Planning for Climate Change

Planning for Climate Change is the third in a series of reports issued by Defenders of Wildlife associated with the conservation of national forest lands, waters and wildlife under the Forest Service's 2012 Planning Rule. Readers may find the two previous reports – Planning for Diversity and Planning for Connectivity – valuable background for understanding the 2012 Planning Rule. [1]

INTRODUCTION

In February 2019, the National Oceanic and Atmospheric Administration (NOAA) announced that 2018 was the fourth hottest year on record globally. In fact, the five hottest years in NOAA's 139-year record have occurred since 2014.[2] This sobering revelation underscores the warnings in the Fourth National Climate Assessment (NCA4) released in November 2018, the definitive multi-agency report on climate change in the United States (USGCRP 2018). Compiled by more than 300 experts, the NCA4 concludes that "Global average temperature has increased by about 1.8°F from 1901 to 2016, and . . . the evidence consistently points to human activities, especially emissions of greenhouse or heat-trapping gases, as the dominant cause" (Hayhoe et al. 2018).

The NCA4's chapter on "Forests" warns that "[t]he ability of U.S. forests to continue to provide goods and services is threatened by climate and environmental change and associated increases in extreme weather events and disturbances" (Vose et al. 2018). This includes extreme wildfire: seven of the ten most destructive California fires have occurred since 2015.[3]

Forests have always been shaped by climate, wildfire, and other disturbances, but their long-term resiliency was maintained in the absence of significant human-driven impacts and their ability to adapt to such perturbations. However, climate change now threatens the persistence of forest ecosystems that lack the capacity to adapt to rapidly changing conditions, such as persistent drought and longer dry seasons, as well as significant changes in the magnitude of wildfire, insect and disease disturbances. These uncharacteristic conditions and disturbances – in combination with human-based stressors – pose a significant threat to the resiliency and persistence of forest ecosystems and resident biodiversity (Vose et al., 2012).

The purpose of this report is to respond to this crisis on our national forests by incorporating adaptation strategies into national forest planning under the 2012 Planning Rule. By illustrating the many adaptation tools found within the rule – including for climate assessment, strategic planning and monitoring – our hope is that both forest and climate adaptation planners and advocates will view national forest planning as a tremendous opportunity to save our threatened national forests.

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[1] Available at: www.defenders.org/publication/planning-diversity and www.defenders.org/publication/planning-connectivity
[2] https://www.ncdc.noaa.gov/sotc/global/201813
[3]http://www.fire.ca.gov/communications/downloads/fact_sheets/Top20_Destruction.pdf

Forests, Biodiversity and Climate Change

The National Forest System

The U.S. Forest Service manages more than 193 million acres within 154 national forests, 20 national grasslands and one national prairie (collectively referred to as "national forests"). National forests encompass three-quarters of the major U.S terrestrial and wetland habitat types (Crumpacker et al 2005). According to the Forest Service, the National Forest System supports nearly 470 animals and plants listed under the Endangered Species Act (ESA) and 3,500 other at-risk species.

National forests are the headwaters of America's watersheds. There are 200,000 miles of streams in America's national forests, which also support many at-risk aquatic species, including over 50 percent of the nation's listed amphibians, one of the most vulnerable taxonomic groups to climate change impacts. In addition, roughly two-thirds of the fish species listed under the ESA occur on national forests, or are potentially affected by national forest management, along with nearly one-third of listed crustaceans (e.g. shrimp and crayfish), and a stunning 80 percent of listed mollusks (e.g. snails, slugs, and mussels).[4]

Climate Change and U.S. Forests

According to the 2018 National Climate Assessment, much of the United States has experienced an observed temperature increase of about 1 to 2°F, and by mid-century temperatures are projected to increase by 2 to 4°F under a low emissions scenario (RCP 4.5) and 3 to 5°F under the higher emissions scenario (RCP8.5), with even larger changes expected in Alaska (Hayhoe et al. 2018). Winters are warming faster than summers,[5] and since winter temperature is a key factor[6] in determining plant species distribution, warmer winters may lead to complete habitat shifts, like sugar maples disappearing from New England. Winter temperatures also improve the survival of many invertebrates that affect forest mortality, such as pine bark beetles.

