Kaibab National Forest’s Climate Change Approach for Plan Revision

This document summarizes the Kaibab National Forest’s climate change approach for plan revision and guidance excerpted from **“**Southwestern Climate Change Trends and Forest Planning: A Guide for Addressing Climate Change in Forest Plan Revisions for Southwestern National Forests and National Grasslands” (USDA 2010a).

Introduction

Climate scientists agree that the earth is undergoing a warming trend, and that human-caused elevations in atmospheric concentrations of carbon dioxide and other greenhouse gases are among the causes of global temperature increases. The observed concentrations of these greenhouse gases are projected to increase. Climate change may intensify the risk of ecosystem change for terrestrial and aquatic systems, thereby affecting ecosystem structure, function, and productivity.

Strategies for protecting climate sensitive ecosystems through management will become increasingly important because changes in climate will likely continue regardless of emissions mitigation. Climate change exacerbates the already difficult task of managing the National Forest System for multiple goals. This appendix summarizes how the Kaibab NF intends to incorporate current and possible future climate change into the land management planning process. The primary consideration for evaluating responses to climate change lies with the Kaibab NF’s ability to modify social, economic, and ecological conditions on the planning unit.

Current Conditions and Trends

Current conditions and trends described in the final environmental impact statement (FEIS) for the Kaibab NF land and resource management plan and alternatives addresses risks, vulnerabilities, and potential ecological changes that could result from climate change. The plan addresses potential climate change impacts that are most likely to affect ecological systems, goods, and services. Evaluation of climate change impacts may lead to recognition that some conditions may be difficult to maintain over time. Particular attention is given to ecosystems that are most at risk due to climate change and vulnerable ecosystem components, such as aquatic systems, grassland plant diversity, and high-elevation ecosystems. Information from the evaluation of current conditions and trends was used to develop the social, economic, and ecological desired conditions in the plan.

Integrating Climate Change into Land and Resource Management Plans

Climate change is addressed as an integrated part of this plan rather than as a standalone set of desired conditions. An example is the desired condition that “The composition, structure, and function of vegetative conditions are resilient to the frequency, extent, and severity of disturbances and components that provide resilience to climate variability.” Integration of climate-relevant desired conditions throughout the plan helps to ensure these concepts are considered during project-level planning.

Desired conditions for the planning unit were developed considering potential climate effects to:

- Increased extreme weather related forest disturbances (floods, drought, wind-throw)

- Water stresses (groundwater, runoff, and timing), aquatic biota
- Wildfire risks
- Shifts in major vegetation types for the Southwest
- Threatened, endangered, and sensitive species
- Forest insects and disease
- Weather related stresses on human communities (temperature, air quality)
- Outdoor recreation
- Wildlife movement and biodiversity

Monitoring

No specific element of the monitoring plan was developed solely for monitoring climate change. However, the plan monitoring program incorporates provisions that should improve understanding of the relationships between key plan components and climate change. For example, an inventory of the aquatic ecosystems and information about water temperatures and waterflows associated with climate change can be useful for tracking variability within ecosystem condition and trends observed over a prescribed evaluation period. Monitoring the frequency and spatial extent of uncharacteristic wildfire occurrences and insect outbreaks would help the Kaibab NF assess how well management is mitigating for hotter, drier, and more fire-prone conditions, and whether existing management is promoting resilient ecosystems. Along similar lines, monitoring springs that are sensitive to variable precipitation and naturally more predisposed to the effects of prolonged drought would help the Kaibab NF to prioritize protection and restoration focused on those ecosystems while gleaning information about endemic species levels and refugia. It may also be possible to discern climate change-related patterns in habitat use through long-term monitoring of songbirds and their habitat.

Although not an exhaustive list, some of the key Kaibab NF monitoring plan questions that have climate change relevance are:

- What percentage of the Kaibab NF is in an uneven-aged open state at the midscale (above 100 acres)?
- How many acres burned with desired fire behavior and effects?
- What is the total area of contiguous acres (above the midscale) at risk for active crown fire?
- What is functional condition of the natural lakes and wetlands?
- What are the areal extent, distribution, and abundance of priority nonnative invasive plants on the Kaibab NF?

