Planning for Climate Change- Defenders of Wildlife

PREFACE

2016 was the hottest year ever recorded on earth, marking three consecutive record setting years.[1] In the summer of 2016 thousands of fish, mainly native mountain whitefish but also iconic Yellowstone cutthroat trout, died in the pristine waters of Montana's famed Yellowstone River. Following the closure of over 180 river miles to all waterborne activity, including fly fishing and rafting, two mainstays of the local recreation-based economy, the Governor declared a state of emergency on the river in order to offer the businesses and workers of the Yellowstone an economic lifeline.

The fish were killed by acute Proliferative Kidney Disease (PKC) brought on by a parasite called *Tetracalsula bryosalmonae*. With summer water flows at historic lows due to earlier snowpack loss and stream temperatures exceeding historic levels by as much as 20 degrees, the cold-water adapted fish easily succumbed to the extreme stress brought on by the highly contagious parasite. Closure of the river was an emergency action to reduce stress on the fish, a strategy that is becoming more and more necessary as fish and wildlife struggle with multiple threats to their persistence. Some biologists called the Yellowstone fish kill a "perfect storm" of stressful events, but in fact what happened on the Yellowstone in the summer of 2016 is the "new normal."

National forests play a critical role in the race to save species from the devastating effects of climate change. The mighty 671 mile Yellowstone originates near the 12,000 foot Younts Peak in the Absaroka Range of the Bridger-Teton National Forest in Wyoming and runs through about 30 miles of national forest land before entering Yellowstone National Park. There are 200,000 miles of streams in America's national forests, along with thousands of at-risk species like the Yellowstone cutthroat. All are threatened to some degree by climate change. This report addresses planning for climate change impacts on U.S. national forests so that we can safeguard the incredible biodiversity they support before they are gone.

This is the third in a series of reports issued by Defenders of Wildlife associated with the conservation of ecosystems 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 reading in understanding the 2012 Planning Rule. [2]

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[1] http://www.noaa.gov/stories/2016-marks-three-consecutive-years-of-record-warmth-for-globe

[2] Available at: www.defenders.org/publication/planning-diversity and www.defenders.org/publication/planning-connectivity

INTRODUCTION

As the lead government agency responsible for climate-based conservation and management of U.S. national forests the Forest Service will play a fundamental role in responding to the climate crisis facing America's forests, fish, wildlife and watersheds.

The Forest Service stewards over 190 million acres of national forests, grasslands and watersheds – nearly 10 percent of all the lands in the nation. National forests support more than 420 animals and plants listed under the Endangered Species Act (ESA) and over 3,000 other at-risk species, many of which will have difficulty adapting or moving in response to likely future climates. To put this in perspective, nearly one in three species listed under the ESA depend on national forests to some degree for persistence. Among these are some of America's most iconic wildlife species. Roughly one in three ESA listed birds rely on national forest habitat, and nearly 40 percent of listed mammals, including gray wolves, Canada lynx, jaguars, Florida panthers and grizzly bears. Because species with existing at-risk populations are likely to be most vulnerable to climate change impacts, including those with specialized habitat needs, limited distributions and limited dispersal abilities, it makes sense to target these species for climate assessment and adaptation planning (Thomas et al., 2004).[3]

National forests will play a pivotal role in developing conservation strategies to help climate-stressed species adapt to changing conditions. For example, the Forest Service can manage streams to maintain cold-water conditions where they exist, by retaining vegetation along streambanks. The Forest Service will also play a major role in enhancing habitat resiliency where it is lacking; for example, by restoring fire to fire-adapted ecosystems or reconnecting fragmented habitats by removing man-made barriers to fish and wildlife movement.

Because of their location, elevation, size and management focus, national forests provide conservation and adaptation values that may be scarce in the surrounding landscape. For many climate and management-stressed species, national forests may offer climate *refugia*: habitat conditions that are present on national forests but increasingly scarce in surrounding landscapes due to development pressure and changes in climate conditions.