Precipitation patterns are also changing due to climate change, generally increasing in the northern contiguous U.S. and Alaska, and decreasing in the Southwest (Easterling et al. 2017). More importantly, across much of the country, precipitation events are becoming concentrated, with a higher percentage of annual precipitation happening in events of higher intensity (Easterling et al. 2017). Heavy rains increase flood risk and runoff, sending damaging levels of sediments and pollutants into aquatic habitats. Type and timing of precipitation is also shifting, with less falling as snow and more as rain.

These precipitation changes have profound implications for the national forests and the nation. About 20 percent of the nation's waters originate in national forests and some 180 million people rely on these sources for their drinking water, including the urban residents of Los Angeles, Portland, Denver, Atlanta and many other large cities (Reference). National forest-based water has been valued at over $7 billion. In the American West, mountain snowpack accounts for roughly 75 percent of streamflows. Altered streamflows and rising

[4] https://www.fs.fed.us/biology/resources/pubs/tes/te_summary_08july08.pdf
[5] https://www.climate.gov/news-features/blogs/beyond-data/climate-change-rule-thumb-cold-things-warming-faster-warm-things
[6] https://www.arborday.org/media/map_change.cfm

water temperatures pose an acute threat to this resource, including to iconic and commercially valuable cold-water dependent species such as native trout and salmonids. Considerable research attention is being focused on the conservation of cold-water ecosystems and cold-adapted native salmonids (Nelson et al., 2016).

Furthermore, the same factors that concentrate precipitation into severe events – higher evaporation rates and more atmospheric moisture-holding capacity – also lead to increased drought (Hayhoe et al. 2018). Projections indicate that much of the western United States will become drier over the course of this century, and severe, extended droughts are already common in Texas, California and elsewhere. Severe droughts parch vegetation, leave trees susceptible to uncharacteristic insect attack and wildfire, and eliminate water resources needed for both aquatic and terrestrial species.

Increases in the frequency and severity of wildfire due to climate-driven drought and longer fire seasons could result in unprecedented and devastating changes to forests and the fish and wildlife they harbor (McKenzie et al., 2004; Gaines et al., 2012). One study estimated that climate change accounted for more than half of the documented increases in forest aridity found in Western U.S. forests over the past four decades, and is the primary driver expanding the seasonal duration, extent and severity of wildfires (Abatzoglou and Williams, 2016).

Compounding the climate-driven fire hazard is the increase in risk to life and property, as people flock to home within forested environments and adjacent to national forests.[7] From 1990 to 2010, the area of land categorized as "wildland-urban interface" (WUI) increased by 33 percent and the number of homes at the WUI grew by 41% (Volker et al. 2018). In recent years, fires destroying hundreds or thousands of structures have occurred in Colorado, Tennessee, Texas, and multiple locations in California. Several of these fires also caused tragic loss of human life. The Forest Service is expending an enormous amount of resources fighting and suppressing wildfires, with costs exceeding $1.2 billion every year since 2012, and almost double that in 2017.[8] Firefighting now consumes over 50 percent of the Forest Service's budget, although a 2018 fix to the wildfire suppression budgeting process[9] offers hope that firefighting costs can be reduced as a proportion of the agency's budget over time.

Providing for Diversity in a Changing Climate

By law each national forest must have a plan in place to direct the management and conservation of the resources within the planning area. Planning for the persistence of forests and other ecosystem types is a challenge compounded by the threat of climate change. At the finer species-scale, planning for at-risk wildlife requires strategic precision. Due to small population sizes, specialized habitat needs, limited distributions and restricted dispersal abilities, imperiled fish and wildlife populations experience heightened vulnerability to climate change impacts (Thomas et al. 2004).

Because of their location, elevation, size and management focus, national forests provide distinctive and critical conservation and climate protection values. America's national forests are strongholds for at-risk fish

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[7] https://headwaterseconomics.org/economic-development/trends-performance/recreation-counties-attract/
[8] https://www.nifc.gov/fireInfo/fireInfo_statistics.html
[9] https://www.usda.gov/media/press-releases/2018/03/23/secretary-perdue-applauds-fire-funding-fix-omnibus

and wildlife, many of which will have difficulty adapting or moving in response to likely future climates. Overall, nearly one in three species listed under the ESA depends on national forests to some degree for their survival, including roughly one in three listed birds, and nearly 40 percent of listed mammals. Many of these, including Canada lynx, grizzly bears, northern spotted owl, and red-cockaded woodpecker (to name a few) are vulnerable to climate change. Conserving these and other fish and wildlife populations on national forests in the face of climate change will require science-driven, systematic and well-coordinated landscape-scale conservation planning efforts to assess and respond to climate-driven threats to habitat (Margules and Pressey 2000).