As part of its 2010 to 2015 strategic plan, the Forest Service launched a “Roadmap for Responding to Climate Change” (USDA 2010b). This comprehensive science-based plan emphasized a set of long- and short-term approaches for managing climate change while providing the agency with a clear, common vision. This strategic plan should help the Forest Service better provide for sustainability over time with climate uncertainty. The roadmap focuses on three primary activity areas: (1) assessing current risks, vulnerabilities, policies, and gaps in knowledge; (2) engaging internal and external partners in seeking solutions; and (3) managing for resilience in ecosystems as well as in human communities. A component of the strategic plan is a “Performance Scorecard” (http://www.fs.fed.us/climatechange/pdf/Scorecard.pdf), to be completed annually by each national forest or grassland. This scorecard has a series of questions focused on the above three activity areas that allow each management unit to assess how well integration of climate change considerations is happening at the local scale. The scorecard assesses agency capacity, partnerships and education, adaptation, mitigation,

and sustainable consumption. All forests are expected to be compliant with 7 of the 10 scorecard elements by 2015.

Decision Documents

Pertinent aspects of climate change would be addressed in the rationale of decision documents, particularly those that may affect the social, economic, and ecological systems within the planning unit that are most at risk. Examples of ecosystems, characteristics, and species most at risk include fire-adapted vegetation, native aquatic species, and endemic species. Examples of socioeconomic systems at risk of change include risks to private property and infrastructure from uncharacteristic fires, livestock grazing, winter recreation, water recreation, and personal use products. Increasingly, tools are available to aid in understanding and evaluating how climate change could affect forest resources. These tools can help with describing existing conditions and trends, developing project design criteria, and evaluating potential effects as they relate to changing conditions (see planning tools below).

Potential Climate Change Effects

Based on current projections, the primary regional level effects of climate change most likely to occur in the Southwest include: (1) warmer temperatures, (2) decreasing precipitation, (3) decreased water availability with increased demand, (4) increased extreme disturbance events, and (5) increased use of national forests for relief from higher temperatures in lower elevation cities. These climate change factors could, in turn, affect ecological, weather related disturbances, and socioeconomic demands, including increases in:

- Frequency of extreme weather events (intense storms);
- Wildfire risks;
- Outbreaks of insects, diseases, and spread of nonnative invasive species;
- Demand for water;
- National forest socioeconomic uses and demands; and
- Changes in habitat quality and quantity for certain desired wildlife and plant species.

Extreme Weather Events

Climate change would likely increase flash floods, making the region’s growing population more susceptible to loss of life and property. While the Southwest is expected to become warmer and drier, it is also likely to experience more flooding. This relates in part to the fact that warm air holds more moisture than cooler air. The frequency of floods is also influenced by the rate of snowmelt in the winter and spring, the character of the summer monsoon, and the incidence of tropical hurricanes and storms in the autumn.

Hurricanes and other tropical cyclones are projected to become more intense in the future. Since Arizona typically receives10 percent or more of its annual precipitation from tropical storms, it is likely that this change would also increase flooding. A potential increase in extreme storms, floods, heat waves, and droughts may present challenges for achieving desired conditions.

Impacts from extreme weather events could include changes in the composition and diversity of desired ecosystems; destruction of habitat; damage to infrastructure such as trails, facilities, and roads; loss of recreation opportunities; and reduced wood and forage supplies. Disturbances that exceed the historic range of natural variation can change the composition, structure, and function of watersheds and some

vegetation types, affecting a wide range of resources. Heavy rains and higher flood levels could affect the structural integrity of built infrastructure and increase maintenance needs. Flooding is a natural and beneficial disturbance in many aquatic systems. However, damage to aquatic systems from flash flooding causes erosion, downed trees, and inundation that can change streamside habitats, affect aquatic life, and impact the functioning condition of stream channels. These disturbances could create challenges in the ability of a forest to achieve desired conditions for aquatic habitats. Overall, increasing weather-related disturbances could divert limited Forest staff and funding to recovery efforts for extended periods, which would delay progress toward desired conditions, or modify them to allow for more dynamic conditions when desired conditions may not be attainable.

