ADAPTIVE MANAGEMENT AND MONITORING

ISSUE STATEMENT

Climate change is expected to significantly affect the health and vitality of forests and to create environmental conditions never before experienced by forest ecosystems, including those of the Sierra Nevada (Innes et al. 2009, Millar et al. 2007, North et al. 2009, Redmond 2006, Mastrandrea and Luers 2012, Barbour and Kueppers 2012). Incorporating climate adaptation concerns into the forest planning process proactively, before major ecosystem changes occur, will likely be less expensive and more effective than a reactive management approach in achieving forest management goals (Blate et al. 2009). Climate adaptation strategies must be incorporated at both the strategic and operational planning level in order to achieve the goal of sustainable forest management (Innes et al. 2009). Because the precise impact that climate change, in combination with other sources of ecosystem stress, will have on the Sierra Nevada is and will remain uncertain, many forest management standards or guidelines contained in the revised forest plans must be amenable to future refinement through an ongoing process that is often referred to as "adaptive management."

In theory, adaptive management involves careful monitoring of forest resources against a clear set of criteria so that unforeseen events can be identified and addressed in a timely fashion by modifying existing standards and guidelines. In practice, however, adaptive management plans designed by the Forest Service in the past have been noncommittal, unclear, unenforceable, and have not resulted in meaningful reassessment and adjustment of standards. "Agencies have often approached adaptive management in a way that prioritizes flexibility, discretion and expedited decision-making and have emphasized less the aspects of the paradigm that allow for learning or require precautious decision-making… agencies risk running afoul of the courts if they cling too strongly to agency discretion and vague adaptive management plans that are bereft of measurable standards and objectives" (Nie and Schultz 2011).

The Forest Service must incorporate into any revised Sierra forest plans an effective adaptive management strategy that assesses likely risk to key local ecosystem values from climate change in combination with other stressors; defines clear, enforceable, and timely triggers and responsive management actions for various levels of predicted impacts; monitors the real-time impact of climate change and other stressors on key Sierra species and ecosystems; and establishes enforceable benchmarks for evaluating and adjusting management (North et al. 2009, Bark et al. 2010, Nie and Schultz 2011). Species and ecosystem protections triggered under adaptive management must be reasonably specific, certain to occur, implementable, subject to deadlines or otherwise enforceable, and sufficiently protective to satisfy applicable legal standards (Nie and Schultz 2011).

In addition to management prescriptions, essential elements of an adaptive management strategy include (1) a monitoring strategy; (2) a mechanism and schedule for review of monitoring data; (3) a mechanism for public involvement in the adaptive management process; and (4) a clear set of criteria and process by which the management process itself can be evaluated and modified. Additionally, the forest plans should identify the critical research questions guiding adaptive management, recommend management actions to facilitate their experimental approach to adaptation at a landscape scale, and include a detailed plan for accomplishing the necessary research. Adaptive management strategies should be clearly articulated in each forest plan, implementable within existing and foreseeable budgetary constraints, and transparently executed with full public involvement (Nie and Schultz 2011; *see* USFS 2012).

Adaptive management in an era of anticipated rapid climate change and heightened uncertainty must be

rooted in a precautionary approach to ecosystem management. Many trends and challenges over the life of a forest plan are reasonably foreseeable, even in an era of climate change and associated uncertainty. "[S]ufficient ecological knowledge and policy options currently exist for effective adaptation efforts to be implemented or improved upon today" for "the vast majority of major threatening processes to biodiversity" (Driscoll et al. 2012). "No regrets" actions that offer high ecological payoffs with minimum risk today as well as in a higher-risk climate future should figure prominently in forest management priorities (Moore et al. 2012).