Management in the face of climate change is commonly referred to as climate change adaptation, defined by the Intergovernmental Panel on Climate Change (IPCC) as "the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities" (McCarthy et al., 2001). Climate adaptation planning involves the development of forward-looking goals and strategies "*specifically designed* to prepare for and adjust to current and future climatic changes, and the associated impacts on natural systems and human communities" (Stein et al. 2014, emphasis added).

The Forest Service can help ameliorate climate-driven and compounding anthropogenic impacts to forest and other ecosystems through the development of forest plans that promote targeted actions that will increase the likelihood that ecosystems and species will persist in the face of climate change.

The Forest Service has a long history of working on climate change, dating to its 2008 Strategic Framework and 2010 National Roadmap for Responding to Climate Change. The agency has thus developed a wealth of expertise and background on assessing climate change impacts and developing adaptation options.[10] In 2012 the Forest Service adopted new planning regulations that give planners extensive tools to integrate adaptation planning into forest planning.

THE 2012 PLANNING RULE

Note to reader: For a complete review of the conservation requirements of the 2012 Planning Rule, please refer to Planning for Diversity.

[10] Including the following publications: "Effects of Climatic Variability and Change on Forest Ecosystems: A Comprehensive Science Synthesis for the U.S. Forest Sector,"(Vose, Peterson, & Patel-Weynand, 2012); "Responding to Climate Change in National Forests: A Guidebook for Developing Adaptation Options" (Peterson et al., 2011); "Forest Adaptation Resources: Climate Change Tools and Approaches for Land Managers," 2nd edition (Swanston et al., 2016), and numerous region-specific assessments.

The 2012 Planning Rule gives the Forest Service clear direction to develop forest plans that respond to climate change impacts to ecosystems and wildlife. A primary goal of the planning rule is to "emphasize restoration of natural resources to make our (national forest) lands more resilient to climate change" (Preamble, 21164). One of the purposes of forest planning is to allow "the Forest Service to adapt to changing conditions, including climate change…" (§219.5(a)). Forest plans developed under the 2012 Planning Rule will also reflect the conservation goals and objectives of the Forest Service' strategic plan, one of which is to "(f)oster resilient, adaptive ecosystems to mitigate climate change" (USDA, 2015c).

The planning rule supports strategic climate planning by adopting an adaptive planning process that includes: 1) an assessment of climate impacts to ecosystems, watersheds, fish and wildlife; 2) the development of the forest plan, including strategies and actions to sustain those resources in the face of climate threats, and; 3) a monitoring and evaluation program to determine whether the forest plan's climate conservation strategies are effective (§219.5(a)).

The planning rule's adaptive framework mirrors those proposed in other adaptation planning guidances (Cross et al. 2012; Stein et al. 2014), and reflects primary principles for adaptation planning, including the establishment of clear conservation goals, adaptive management, the use of vulnerability assessment, best available science and science-management partnerships (Joyce et al. 2009; Littell et al. 2012; Peterson et al. 2011).

Assessing Climate Change Impacts to Ecosystems and At-risk Species

Climate change adaptation requires an understanding of how climate change may impact a given biological system so that appropriate management strategies can be identified. The 2012 Planning Rule requires ecological assessments that should be treated as climate change *vulnerability assessments* for key ecosystem components, species, habitats and resources. **Vulnerability** to climate change refers to the degree to which an ecological community or individual species is likely to experience harm as a result of changes in climate (Schneider et al. 2007). Vulnerability is a function of **exposure** to climate change – the magnitude, intensity and duration of the climate changes experienced, the **sensitivity** of the species or community to these changes, and the **capacity** (of the species or system) **to adapt** (IPCC 2007; Williams et al. 2008). A vulnerability assessment can help to identify which species or systems are likely to be most strongly affected by projected changes in climate and provides a framework for understanding why particular species or systems are likely to be vulnerable (Glick et al. 2011). Such an assessment informs conservation planning by identifying climate-related threats and resulting stresses, which then become part of the decision-making process undertaken to identify and prioritize conservation strategies.[11]

Under the 2012 Planning Rule, the forest planning process begins with an assessment of social, economic and ecological conditions and trends within and affected by the forest planning area. The purpose of the assessment is to determine whether the current forest plan needs to change in order to sustain resources.