Wildfire

Historically, wildfires have played an important role in the vitality of fire-adapted ecosystems. Past forest management and fire suppression practices have changed the dynamics of fire on the landscape within the Southwestern Region's national forests and grasslands, resulting in greater fuel loads and risk of wildfire. Federal land management agencies in the West routinely exceed expenditures of over $1 billion per year for wildfire suppression. Since about the mid-1970s, the total acreage of area burned and the severity of wildfires in ponderosa pine and mixed conifer forest have increased.

Fire frequency and severity are likely to increase as temperatures rise and precipitation decreases. Severe wildfires reduce the land's ability to sequester and store carbon. Population growth in the Southwest may also lead to greater numbers of human-caused wildfires. The 2002 Rodeo-Chediski Fires and the 2011 Wallow Fire in Arizona were started by humans. Combined, these fires burned over a million acres.

Outbreaks of Insects, Diseases, and Nonnative Invasive Species

Disturbances associated with climate change can have secondary impacts indirectly caused by wildfire and climate related extremes. Increased variation in temperature and moisture can cause stress and increase the susceptibility of forest ecosystems to invasions by insects, diseases, and nonnative species. New environmental conditions can lead to a different mix of species that tend to favor plants and animals that can adapt their biological functions or are aggressive in colonizing new territories (Whitlock 2008). However, changes in adaptability may be too slow given the predicted rate of change. Species that are already broadly adapted may become more prevalent and species with narrow adaptability may become less prevalent. Disturbance factors that create more vulnerability in native ecosystems or require extensive controls to maintain the status quo are likely to adversely affect the health and diversity of forests.

Desired conditions for healthy forests include resilience to dramatic changes caused by abiotic and biotic stressors and mortality agents (e.g. pine beetle) and a balanced supply of essential resources (light, moisture, nutrients, growing space). Insects and diseases typically invade in cycles followed by periods of relative inactivity. Nonnative invasive species, such as cheatgrass and saltcedar, are expected to continue to increase in numbers and extent. Vulnerabilities to forest threats from an environment that may be much different from the historic range of natural variability is an active area of research, and includes developing new management approaches for changing conditions.

Diminishing Water Resources

Locations of most snowpack and upland reservoirs are on national forests in the Southwest. In much of the Southwest, less precipitation is falling as snow and spring melting is occurring earlier in the year. The Colorado River, Rio Grande, and several other southwestern rivers have streamflows that appear to be peaking earlier in the year, suggesting that the spring temperatures in these regions are warmer than in the past, causing snow to melt earlier. Water supplies are projected to become increasingly scarce, calling for

tradeoffs among competing uses, potentially leading to conflict. In the Southwest, intense debate is likely to occur over resource allocation and conservation of available supplies.

Climate Related Socioeconomic Demand

Populations in Arizona and New Mexico are growing at an unprecedented rate. As of the American Communities Survey in 2006, Arizona's population was over 6 million. The total increase for Arizona between 1980 and 2006 was 123 percent. The combination of population growth and climate change would likely exacerbate climatic effects, putting even greater pressure on water, forests, and other resources. Climate change could have long-term impacts on many of the amenities, goods, and services from forests, including productivity of locally harvested plants; local economics through land use shifts from forest to other uses; forest real estate values; and tree cover and composition in urban areas and associated benefits and costs.

Climate Change and Wildlife Habitat

While climate change has the potential to affect all wildlife species, some are inherently more vulnerable than others, particularly species with specialized niches, limited mobility, and limited physiological adaptability. Certain habitats are more vulnerable to a changing climate. For example, springs and seeps are a valuable natural water source for a variety of birds and mammals, particularly in arid environments. These areas may offer critical refugia for rare and narrow endemic species. However, springs are especially sensitive to variable precipitation and likely to dry up during prolonged drought. As such, the unreliability of natural water resources would make it harder for wildlife species to persist, pushing the limits of their natural range.