[3] *Climate change adaptation* is defined by the Forest Service as "(a)djustments in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. This adaptation includes initiatives and measures to reduce the vulnerability of natural and human systems against actual or expected climate change effects." *Climate change planning* is characterized by the development of conservation strategies for lands, waters and wildlife that are "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).

For example, in 2013 the U.S. Fish and Wildlife Service (USFWS) identified climate change as the primary threat to the wolverine in the continental United States. Wolverines rely on deep spring snow to rear their young, so they are especially vulnerable to the loss of their alpine habitat due to climate change. Scientists predict that wolverines in the lower 48 states may lose two-thirds of their suitable, snow-covered habitat by the end of the century. National forests supporting wolverines will need to recognize the key role they play in the species' conservation, manage alpine refugia habitat to alleviate possible management stresses, and proactively plan to provide for connections between increasingly isolated snowy habitats.

This century will be defined by how intelligently we manage our water, watersheds and aquatic resources in the face of rapid environmental change. National forests are the nation's reservoirs. National forests support over 50 percent of the nation's listed amphibians, one of the most vulnerable taxonomic groups to climate change impacts. For example, the national forests within the Sierra Nevada Mountains host both Sierra Nevada (*Rana sierra*) and a distinct population of mountain (*Rana muscosa*) yellow-legged frogs, as well as Yosemite toads (*Anaxyrus canorus*), all of which are listed under the ESA and face compound threats to their wet meadow and riparian habitat from climate-driven drought coupled with harmful management practices such as livestock grazing and introduction of non-native fish.

In addition, roughly two -thirds (92 of 139) of the fish species listed under the ESA occur 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, octopuses, and mussels). Many freshwater mussels concentrated in national forest streams in America's south are being pushed to the brink by warming waters, drought, development and pollution. brink.

Altered streamflows and rising water temperatures pose a particularly acute threat to iconic and commercially valuable cold water dependent species such as native trout and salmon, many of which rely on national forest aquatic ecosystems for survival. National forest fish conservation managers are pursuing a range of management strategies to counter these changing conditions, including maintaining as much water as possible in streams during critical periods, restoring aquatic habitat and connectivity (for example by removing harmful barriers to fish passage such as culverts), and restoring streamside forests and vegetation, which shade and cool streams.

As one of the nation's primary drinking water providers, climate change impacts to national forest watersheds also have profound implications for humans. 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. National forest based water has been valued at over $7 billion.

As for the defining ecosystem of national forests – forests - changes in temperature and precipitation will have a major impact on the forces that shape them. Forests have always been shaped by wildfire, insects and disease, but their natural resiliency was maintained in the absence of human driven impacts that lead to habitat loss, degradation and fragmentation.

The immediate repercussions of a changing climate, such as persistent drought and longer dry seasons, will change the magnitude of these impacts on forests and, in combination with other interacting management-based stressors such as development and fire suppression, pose a serious threat to their resiliency and persistence.[4] The Third National Climate Assessment, the definitive report compiled by more than 300 experts summarizing the impacts of climate change on the United States, concluded that "(c)limate change is increasing the vulnerability of many forests to ecosystem changes and tree mortality through fire, insect infestations, drought, and disease outbreaks" (Joyce et al, 2014).

Uncharacteristically high-severity disturbance from insect infestations, drought, wildfire or hurricanes have occurred in the southeast, southwest, northern Rockies, and Alaska in recent years (Goetz et al. 2012). A recent study estimated that climate change accounted for more than half of the documented increases in forest dryness 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). Increases in the frequency and severity of wildfire due to climate-driven drought and longer fire seasons – coupled with ongoing management stressors like invasive species and fire suppression – could result in unprecedented and devastating changes to forests (McKenzie et al, 2004; Gaines et al, 2012).