[11] Excerpted from the Defenders of Wildlife report: *Integrating Climate Change Vulnerability Assessments into Adaptation Planning.*

Most, if not all forest plans, many of which are significantly dated, will need to be updated to reflect climate change impacts on the sustainability of natural resources and affiliated social and economic systems.

The ecological assessment applies best available scientific information to evaluate climate change impacts to the ecosystems, watersheds, and at-risk species within the forest planning area. The planning rule specifically requires the assessment to appraise fifteen different topics, including "[s]ystem 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*" (§219.6(b)(3), emphasis added). The assessment should therefore be treated as a climate vulnerability assessment because it identifies resources that may need management support in adapting to change. To support adaptive management, the assessment should also identify information gaps, uncertainties, and assumptions associated with ecosystem and species adaptation to climate change.

One purpose of the assessment is to inform how the revised forest plan can restore and sustain ecosystems, watersheds, and fish and wildlife populations in the face of climate impacts. A key challenge for forest planners will therefore be integrating climate change impacts into the assessment of ecosystems and affiliated wildlife. Specifically, the assessment must consider climate impacts on 1) the integrity/resiliency of the forest's ecosystems and watersheds (defined as the condition of various ecosystem attributes), and 2) the habitat and management conditions that support the recovery and persistence of at-risk fish and wildlife populations.

The assessment will identify ecosystem attributes and species for analysis and management planning emphasis within the forest planning area. The assessment will also document potential *species of conservation concern* for long term persistence in the planning area, and climate threats may be a factor in determining that a species is of conservation concern.

For each of the forest's ecosystems, a set of measurable *ecosystem characteristics* will be evaluated to determine the status of the ecosystem and whether it is departed from reference conditions, understood as those conditions that sustain ecosystems in the face of climate change. The purpose of this ecosystem assessment is to support management that will maintain or *restore* the integrity/resiliency of ecosystems. The selection of ecosystem characteristics for assessment and planning should consider if the characteristic is helpful for understanding the effects of climate change on ecosystems. For example, the characteristic may be vulnerable to climate impacts (e.g., wildfire frequency and severity, or water temperature).

The assessment will evaluate likely climate impacts – operating in concert with other stressors (such as sedimentation from roads, barriers to connectivity, or water withdrawals) – on ecosystem characteristics and habitat/management conditions for at-risk species. To do this, the assessment compares the status and trend of the characteristics and conditions against a *climate-informed reference model* using information on the *natural range of variation* (NRV). The reference condition can be thought of as the "natural" condition that would be expected in the absence of human influence, *considering likely climate effects*. In this way it differs from the *historical range of variation*. While these future reference conditions should be informed by historical ecological information, they need to incorporate expected changes in climate.

If the assessment finds that ecosystem attributes or habitat conditions are departed, or will depart from, climate informed reference conditions, this indicates that the resource may not be sustained in the face of climate change under current management. The threat to sustainability could be caused by management stressors, by climate impacts operating in concert with management stressors, or by climate impacts alone. The purpose of the assessment is to alert the forest planning process to the vulnerability of the resource, and to identify the specific threat and necessary desired condition so that it can be addressed within the revised forest plan.

Climate Conservation Strategies for Forest Planning

In this section we present how forest plans can incorporate resistance, resilience and transformation strategies into forest plans.

The findings presented in the assessment are used to develop the forest plan, which will outline the strategies and actions necessary to maintain or restore ecosystems and fish and wildlife habitats in the face of climate change. Because ecosystems and fish and wildlife populations are generally not adapted to the rapid environmental change brought upon by climate change, it will be necessary to manage for their adaptation to those changing conditions. Strategies to adapt to these changes recognize three overarching categories of adaptation options:

Resistance strategies attempt to keep a system unchanged or intact, despite changing conditions. They are intended to reduce the exposure of a species or habitat to climate-related stresses. For instance, in the face of higher temperatures it may be possible to reduce the exposure experienced by a species of concern by restoring streamside vegetation to minimize changes in stream temperatures or to shade nests to reduce incubation temperatures. Managers may also use models to pinpoint "climate refugia" – areas that are expected to undergo less change over time, such as north-facing slopes, deep shaded coves, or groundwater-fed streams – and take steps to ensure that they are protected from other threats.