Managing for landscape connectivity will be important, as connectivity facilitates movement of species among habitats (Taylor et al. 1993, Millar et al. 2007). Connectivity has two components, structural and biological connectivity and biological components. Structural connectivity, the spatial structure of a landscape, can be described from map elements. Biological connectivity is the response of individuals to the scale of landscape features (Brooks 2003). Promoting connectivity in landscapes with flexible management goals that can be modified as conditions change may assist species to respond naturally to changing climates. Reducing fragmentation and planning at landscape scales to maximize habitat connectivity will become increasingly important (Millar et al. 2007).

Management Strategies to Address Key Climate Change Concerns

Actions to address climate change factors of most concern are those that:

1. Reduce vulnerability by restoring and maintaining resilient native ecosystems;
2. Anticipate increases in forest recreation;
3. Use markets and demand for wood and biomass for restoration, renewable energy, and carbon sequestration;
4. Enhance adaptation by anticipating and planning for intense disturbances;
5. Conserve water; and
6. Monitor climate change influences.

Managing ecosystems under uncertainty necessitates flexible and adaptive approaches that are reversible, are implemented in incremental steps, allow for new information and learning, and can be modified with

changing circumstances (Millar et al. 2007). Southwestern ecosystems have evolved under a long and complex history of climate variability and change. Taking into consideration the number of mega-droughts and other climate related variation, through time, southwestern systems have some built-in resilience. The revised plan focuses on restoring and maintaining resilience in forest and grassland ecosystems. Risks of increased wildfire, insects and disease outbreaks, and invasive species represent ongoing, broad-scale management challenges. These issues are not new. However, climate change has the potential to increase and exacerbate the impacts of these ecosystem risks.

Because our understanding of climate change is rapidly evolving, management decisions that are robust to uncertainty, while being both strategic and tactical in nature, would likely be most effective at managing for climate change. Peterson et al. (2011) have developed a guidebook for climate change response on national forests. It recommends the following strategies that incorporate both science and management: (1) become aware of basic climate change science and integrate that understanding with knowledge of the local resource conditions and issues (review); (2) evaluate sensitivity of natural resources to climate change (rank); (3) develop and implement options for adapting resources to climate change (resolve); and (4) monitor the effectiveness of on-the-ground management (observe) and adjust as needed.

Restoring and maintaining resilience would likely improve the potential for ecosystems to retain or return to desired conditions after being influenced by climate change related impacts and variability. Managing for resistance (e.g., maintenance thinning to prevent catastrophic fire, forest insect or disease pandemics) and resilience (e.g., noxious weed control) offer meaningful responses to climate change.

Prescribed fires are a management tool that can serve multiple purposes, from sustaining desired conditions for fire-adapted ecosystems and sustaining habitat for threatened and endangered species to reducing fuel loads. Prescribed burning is also a management strategy that will be important for maintaining desired habitats in a changing climate with more natural disturbances. With projections of more frequent storms and other more extreme weather events and increased stress from forest pests in a warmer, drier climate, prescribed burning will continue to be an important management strategy for the future.

Forests serve as significant carbon reservoirs; however, large-scale fire events can counter this benefit by releasing significant amounts of carbon into the atmosphere. Fuel treatments (e.g., thinning, prescribed fire), as identified in the proposed action, promote low-density stand structures characterized by larger, fire resistant trees. This strategy should afford greater carbon storage in southwestern fire-adapted ecosystems over time (North et al. 2009, Hurteau and North 2009). Although fire-excluded forests contain higher carbon stocks, this benefit is outweighed in the long term by the loss that would be likely from uncharacteristic stand-replacing fires (Hurteau et al. 2011) if left untreated.

Prescribed burning helps to mitigate the negative impacts of stand-replacing fire in dry, dense forests by consuming less biomass and releasing less carbon into the atmosphere (Wiedinmyer and Hurteau 2010). Further, research has shown that the long-term gains acquired through prescribed fire and mechanical thinning outweigh short-term losses in sequestered carbon. In the long term (e.g., 100 years), thinning and burning would create more resilient forests that are less prone to stand-replacing events, and subsequently able to store more carbon in the form of large trees.