The Forest Service is expending an enormous amount of resources fighting fires, a problem that becomes more acute as more people move into the areas adjacent to national forests. For example, 2015 was a record for wildland fire in the U.S.: it marked the first time that over 10 million acres burned (NIFC 2016a), and federal fire suppression costs exceeded $2 billion for the first time ever (NIFC 2016b). Firefighting now consumes over 50 percent of the Forest Service's budget and, barring a fix to the budgeting process and changes in suppression policies, is expected to account for two of every three dollars of the agency's budget by 2025.

The 2012 Planning Rule

Helping fish and wildlife adapt to climate change will require robust, proactive and well-coordinated landscape-scale conservation planning efforts that include climate science, threats and response strategies.

[4] The forest planning directives describe interacting stressors as: "Interacting stressors may include fire, insects, invasive species, loss of spatial connectivity, disruption of natural disturbance regimes, geologic hazards, water withdrawals and diversions, and changes in social, economic, and cultural conditions that affect the plan area, among others" (FSH 1909.12, Chapter 30).

The Forest Service is well positioned to integrate climate change planning into their planning and management. In 2012 the Forest Service adopted a new land management and planning regulation (36 CFR §219 and www.fs.usda.gov/planningrule) to guide the development of land management plans – commonly called *forest plans*. The 2012 Planning Rule is a regulation that implements the National Forest Management Act (NFMA, 1600 U.S.C. § 1600 et seq.), the primary law governing management and conservation of our national forests. Forest plans guide conservation and management actions that occur on all of the nation's national forests (e.g. where and how to conserve and recover at-risk species, or where to harvest timber).

Because the planning rule explicitly requires forest plans to incorporate climate change, it provides a robust platform for integrating adaptation planning into the forest planning process. It encourages the development and implementation of adaptation strategies to make national forests, along with resident fish, wildlife and plants, more resilient to the stresses of climate change,[5] and reflects primary principles for adaptation planning (Joyce et al, 2009; Cross et al, 2012; Stein et al, 2009; Peterson et al, 2011; Littell et al., 2011), such as:

- An adaptive management planning framework that includes an assessment of climate impacts to ecosystems, wildlife and watersheds, the development of strategies and actions to sustain those resources in the face of climate threats, and a monitoring and evaluation process to determine whether the climate conservation actions are effective.
- A clear conservation goal to maintain or restore the climate resiliency of national forest ecosystems and the establishment of specific management objectives for ecosystems and species.
- The use of best available scientific information, including climate effects and adaptation information, as well as science-management partnerships to inform the adaptation planning process.

Assessing Climate Effects

Assessing how climate impacts act as system drivers (i.e. as an ecological process operating with other disturbance processes, such as the frequency and severity of fire) and interact with other

[5] The Preamble to the planning rule stated that "the Department and the Forest Service find that a planning rule must…emphasize restoration of natural resources to make our NFS lands more resilient to climate change" (Preamble 21164) and that the rule should 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 (§219.7(c)(2)(ii)), one of which is to "(f)oster resilient, adaptive ecosystems to mitigate climate change" (USDA, year).

management stressors[6] to affect the sustainability of natural resources is a foundational element of adaptation planning. Assessments inform planning by identifying climate-related threats and resulting stresses, which then become part of the decision-making process undertaken to identify and prioritize responsive conservation strategies.

The Forest Service is making a concerted effort to make vulnerability assessments available for use in forest planning and other management processes. For example, the Northern Rockies Adaptation Partnership (NRAP) is a science-management collaboration involving the 13 national forests of the Northern Region, the Forest Service's Pacific Northwest and Rocky Mountain Research Stations, the National Park Service (Glacier, Yellowstone and Grand Teton) and other academic and non-governmental institutions. NRAP conducts vulnerability assessments to develop adaptation strategies for use in national forest planning.[7] A draft 2017 report – *Climate Change Vulnerability and Adaptation in the Northern Rocky Mountains* – assessed climate vulnerability of water resources (including snowpack and glaciers), cold-water salmonids, forest and rangeland vegetation, ecological disturbance and wildlife across the region.