Resilience strategies capitalize on the ability of a system to "bounce back" from a disturbance and return to a structurally and functionally similar state. Thus, many of these strategies attempt to reduce the sensitivity of the species or habitat to climate change. Resilience strategies may include habitat protection, restoration, management and other activities that improve the overall health of the system, such as reducing the likelihood of uncharacteristic fire, improving wetland function, alleviating competition from invasive species and adding artificial nest boxes to boost reproduction.

Transformation (also called "transition" or "realignment") strategies recognize that climate changes may very well produce a fundamental change in a system's structure and/or function. The goal is to increase the adaptive capacity of the system by allowing it to respond in new ways. Examples include increasing connectivity to allow species to shift their ranges, or proactively conserving areas that are predicted to be the future range of a target species or habitat. Planting salt-tolerant species to help a freshwater wetland transition to a saltmarsh is an example of a sea-level rise transformation strategy. More aggressive strategies, such as moving species to areas outside their historical range, may be controversial and require careful consideration.

Planning for Resistance

In cases where the assessment has indicated that an ecosystem characteristic or condition for an at-risk species is likely to persist in the face of likely climate effects, the forest plan should adopt a resistance-oriented strategy. Resistance-oriented (or maintenance) strategies are intended to reduce exposure to climate-related stresses, and often capitalize on opportunities to protect "climate refugia" areas projected to have less exposure to climate change impacts. Due to the wide range of elevational gradients and physiographic characteristics within many national forests, they will play a critical role in providing climate refugia for a significant number of climate and management-stressed fish and wildlife populations.

Forests should also plan to implement management strategies that enhance habitats' ability to continue to provide areas of reduced exposure, and many national forests will need to provide these valuable climatic conditions. Examples include restoring riparian vegetation to provide stream shading and recognizing the water retention benefits of beaver ponds.

Forest plans should identify, designate and protect predicted climate refugia; these areas likely meet the rule's test of fulfilling a unique and special purpose on the forest. It is likely that forests will also have to designate and protect areas outside of existing reserves to offer landscape-scale refugia networks for fish, wildlife and plants displaced from existing protected areas due to climate impacts; one study estimates that only a fraction of existing protected areas will offer stable climatic habitat conditions in the future (Batllori et al., 2017). Importantly, in addition to designating landscape-scale climate-reserve networks, the forest plan will need to establish non-reserve – or matrix-based strategies – to constrain management actions that may degrade refugia conditions outside of protected reserves (Lindenmayer and Franklin, 2002).

For example, within the range of bull trout, forest plans should identify and prioritize the conservation of bull trout cold-water habitats that are most likely to resist the effects of climate change. Specifically, cold-water habitats fed by springs are expected to be more resistant to climate change impacts than other warmer and lower-elevation habitats, due to the uniformity of groundwater temperature. In addition, forest plans may need to provide the necessary constraints on projects and activities that could degrade cold-water conditions for bull trout, for example by limiting negative impacts to native trout including livestock grazing, logging (and related road networks), mining and harmful water management (Behnke and Tomelerri, 2002).

Planning for Resilience

In cases where the assessment has indicated that a characteristic or condition for an at-risk species is departed from future reference conditions, or is likely to be departed in the future, the forest plan should adopt a resilience-oriented strategy. Resilience-oriented (or restorative) strategies recognize the system will be exposed to changing climate conditions and are intended to minimize the severity of climate change impacts, reduce sensitivity to those impacts, and improve the ability of ecosystems and species to "bounce back" from a climate-related stress. Many of these strategies will include restorative or resiliency-enhancing management that improve the functionality of an ecosystem by moving it towards the climate informed reference condition. Resiliency actions may focus on altering ecosystem structure and composition in order to prepare the system for climate-driven changes in disturbance regimes.

For example, an assessment may find that seasonal stream flows – a condition necessary to sustain at-risk fish – are departed from reference levels due to climate-driven changes in precipitation patterns and exacerbated by ongoing water withdrawals. While the forest plan may not be able to address the underlying climate change stress, it may be able to affect the withdrawals.