Slash resulting from mechanical thinning can be used in place of fuels (North and Hurteau 2011, Sorenson et al. 2011). Not all forest products sequester carbon equally. For example, products with longer on average lifespans (e.g., houses), have a greater potential to store carbon than short-lived products such as fence posts. In addition, biomass products created from slash can be used in place of fossil fuels, greatly reducing carbon emission into the atmosphere (Ryan et al. 2010). These types of discussions of tradeoffs in emission and carbon storage rates are likely to be increasingly relevant in decision making.

Wood products that can substitute for building materials such as steel and concrete produce far less greenhouse gas emissions during their production while simultaneously sequestering carbon (Ryan et al. 2010).

Although current programs and guidance are already in place to limit introduction of nonnative species, treat invasive species, and control insects and diseases, these efforts are likely to become more critical to maintaining desired conditions for healthy forests under a changing climate. Due to the fragmented land ownership patterns, success in reducing forest pests requires going beyond national forest boundaries, and continued collaboration with partners will be needed. In addition, management practices (such as prescribed selection cutting for age class diversity) that sustain healthy forests and provide adequate nutrients, soil productivity, and hydrologic function promote resilience and reduce the potential for disturbance and damage.

The Wildlife Society with the Inkley et al. (2004) recommended several actions to help wildlife adapt to climate change and its potential effects on wildlife. These include: (1) managing for diverse conditions; (2) reducing nonclimate stressors on ecosystems; (3) reducing the risk of uncharacteristic high-intensity fires; (4) conducting medium and long-range planning; (5) ensuring ecosystem processes; and (6) employing monitoring and adaptive management, as well as controlling for invasive plant species. Finally, it will be important to set priorities by appropriately balancing sensitive and vulnerable species and systems with those that are resistant and resilient (Glick and Edelson 2011).

On the Kaibab NF, existing collaborations between the AGFD and Coconino County generally encourage the protection of open lands and the preservation of the land’s natural character within local and regional contexts. These collaborative strategies should decrease the potential for future land fragmentation while improving the overall integrity of the landscape. This should also provide for more resilience with regard to climate change for those wildlife species that may need to adjust migration routes, foraging corridors, or breeding grounds.

Planning Tools

To assist each national forest with better integration of climate change considerations into project-level planning, the Agency is actively engaged in developing user-friendly planning tools, assessments, and Web-based resources. For example, resource managers are encouraged to use rapid assessment tools, such as the Climate Project Screening Tool (CPST) (Morelli et al. 2012). The CPST is a decision-support tool that provides a direct link between best available science and management actions. Further, it is a process-oriented activity that integrates climate change trends for a particular region, with project design considerations for various resource areas. Composed of a series of climate change related questions relevant to the area of interest (developed collaboratively by scientists and interdisciplinary team specialists), the final outcome of the exercise for a particular project is a decision of proceed, modify, or cancel, given how well it meets the climate change considerations in the preceding questions, e.g., does it still make sense to do the project? Finally, this tool helps managers set priorities by considering the effects of different projects with regard to climate change, and helping to reduce management uncertainty.

Specifically for wildlife, the Forest Service Rocky Mountain Research Station has developed a System for Assessing Vulnerability of Species (SAVS). This system helps wildlife specialists quantify the relative impact of expected climate change effects for terrestrial vertebrate species. This decision-support tool uses criteria related to expected response or vulnerability of species in a questionnaire to provide a framework for assessing vulnerability to climate change. The questionnaire focuses on habitat, physiology, phenology, and biotic interactions. This tool helps to inform management by identifying specific traits and issues related to vulnerabilities of individual species. Additional information on this

application can be found at: http://www.fs.fed.us/rm/grassland-shrubland-desert/products/species-vulnerability/

Finally, a comprehensive Web site has been launched that serves as a clearinghouse for climate change related information. Organized by resource area, this is a "one-stop shopping" site that provides scientists and managers with the information and resources needed to incorporate the most up-to-date climate change considerations into both near and long-term planning initiatives: http://www.fs.fed.us/ccrc/.