The potential for ecosystem resilience in the face of both climate variability and experimental management strategies will increase by reducing current sources of ecosystem stress (e.g., habitat fragmentation, invasive species, extractive activities, grazing, land clearing, and pollution); re-establishing habitat connectivity to facilitate climate-induced species migration and dispersal; boosting depleted populations; and promoting heterogeneous, multiple-aged forest stands (Blate et al. 2009, Driscoll et al. 2012). In applying such adaptation strategies across the landscape, protected areas would be established and connected across the environmental gradients of elevation and latitude to facilitate the movement of species in response to climate change. When more active management of forests is employed to limit exposure to climate change impacts such as drought, fire, invasive species, and insects (Blate et al. 2009), additional care must be taken to minimize negative impacts to high-value habitat elements for high-risk species, e.g., decadent and intermediate-to-large trees, woody debris, and moist microclimates supporting high tree densities that are of critical importance to old forest associated species (North et al. 2009, Driscoll et al. 2012).

Adaptive management can be an integral part of dynamic landscape conservation plans geared toward preserving ecosystem function and resilience and explicitly addressing the climate adaptation needs of wildlife and biodiversity at a landscape scale (Mawdsley et al. 2009). The focus of successful management strategies will likely shift from maintaining forest structure and composition to supporting ecological process and ecosystem function (Millar et al. 2007). For example, the importance of frequent, mixed-intensity fire in shaping the Sierran mixed-conifer ecosystem suggests that adaptive management designed to manipulate the process of fire could enable our regional forests to reach dynamic equilibrium under modern changing climate conditions, increase forest heterogeneity, and bolster resilience to climate change.

Forest plans and associated environmental impact statements should be guided by a vulnerability assessment that "employs the best available science to characterize vulnerability, uses state-of-the-art modeling to assess likely exposure to climate change and its effects, and documents sources of uncertainty" (Aplet et al. 2010). Vulnerability assessments are fundamental to the forest planning process in the face of climate change. They are used to examine forest resources and determine which elements are sensitive and which have the ability to adapt, while also identifying the likely consequences to those resources of anticipated climate change (Aplet et al. 2010; *see, e.g.,* Santos et al. 2012). Vulnerability assessments can and should assess other stressors that will likely interact synergistically with climate change and amplify its impacts, such as habitat change, pollution, and increasing resource demands (Santos et al. 2012, Hansen and Hoffman 2011, Driscoll et al. 2012). Adaptive management informed by vulnerability assessments would prioritize actions designed to reduce vulnerability of key local resource values through such strategies as reduction of anthropogenic stressors, establishment of reserves, regulation of recreational use, and habitat restoration (Aplet et al. 2010).

While the impacts of climate change may or may not manifest themselves over the life of the forest plan revision, the goal of an adaptation-based

adaptive management strategy is to test and refine responsible management strategies in light of evolving science, anticipated future climate conditions, and monitoring results in order to better inform future management efforts, guide ecosystem response to climate change as it unfolds, and effectively manage risk to our forest resources. Whenever there is a likely link between experimental manipulation and outcomes, adaptive management that incorporates experiments into modeling is possible. Experimental actions under adaptive management "should be designed to do no harm, be flexible (maintaining the ability to reverse mistakes), and address the areas of greatest need, effectively minimizing negative climate impacts on biodiversity and natural resources" (Moore et al. 2012). Conservative pilot projects should precede large-scale deployment of any action with uncertain and potentially negative consequences to species or ecosystems (Id.).

In situations where high uncertainty is coupled with low controllability of outcomes (when system manipulations are difficult or impossible), the strategy of scenario planning can be particularly helpful (Peterson et al. 2003, Aplet et al. 2010, Welling 2008, Moore et al. 2012). "The central idea of scenario planning is to consider a variety of possible futures that include many of the important uncertainties in the system rather than to focus on the accurate prediction of a single outcome" (Peterson et al. 2003). Scenario planning can help create a set of resource management steps for national forests that are robust to multiple climate futures (Moore et al. 2012). In the forest planning context, it could involve developing strategic responses to high, medium, and low climate disturbance scenarios for a suite of locally important measurable resource values (e.g., ecosystem diversity or water quality and fish habitat), which can be examined under NEPA in the planning process. Though the forest plan must include a streamlined review and public comment provision for such decision points, this type of scenario-based planning has the benefit of enabling managers to change course rapidly once the plan has been adopted, as several different options will already have undergone the NEPA process and can therefore be readily used (Nie and Schultz 2011). This approach can also save some later analysis costs (*see* Bark et al. 2010).