Or, an assessment may find that current forest conditions may not be sustained in the face of increased instances of severe wildfire. In these cases, the plan may direct efforts to enhance the heterogeneity areas of ecosystems that have been simplified and compromised by prior management actions. The plan may also establish desired conditions for fire prone forests that reflect future conditions, including managing for areas that are ecologically and socially able to support high severity wildfire. Removing stressors that compromise essential ecosystem processes, such as aggressive suppression of fire or the creation of non-resilient forest stands (e.g. via clearcutting), can be targeted for modification in the plan to enhance resiliency to wildfire. Forest plans should identify areas of high and low resiliency to prioritize management actions. Planning for more prescribed and managed wildfire will be essential to enhancing the resiliency of fire adapted forests.

Removing other stressors (like invasive species) or constraints to population rebound (such as by providing nest boxes) are also strategies for resilience that are within the purview of the forest's planning and management.

For many at-risk fish and wildlife populations, abating management threats and maintaining existing suitable habitat conditions may not be enough to ensure persistence; it will also be necessary to restore key conditions for which the species is adapted or more likely to adapt to. For example, , bull trout require streams with complex habitat structure, including deep pools, overhanging banks, riparian vegetation, and large woody debris (USFWS, 2015). For many national forest streams, each of these key characteristics may be departed from the reference conditions that are necessary to recover bull trout populations.

Planning for Transformation

Finally, there may be cases, given the rapid or significant nature of the climate effects, where maintenance or restoration strategies are unlikely to sustain a specific fish or wildlife population. In these cases, transformation-oriented strategies may be necessary to manage systems so that they respond in new ways. For instance, a forest plan may need to facilitate a shift in the range of a climate-threatened fish, wildlife or plant population.

For example, climate-driven snow loss and the transition from snow to rain-dominated precipitation conditions impact soil temperature by diminishing the insulation function provided by snow. Yellow-cedar, found in southeast and coastal Alaska, is threatened by spring freezing, which increasingly occurs in the absence of snowy thermal cover. A recent article estimated that half of the yellow-cedar's native range in coastal Alaska is threatened by this climate driven mortality (Buma et al., 2016). Because yellow-cedar is long-lived and has low productiveness, the species is limited in its ability to adapt to climate change and may require intentional transformation-oriented adaptation strategies. For instance, in 2009 the Tongass National Forest planted yellow-cedar, on a trial basis, near Yukutat, Alaska, an area where the species did not previously grow, and which is at the northern limit of the species range. Survival of more than 90 percent of the planted trees indicates that facilitated range shift (sometimes referred to as "assisted migration") may be a viable adaptation strategy for the species (Hennon et al. 2016).

Expressing Climate Change Strategies as Plan Components

Forest plans will guide climate conservation strategies through the development of *plan components*, which shape and direct the management actions that will be implemented under the plan. Plan components include desired conditions, objectives, standards, guidelines, and suitability of lands. Ideally, plan components should have clear geographic applicability, which means they can be applied to certain areas of the forest identified as being important to maintaining or restoring necessary climate conservation conditions for fish and wildlife populations.

Desired Conditions

Forest plans must include clear and measurable descriptive statements about the desired future conditions for the key ecosystem characteristics and ecological conditions identified as being important for the resiliency of ecosystems and persistence of at-risk species. Generally, the desired conditions for ecosystems and habitats within a forest plan are those that will be sustainable in the face of climate change. For management, the objective will be to maintain the desired condition where it currently exists, or to restore it where it is absent. Desired conditions should articulate the actual measurable desirable reference conditions. Desired conditions should reflect the forest's distinctive roles and contributions to conserving habitat in the face of climate change; for example, many forests should have desired conditions to maintain the resilient conditions of areas that are expected to provide future climate refugia conditions not found on the surrounding landscape.

Desired conditions can be applied across the forest, throughout an entire ecosystem type, or can be targeted to specific areas. Forest plans should identify areas where the current condition is desirable and needs to be maintained, as well as areas where the current condition is not-desirable and require restoration in order to enhance resiliency. Areas should be prioritized for restoration based on their importance to conservation and resiliency. The application of plan components within specific areas (e.g. management areas, geographic areas, or other areas designated to maintain unique and special characteristics) should be used to concentrate climate change response and climate conservation strategies within specific areas of the forest.