Summary

By managing for resistant and resilient ecosystems, promoting landscape connectivity, and implementing concepts of adaptive management, land and resource management plans can provide the framework for responding to new information and changing conditions related to climate change that have the potential to increase impacts to ecosystem risks. The revised Kaibab National Forest Land and Resource Management Plan should provide clear management direction and include the necessary monitoring and mechanisms that would facilitate adaptation over time.

References

Brooks, C. P. 2003. "A scalar analysis of landscape connectivity." *Oikos* 102: 466–439.

Glick, P., B. A. Stein, and N. A. Edelson (editors). 2011. Scanning the Conservation Horizon: A Guide to Climate Change Vulnerability Assessment. National Wildlife Federation, Washington, DC.

Hurteau, M. and M. North. 2009. Fuel treatment effects on tree-based carbon storage under modeled wildfire scenarios. *Frontiers in Ecology and the Environment* 7: 409–414.

Hurteau, M. D., M. T. Stoddard, and P. Z. Fulé. 2011. The carbon costs of mitigating high-severity wildfire in southwestern ponderosa pine. *Global Change Biology* 17: 1516–1521.

Inkley, D. B., M. G. Anderson, A. R. Blaustein, V. R. Burkett, B. Felzer, B. Griffith, J. Price, and T. L. Root. 2004. Global climate change and wildlife in North America. Wildlife Society Technical Review 04-2. The Wildlife Society, Bethesda, Maryland, USA. 26 pp.

Joyce, L. A., G. M. Blate, et al. 2008. National Forests. Preliminary Review of Adaptation Options for Climate-Sensitive Ecosystems and Resources. In: S. H. Julius, J. M. West, J. S. Baron et al. (editors). Washington, DC, U.S. Climate Change Science Program and the Subcommittee on Global Change Research**:** 3-1 to 3-127.

Millar, C. I., N. L. Stephenson, et al. 2007. Climate Change and Forests of the Future: Managing in the Face of Uncertainty. *Ecological Applications* 17(8): 2145–2151.

Morelli, T. L., S. Yeh, N. Smith, M. B. Hennessy, and C. Millar. 2012. Climate Project Screening Tool. Res. Pap. PSW-RP. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. Online at http://www.fs.fed.us/psw/publications/documents/psw_rp263/psw_rp263.pdf

North, M. and M. Hurteau. 2011. High-severity wildfire effects on carbon stocks and emissions in fuels treated and untreated forest. *Forest Ecology and Management* 261: 1115–1120.

North, M., M. Hurteau, and J. Innes. 2009. Fire suppression and fuels treatment effects on mixed-conifer carbon stocks and emissions. *Ecological Applications* 19: 1385–1396.

Peterson, D.L., C.I. Millar, L.A. Joyce, M.J. Fruniss, J.E. Halofsky, R.P Neilson, and T.L. Morelli. 2011. Responding to climate change on national forests: A guidebook for developing adaptation options. Gen. Tech. Rep. PNW-GTR- Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station.

Ryan, M. G., et al. 2010. A Synthesis of the Science on Forests and Carbon for U.S. forests. *Issues in Ecology* 13: 1–16.

Sorensen, C., A. J. Finkral, T. E. Kolb, C. Huang. 2011. Short and long-term effects of thinning and prescribed fire on carbon stocks in ponderosa pine stands in northern Arizona. *Forest Ecology and Management* 261: 460–472.

Taylor, P. D., L. Fahrig, et al. 1993. Connectivity is a vital element of landscape structure. *Oikos* 68: 571–573.

Whitlock, C. 2008. Turning Up the Heat...On a Bubbling Cauldron of Forest Threats. Compass. USDA Forest Service, Southern Research Station.

Wiedinmyer, C. and M. D. Hurteau. 2010. Prescribed fire as a means of reducing forest carbon emissions in the western U.S. *Environmental Science and Technology* 44: 1926–1932.

USDA Forest Service, Southwestern Region. 2010a. “Southwestern Climate Change Trends and Forest Planning: A Guide for Addressing Climate Change in Forest Plan Revisions for Southwestern National Forests and National Grasslands.”

USDA Forest Service. 2010b. National Roadmap for Responding to Climate Change. 30 pp.