Adaptive management of natural resources—framework and issues. Journal of Environmental Management. 92: 1346–1353.

Williams, B.K. 2011b. Passive and active adaptive management: approaches and an example. Journal of Environmental Management. 92: 1371–1378.