Objectives

As noted, in some areas the objective will be to maintain the desired climate-resilient or resistant condition. In other areas, the objective will be to restore or enhance ecosystem resiliency or habitat integrity. The purpose of plan objectives is to prioritize the most important actions necessary to maintain or achieve desired conditions and to ensure that progress is made toward the desired conditions. Objectives should be used to identify and prioritize the most important climate conservation actions in the forest planning area, for example, those cases where the assessment documented clear vulnerability to climate change impacts and noted activities that could restore the characteristic or condition or alleviate threats that compound the magnitude of the climate impact. For example, a forest plan could establish an objective to improve aquatic ecosystem connectivity and resiliency by removing 15 problematic culverts in specific drainages over the life of the plan, or to conduct prescribed burning across a number of acres within certain forest types over the life of the plan.

Standards and Guidelines

Standards and guidelines constrain projects and activities that may pose a threat to key ecosystem characteristics or conditions for at-risk species and will frequently be used to maintain desired conditions by avoiding harmful effects. Because standards and guidelines are geared towards management actions, they will be used to address particular interacting management stressors that magnify climate effects. For instance, forest plans can use standards and guidelines to prohibit certain types of timber harvest or other management actions in riparian areas in order to ensure that cold water conditions are maintained for at-risk fish. Standards and guidelines can also be used to direct resiliency-based actions, for example by specifying how timber harvest should be conducted in order to retain the appropriate forest structures necessary for ecosystem integrity and the persistence of at-risk species. Desired conditions, objectives, and standards and guidelines will be used in concert to sustain resources and improve the resiliency of the planning area to climate change.

Forest plans will also make determinations that certain areas are suitable for certain uses, such as timber production. Suitability determinations should be informed by climate change vulnerability assessments; for instance, a plan could determine that timber production is not compatible with certain areas that are critical for sustaining resources in the face of climate change.

Connectivity

Forest plans must provide for the maintenance or restoration of connectivity as a dimension of ecological integrity (§219.8(a)(1)). Because well-distributed populations are more resilient than isolated ones, managing for connectivity is especially important for enabling adaptation to stressors, including climate change. In fact, a review of 22 years of recommendations for managing biodiversity in the face of climate change found improving landscape connectivity is the most frequently recommended strategy for allowing biodiversity to adapt to new conditions (Heller and Zaveleta 2009). Connectivity should therefore play a prominent role in forest planning for climate conservation.

Assessments should determine a reference condition for landscape pattern that will support the ability of fish and wildlife populations to adapt to changing climate conditions. Barriers to connectivity should be identified and prioritized for removal within forest plans. Generally, forest plans should aspire to create a more resilient transportation network, given the significant negative effects roads and other routes have on ecosystem functionality, watershed conditions, and species persistence. Areas important for connectivity should be identified within forest plans.

Reconnecting fragmented habitat for fish and other aquatic species should be a high priority adaptation strategy on all national forests, given that there are more miles of road within the National Forest System (375,000) than stream (200,000), resulting in at least 40,000 places where roads cross streams.

Desired conditions should be supported by one or more objectives to prioritize areas for restoration of connectivity and possibly standards or guidelines to constrain management actions that may impede achievement of the desired connected conditions.

Implementation, Monitoring and Evaluation

After the plan has been finalized, projects and activities will be implemented in order to achieve the plan's desired conditions and objectives; all projects and activities must be consistent with the plan components.

The forest should begin implementing the priority climate conservation activities to fulfill the desired conditions; many of these will be resiliency-oriented strategies to restore or enhance key ecosystem characteristics and conditions for at-risk species that have been degraded by management actions and are not likely to be resilient to future climates. Priority implementation actions should be undertaken in key areas identified within the forest plan.

The forest will also implement other plan direction, including activities to fulfill other multiple-use objectives, such as timber harvest, grazing, mineral development and recreation management. Some of these activities may contribute stress to climate-threatened resources (and should have been identified and evaluated in the assessment), in which case the management constraints of the forest plan (standards and guidelines) will be employed to avoid or mitigate the stress to ecosystem characteristics and conditions supporting at-risk species. Project-level analysis will be conducted to disclose environmental effects and ensure the activity is consistent with the forest plan.

In addition, a monitoring program will evaluate the plan's effectiveness, including the efficacy of the climate conservation strategies. The monitoring program establishes monitoring questions and indicators to evaluate the effect of the plan on watershed conditions, key ecosystem characteristics, and ecological conditions for at-risk species.