In some cases, existing vulnerability assessments will be available for integration into the forest planning assessment. For example, the Forest Service in Alaska developed a *Climate Change Vulnerability Assessment for the Chugach National Forest and the Kenai Peninsula* in order to inform the revision of the Chugach forest plan.[8] The assessment evaluated climate impacts to important ecosystem and social resources over a 30 to 50-year time horizon, including glaciers and icefields, coasts and seascapes, salmon, vegetation, wildlife and infrastructure. Information documented in the assessment informed the development of the draft Chugach forest plan.

The Chugach assessment highlighted the vulnerability of crucial tidal marsh ecosystems, particularly in the Copper River Delta. Climate driven sea level rise, along with natural coastal subsiding, results in the loss, change and migration of crucial marsh habitat, with consequences for at-risk wildlife species such as the dusky Canada goose, which nests in the wetlands of the Copper River, and is a species with known persistence concerns on the Chugach National Forest.

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[6] The planning rule directives define stressors as: "Factors that may directly or indirectly degrade or impair ecosystem composition, structure, or ecological process in a manner that may impair its ecological integrity, such as invasive species, loss of connectivity, or the disruption of a natural disturbance regime" (FSH 1909.12, Chapter Zero Code).

[7] http://adaptationpartners.org/nrap/

[8] The publication, which was still under production at the time of the development of this report, is available here: www.fs.usda.gov/Internet/FSE_DOCUMENTS/fseprd486648.pdf

The forest planning process starts with an assessment of resources, conditions, and values on the forest. The assessment identifies and evaluates existing information relevant to the forest plan area. The assessment assumes the influence a changing climate.[9]

An ecological assessment will document the best available science on climate change impacts to ecosystems, watersheds, and at-risk species, and specifically evaluate "the ability of terrestrial and aquatic ecosystems on the plan area to adapt to change" (§219.6(b)(3)). To support adaptive management, the assessment also identifies information gaps, uncertainties, and assumptions associated with ecosystem and species adaptation to climate change.

The conservation objective of the planning rule is to maintain or restore the integrity of ecosystems[10] and sustain the constituent fish, wildlife and plants of those systems. It is not feasible to assess climate impacts for every dimension of an ecosystem, and in order to put in place an effective planning scheme for resources, the planning rule guides the Forest Service to select ecological indicators for assessment, management and monitoring.

For ecosystems, the planning rule directs the agency to select key characteristics indicative of the structure, function, composition and connectivity of the ecosystem.[11] The condition of the individual characteristics, when viewed in their entirety, should portray the ecological health and functionality of the ecosystem. For at-risk species, the planning rule directs the agency to identify the key habitat and other conditions necessary to support species, and manage to sustain or restore those conditions. [12] Because species with existing at-risk populations are likely to be most vulnerable

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[9] The planning rule directives define evaluate in the context of the assessment: The term "evaluate" means that the Interdisciplinary Team describes the on-the-ground conditions and estimates the trends, assuming the existing plan remains in place and *assuming the influence of a changing climate"* (FSH 1909.12, Chapter 10).

[10] *Ecological integrity.* The quality or condition of an ecosystem when its dominant ecological characteristics (for example, composition, structure, function, connectivity, and species composition and diversity) occur within the natural range of variation and can withstand and recover from most perturbations imposed by natural environmental dynamics or human influence.

[11] (1) Composition. The biological elements within the different levels of biological organization, from genes and species to communities and ecosystems. (2) Structure. The organization and physical arrangement of biological elements such as, snags and down woody debris, vertical and horizontal distribution of vegetation, stream habitat complexity, landscape pattern, and connectivity. (3) Function. Ecological processes that sustain composition and structure, such as energy flow, nutrient cycling and retention, soil development and retention, predation and herbivory, and natural disturbances such as wind, fire, and floods. (4) Connectivity. Ecological conditions that exist at several spatial and temporal scales that provide landscape linkages that permit the exchange of flow, sediments, and nutrients; the daily and seasonal movements of animals within home ranges; the dispersal and genetic interchange between populations; and the long distance range shifts of species, such as in response to climate change.