To better inform adaptive management and scenario-based planning, and to make clear when new scenarios or new management strategies are needed, forest plans must include comprehensive monitoring systems to better understand the changing forest system over time, including critically important species-level monitoring. "[W]ithout monitoring, there can be no improved understanding of conditions or responses to management actions, and therefore, no informed adjustment of on-the-ground practices" (Nie and Schultz 2011). Robust monitoring of ecosystems and forest management responses provides both a basis for vulnerability and risk assessments and a means of evaluating the effectiveness of strategies to reduce stressors and adapt to changing conditions (Blate et al. 2009, Innes et al. 2009). Ecologists should be involved in the design and integration of robust monitoring programs that include a formal system for regularly evaluating monitoring and research data, and triggers should be clearly defined for management adjustments and forest plan amendments based on changes detected through monitoring (Driscoll et al. 2012). Existing monitoring systems should be assessed, strengthened, and better coordinated in light of anticipated increased demands for effective collection, analysis, and interpretation of environmental information (Mawdsley et al. 2009; *see also* USFS 2010). Both stand- and forest-level monitoring are necessary for adaptive management to be truly effective (Innes et al 2009), and broader-scale monitoring is another foundational requirement for adaptive management under the 2012 National Forest Management Rule. 36 C.F.R. § 219.12(b). Formal evaluations of ongoing monitoring results, ideally involving independent scientists as well as Forest Service staff, are required every two years under the 2012 National

Forest Management Act rule. 36 C.F.R § 219.12(d).

Support for adequate monitoring is the fundamental anchor fostering science-based, well-informed adaptive management. Absent adequate funding for monitoring, adaptive decision-making will suffer from high levels of uncertainty and a loss of public trust. Given the high stakes associated with rapid environmental change, the Forest Service must shift priorities to include significant funding for robust, multi-scale monitoring as a key component of future forest plans in the Sierra Nevada. If resources are not available for effective and ongoing monitoring, the Department of Interior guidelines recommend that adaptive management not be employed (Williams et al. 2009). "Simply put, adaptive management is not possible without effective monitoring" (Id. at 12).

As mentioned above, incorporating climate adaptation concerns into the forest planning process proactively, before major ecosystem changes occur, will likely be less expensive and more effective than a reactive management approach in achieving forest management goals. Given the uncertainties associated with climate change and the high level of risk posed to Sierra Nevada forest resources, adaptive management and scenario-based planning are some of the best tools currently available to forest planners and should be responsibly incorporated into forthcoming forest plan revisions.

POLICY ACTIONS NEEDED

Proposal for Revision to Forest Plan Direction

A. Desired Condition *The following statements represent the desired future condition of the administrative setting and may not reflect the current conditions.*

Desired Condition AM-1. Social and administrative infrastructure is in place to support the flexible management necessary to respond to changing climate and other shifting ecological pressures.

Desired Condition AM-2. Thresholds that trigger changed management are established and detailed management alternatives are developed for various predicted climate and ecosystem response trajectories.

Desired Condition AM-3. The adaptive management cycle is transparently implemented and accessible to the public.

Desired Condition AM-4. Regular reports on monitoring and responsive management proposals are made available to stakeholders by dates certain.

Desired Condition AM-5. A structure for collaboration is established that defines how public involvement will be facilitated, how information will be shared, and how conflicts will be resolved.

Desired Condition AM-6. Risk and uncertainty are clearly articulated and addressed, with vulnerability assessment informing the management decision process.