Forest monitoring programs will also directly monitor changes in the condition of *focal species*, which will be selected to provide insight into the integrity of the ecosystem to which they belong. Forest plans should select focal species sensitive to climate impacts to evaluate whether strategies to maintain, restore or enhance ecosystem integrity are effective. Species that are known to play an important role in enhancing and maintaining ecological integrity, such as beavers and woodpeckers, should be considered as focal species.

Focal species can be selected from the pool of at-risk species; if there is uncertainty over the relationship between an at-risk species and the conditions needed to support its persistence, the forest should consider direct monitoring of the species within the plan area, if monitoring methods are available and feasible.

While the rule encourages the monitoring of the ecological conditions that support at-risk species, it should be noted that at-risk species vulnerable to climate effects can be directly monitored (i.e. distribution, occupancy, or demographic rates), even if not designated as focal species. For example, the Flathead National Forest will directly monitor the condition of cold-climate adapted whitebark pine, a candidate for listing under the ESA. The forest will also evaluate the effectiveness of actions to restore whitebark pine populations, including prescribed burning and the planting of white pine blister rust-resistant seedlings; the non-native fungus, interacting with fire suppression and rising temperatures, threaten the persistence of whitebark throughout much of its range.

Forest-level monitoring programs will operate in conjunction with broader-scale monitoring strategies developed at the regional level; many climate change impacts will likely be most effectively monitored and evaluated at scales larger than individual national forests, and it is important that forest-level and broader-scale climate monitoring be well-coordinated.

There will be at least two primary areas of uncertainty associated with the climate conservation strategies that should be addressed and reduced through the monitoring program. First, it is likely that some of the underlying assumptions behind the climate conservation strategy, such as predicted precipitation levels or changes in disturbance regimes, do not come to pass. The monitoring program must track actual climate-driven changes within the plan area so that the plan can be adjusted if necessary. Science-based partnerships and coordination with climate researchers will be fundamental in acquiring new information. New information and advances in best available science, outside of the forest monitoring program, can also illicit changes in the forest plan. For instance, science may reveal concerning vulnerabilities to fish or wildlife populations previously thought to be secure within the planning area.

Second, it is likely that some of the climate conservation actions assumed to improve ecosystem or wildlife population resiliency may in fact not have the desired effect and will need to be adjusted in the forest plan. For instance, in some settings, the assumption that reductions in stand densities will create more resilient conditions to climate-driven wildfire disturbances may be contradicted by effectiveness monitoring. Or, monitoring may reveal that resiliency-building actions have unforeseen negative effects on other resources that were not considered during the development of the plan.

Given the uncertainty associated with climate change effects, as well as the high degree of uncertainty over the efficacy of climate conservation actions, a robust and well-funded adaptive monitoring program is an absolute necessity; it must not be an afterthought or abandoned, as has been the unfortunate case over the years in natural resource management (Lindenmayer and Likens, 2010). In addition, it is important to not equate uncertainty with flexibility; forest plans need to establish a range of measurable future conditions based on the best available science, as hypotheses for testing, as opposed to open-ended plans, which lack both accountability and the necessary direction for effective conservation.

CONCLUSION

Climate change poses an enormous risk to our forests and the fish, wildlife and biodiversity they harbor; it also threatens our communities and way of life, which are so intertwined with our national forests.

In 2016 then Forest Service Chief Tom Tidwell gave a speech on the subject of forest restoration in the era of climate change, in which he painted the dire picture facing America's national forests:

> (O)ur forests are facing some of the greatest challenges in history. In California alone, we have 66 million dead trees due to extreme drought and epidemic insect outbreaks. Years of fire suppression and fuel buildups, along with the hot, dry conditions that come with climate

change, are causing immense wildfires. These fires release enormous amounts of carbon dioxide, sterilize soils, and severely hamper carbon sequestration.

Yet the Chief concluded his speech on a positive note, reminding people that meeting the climate change challenge will take bold and ambitious action, but that the Forest Service had the tools to do so:

> In 2012, we adopted a landmark forest planning rule – the first such rule in a generation – to guide management of the 77 million hectares of national forests and grasslands. As units revise their land management plans, they evaluate climate stressors and monitor impacts on forest health.

The Forest Service, along with all of the stakeholders involved in forest planning, have the opportunity to take the necessary bold and ambitious actions that will support the persistence of forests, fish and wildlife. We hope this report contributes to that effort.

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