[12] *Ecological conditions.* The biological and physical environment that can affect the diversity of plant and animal communities, the persistence of native species, and the productive capacity of ecological systems. Ecological conditions include habitat and other influences on species and the environment. Examples of ecological conditions include the

to climate change impacts, including those with specialized habitat needs, limited distributions and limited dispersal abilities, it makes sense to target these species for climate assessment and adaptation planning (Thomas et al., 2004). This scheme facilitates adaptation planning, where a fundamental procedure is to identify and manage those elements of the ecosystem that can be manipulated to reduce climate stress on ecosystems and species (Cross et al., 2012).

The ecological assessment begins with the identification of the ecosystems and the at-risk species within the forest planning area. The assessment should clearly document the ecological conditions that are necessary to support each of the at-risk species so that the conditions can be evaluated for climate impacts; the assessment must also evaluate the other risks to those conditions, including potential management stressors, such as timber harvest, grazing or fire suppression. At-risk species include species listed, proposed for listing, or candidates for listing under the ESA and others designated by the Forest Service as being species of conservation concern (SCC) based upon best available science.[13]

Some species listed under the ESA have benefited from climate vulnerability assessment. For example, bull trout (*Salvelinus confluentus*) were listed as threatened under the ESA in 1999 and rely upon cold, pristine streams and lakes within the states of Washington, Oregon, Idaho, Montana and Nevada. Bull trout are threatened by habitat loss and fragmentation, competition from non-native fish, disease and other threats, including climate change. Rising temperatures and lower stream flows degrade the cold water habitat conditions that bull trout require for spawning and rearing, leading to further habitat loss and degradation. But the loss of cold-water habitat will not be uniform throughout the range of bull trout, some areas are more likely than others to retain cold-water conditions over time, due to factors such as high elevation, low insolation or high rate of groundwater inflow, thus providing climate refugia for the fish (USFWS, 2015).

As a species listed under the ESA, bull trout benefit from the designation of critical habitat within their mountainous stream ecosystems; critical habitat is deemed essential for the conservation of listed species and provides extra regulatory protection. When developing critical habitat for bull trout, the Fish and Wildlife Service used a climate change vulnerability assessment to determine the bull trout cold water habitats that were most likely to resist the effects of climate change so that they could be prioritized for conservation. Specifically, cold water habitats fed by springs were

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abundance and distribution of aquatic and terrestrial habitats, connectivity, roads and other structural developments, human uses, and invasive species.

[13] A species of conservation concern is a species, other than federally recognized threatened, endangered, proposed, or candidate species, that is known to occur in the plan area and for which the regional forester has determined that the best available scientific information indicates substantial concern about the species' capability to persist over the long-term in the plan area.

determined to be more resistant to climate change impacts than other warmer and lower elevation habitats.

The USFWS developed a recovery plan for bull trout in 2015. Whereas the initial 1999 listing decision did not incorporate climate change information, climate impacts were considered in the 2015 recovery plan. Specifically, for example, the recovery plan acknowledged the effect of both brown and brook trout on the persistence of bull trout; climate change is allowing for an expansion of these more temperature tolerant fish into warming waterways. In response, bull trout conservation managers must maintain the cold water conditions required for bull trout recovery.

Climate threats may be a factor in determining that a species is of conservation concern on the forest. Species threatened by climate change cannot be rejected as SCC simply because the Forest Service cannot directly address the climate threats within the forest plan.; On the contrary, a comprehensive assessment that addresses all the stressors and drivers to the species' key ecological attributes may well reveal opportunities to reduce other interacting management stressors on the species and thus alleviate climate driven effects.

There will be overlap between key characteristics of ecosystem integrity and ecological conditions necessary to support at-risk species. Stream flows and flow regimes, stream temperature, distribution of native trout or non-native species within a stream system, the fragmentation of stream segments, and the composition of native vegetation within a streamside zone, are all examples of characteristics of ecosystem integrity that are also ecological conditions that support at-risk cold-water native fish.