B. Objectives

Objective AM-1. Implement an adaptive management program (AMP), involving both scientists and managers, that incorporates the following steps:

1. Evaluate the potential set of climate and ecosystem conditions over the lifetime of the new plans and the likely range of management responses.

2. Gather and synthesize existing knowledge to develop working model(s) about how the ecosystem works in order to make first approximation predictions of future conditions and management outcomes. Clearly identify what is known (certain) versus unknown (uncertain) with respect to future conditions and management outcomes.

3. Assess risk, exposure, uncertainty, and vulnerability associated with key local resource values.

4. Determine current management goals based on these comprehensive risk and vulnerability assessments.

5. Identify the resources, skills, and infrastructure needed to implement monitoring and adaptive management.

6. Identify thresholds or benchmarks that will be used to trigger a review of management.

7. Design and implement management in accordance with principles of experimentation.

8. Monitor, evaluate, and disclose the results of the management action by dates certain and at least every two years (36 CFR § 219.12 (d)).

9. Incorporate what is learned into the conceptual model of how the ecosystem works, basing future management on improved understanding of ecological processes.

10. Collaboratively and transparently adjust management as indicated by results

Objective AM-2. Integrate results from the forest-specific AMP with the regional AMP framework, as appropriate.

Objective AM-3. Define and support a collaborative stakeholder process for sharing and vetting monitoring information with the public in a open, transparent and consistent manner.

C. Standards

Standard AM-1. The ongoing implementation of the all aspects of the AMP is a prerequisite to project approval and implementation. For example, if meadow condition assessment and evaluation has not been completed, activities that have the potential to impact meadow systems may not be permitted or approved until the annual monitoring and evaluation have been completed.

Standard AM-2. The AMP is both internally and independently reviewed at five year intervals (at a minimum) to evaluate its effectiveness in meeting the goals and objectives in the forest plan.

Standard AM-3. Where uncertainty and potential risk associated with management actions are high, the precautionary principle must guide adaptive management. Activities are assessed for risks associated with a full range of actions and management options. More aggressive action should be limited to ecosystems that are most degraded.

Standard AM-4. All projects will be consistent with the forest plan standards, which should include the global standards for the following issue areas which are described in detail in Section IV for this conservation strategy, in addition to any forest-specific standards designed to protect locally important resource values.

Recommended Actions at the National Forest Level Not Directly Addressed in the Forest Plan

- Ensure that there are adequate resources, including funding and staff with the appropriate qualifications, to effectively monitor forest conditions and resource values and implement responsive, transparent adaptive management.

- Establish completion of monitoring goals and disclosure of results as prerequisite to approval of actions proposed as part of an adaptive management strategy.

Recommendations for New Regional Direction or Policy

- Focus the allocation of funds from the Regional level to the National Forest level to actions that are justified by monitoring results and that have been demonstrated to be consistent with the regional standards defined above.

- Use the adaptive management and monitoring strategy developed at the national forest level to determine the allocation of funds from the Region to each national forest. Allocate funds first to those monitoring and adaptive management efforts addressing information gaps that have implications for regional management beyond the specific national forest and which present low risk to key resource values.

- Design an adaptive management and monitoring framework for rangewide issues that integrates actions undertaken and information gathered at the forest level with forests throughout the region.

- Provide scientific oversight and support for the adaptive management program.

- Ensure that an ongoing technical and scientific capacity will be available to the policy and management bodies to evaluate, review, and assist in design of adaptive management strategies where appropriate.

- Use a collaborative process among managers, technical staff and stakeholders to design an integrated Adaptive Management Program (AMP) for the region and each national forest. Experiences gained during the Practices from the Sierra Adaptive Management Project should help inform this process, e.g., http://snamp.cnr.berkeley.edu/documents/465/.

Additional Recommendations

- Promote the involvement of staff and decision makers from California Department of Fish and Game, US Fish and Wildlife Service, California Regional Water Quality and other relevant resource agencies in the development and implementation of the AMP.

- Promote the involvement of local and statewide conservation groups in the development and implementation of the AMP.

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