The ecosystem characteristics selected for assessment should be measurable and limited to a manageable number. To limit and prioritize characteristics selected for assessment and management, the characteristics should strongly represent the conservation needs of multiple individual species associated with the ecosystem, and should be helpful for understanding the effects of climate change.

After the characteristics and conditions have been identified, the assessment will establish a reference model using information on the natural range of variation (NRV). Characteristics and conditions are measured against the reference model to determine if ecosystems are (and will likely continue to be) functioning properly and if conditions for at-risk species are being (and will likely continue to be) provided. This assessment assumes climate change impacts will continue. The assessment should consider possible future scenarios for climate change and identify those most likely to occur based on the best available scientific information.

Critically, the assessment needs to clearly articulate the cases in which the Forest Service has the ability to restore a key characteristic or condition that is degraded, and if so, how the forest plan could do so. A departure from the reference condition could be caused by management actions (i.e.

the fragmentation by roads of historically naturally connected habitat) or by climate impacts operating in concert with management stressors. For example, the assessment may find that seasonal stream flows are departed from historical/reference levels due to changes in temperature and precipitation patterns and exacerbated by ongoing water withdrawals. Or, that uncharacteristic wildfire severity (outside of the expected natural range) may be influenced by climate-driven drought acting in concert with fire suppression actions.

The Flathead National Forest assessment evaluated the cold-climate adapted whitebark pine, which is a candidate for listing under the ESA based on multiple interacting threats including widespread non-native white pine blister rust fungus, bark beetles, fire suppression and exclusion, and climate change effects. Whitebark is being supplanted within its historical ecological niche by other species. The assessment noted that the species prefers higher elevations (above 6000 feet), exposed sites, is intolerant to shade, and is moderately fire tolerant. The assessment also noted how the forest plan could restore whitebark pine, listing prescribed burning and planting of rust-resistant seedlings as management actions that can be taken by the agency in response to climate effects. The effectiveness of those restoration actions are then monitored under the Flathead's forest plan monitoring program.

Conceptual models

We recommend the use of conceptual models in forest planning to highlight how the forest plan can address the interacting stressors that exacerbate climate impacts on target resources. Effective adaptation strategies can be identified by developing conceptual models that specifically identify the various threats to conservation targets, show how each produces a stress to that target, and indicate how various threats interact to produce similar or synergistic stresses. Conceptual modeling allows the planner to map the issues, see the interactions, and find the places for interventions, and even illustrate the feasibility of different option (Figure 2). While not required in the policy guidance supporting the planning rule, we strongly recommend that these types of models be collaboratively developed with stakeholders and experts during the assessment phase.

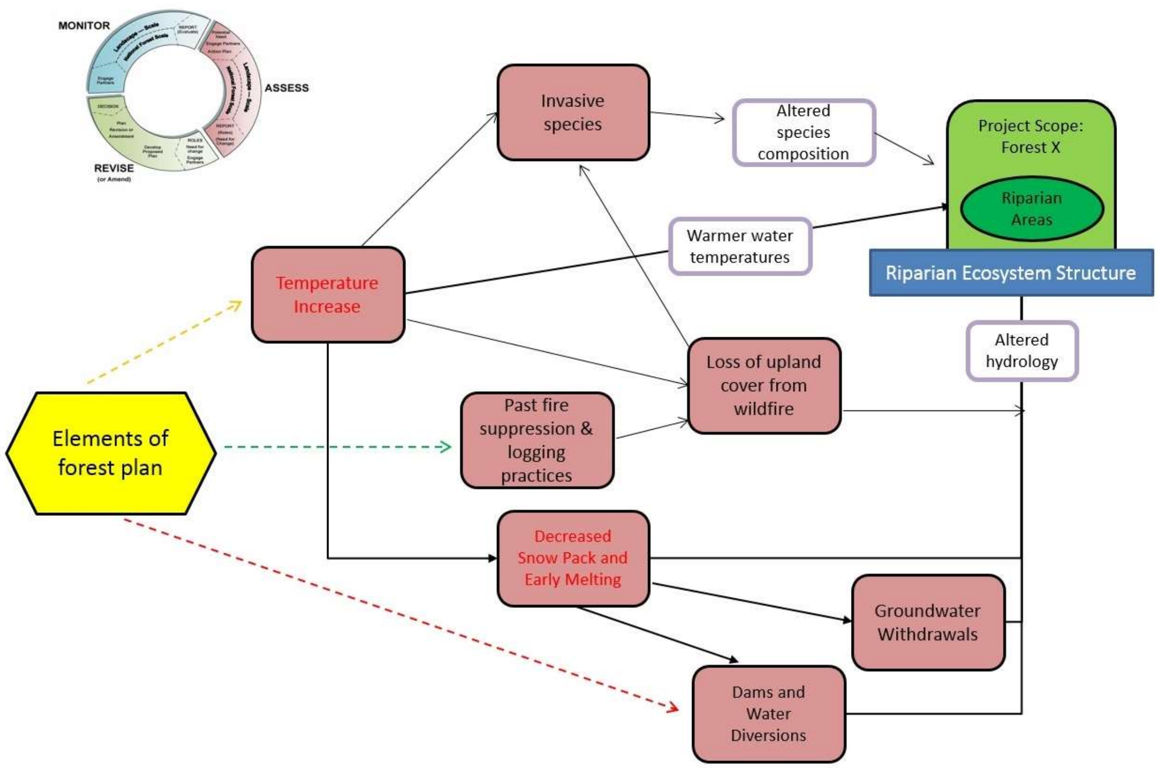

Figure 1: A conceptual model illustrating how a forest plan can identify adaptation actions for a conservation target. Threats to a conservation target (Riparian Ecosystem Structure, i.e. streamside habitat) from two specific climate change impacts (Temperature Increase and Decreased Snow Pack and Early Melting) are identified. Arrows to threats (Invasive species, Loss of upland cover from wildfire, etc.) show how climate change might produce synergies with these. The manifestation of the threat to the target is indicated in the "stress" boxes (Altered species composition, Warmer water temperatures, Altered hydrology). A forest plan may not be able to address an upstream water diversion (red arrow), but they can correct past forest management practices by restoring degraded forests (green arrow), and while they may not be able to halt climate change, may be able to moderate water temperature increases (yellow arrow), for example by restoring shade cover to streams.

Adaptation Strategies

The assessment results in status determinations on the likely future condition of ecosystems, watersheds and conditions for at-risk species, assuming climate effects and continued implementation of the current forest plan. Some ecosystem characteristics and conditions for at-risk species will be functioning and require continued maintenance and protection; others will be departed from reference conditions and require restoration and conservation actions.

After the assessment is completed, the forest will issue a "need to change" document which outlines what planning elements of the current plan need to be updated, or what new direction added, to address climate vulnerable resources that will not be sustained under the current plan. To facilitate public engagement, the "need to change" document should clearly identify what changes and new plan direction are needed to address climate-vulnerable resources.

Following the need-to-change step, the forest will develop and issue for public comment a "proposed action" that introduces initial planning strategies, including those needed to maintain or restore climate vulnerable resources. The proposed action initiates the National Environmental Policy Act (NEPA) process for the development of the forest plan. It is likely that collaborative meetings will have preceded the issuance of the proposed action to discuss possible forest plan strategies. Some of these collaborative meetings should be dedicated to discussions of the forest's adaptation strategies.

Adaptation strategies is a term used in the adaptation planning field, but not in forest planning. Nevertheless, forest plans will be adopting and implementing several conventional adaptation strategies under the framework of the planning rule.

In cases where the assessment has indicated that an ecosystem characteristic or condition for an at-risk species is likely to remain in a functional condition, considering climate effects (i.e. the characteristic is likely to remain within the climate-informed NRV), the forest plan should adopt a *resistance-oriented* strategy. Resistance-oriented (or *maintenance*) strategies are intended to build resistance to climate-related stresses, and often capitalize on opportunities to protect areas projected to have less *exposure* to climate change impacts. For example, forest plans could identify likely climate "refugia," or areas likely to experience less change than the surrounding landscape (e.g., springs fed by cold groundwater, north-facing slopes, etc.), and establish measures to prohibit actions that may degrade those key characteristics or conditions (e.g., by prohibiting the removal of shade-providing riparian vegetation).

For example, the Chugach National Forest determined that its forest plan could offer a resistance-oriented strategy to maintain the current distribution of yellow-cedar, a species threatened by climate change in other parts of its range.

> The (Chugach) national forest is home to the northern most Pacific coastal temperate rainforest and is the northern edge for several trees characteristic of this ecosystem, including Sitka spruce, western hemlock and yellow-cedar. Yellow-cedar is a species in decline throughout much of its range due to climate change, but it is thriving in small pockets in Prince William Sound and, based on climate projections, is less vulnerable to decline in this location than in southern populations. (Chugach National Forest, 2015)

In cases where the assessment has indicated that a characteristic or condition for an at-risk species is degraded or is likely to be degraded in the future due to climate and/or other threats, the forest plan should adopt a *resilience-oriented* strategy. Resilience-oriented (or *restorative*) strategies are intended to minimize the severity of climate change impacts, reduce vulnerability, and improve the ability of ecosystems and species to "bounce back" from a climate-related stress, thereby reducing the system's *sensitivity* to climate impacts. Many of these strategies will include restorative management and other activities that improve the functionality of an ecosystem by moving it towards the climate informed reference condition. For example, forest plans could include a strategy to restore fire regimes (i.e. frequencies and severities) through prescribed burning or the cessation of suppression activities, or restore characteristic vegetation along stream banks degraded by grazing activities. Note that the resilience strategy may involve the reduction of interacting threats that also compromise integrity.

Forest plans may also need to adopt *transformation-oriented* strategies, which are intended to increase the *adaptive capacity* of the system by allowing it to respond in new ways. For example, forest plans could include measures to increase connectivity to allow species to shift their ranges, or identify and protect from degradation geographic areas that are modeled to be likely future range of a target species or habitat.

Plan Components

Forest plans will guide adaptation strategies through the development of *plan components*, which direct the management and conservation actions that will be implemented under the plan. Plan components include desired conditions objectives, standards, guidelines, and suitability of lands (Table 1). In addition, plans identify management and geographic areas. [14] Plan components must take into account the effects of changing climate (219.8(a)(1)(iv)) and must have clear geographic applicability, which means they can be applied to certain areas of the forest identified as being important to conserving ecosystems and species in the face of likely climate changes.

Table 1. Plan components associated with adaptation strategies under the 2012 Planning Rule

Plan Component	*Description*
Desired Conditions	A description of specific social, economic and/or ecological characteristics of the plan

[14]A **management area** is a land area identified within the planning area that has the same set of applicable plan components. A management area does not have to be spatially contiguous, whereas a **geographic area** is a spatially contiguous land area identified within the planning area.

	area (or a portion of the plan area) toward which management of the land and resources should be directed. Desired conditions must be described in terms specific enough to allow progress toward their achievement to be determined, but do not include completion dates.
Objectives	A concise, measurable and time-specific statement of a desired rate of progress toward a desired condition or conditions. Objectives should be based on reasonably foreseeable budgets.
Standards	A mandatory constraint on project and activity decision-making

	established to help achieve or maintain the desired condition or conditions, to avoid or mitigate undesirable effects or to meet applicable legal requirements.
Guidelines	A constraint on project and activity decision-making that allows for departure from its terms as long as the purpose of the guideline is met. Guidelines are established to help achieve or maintain a desired condition or conditions, to avoid or mitigate undesirable effects or to meet applicable legal requirements.

Desired conditions

Generally, forest plans should include desired conditions for the key ecosystem characteristics and ecological conditions for the at-risk species. The desired condition is the climate informed future range of conditions that will sustain ecosystem resiliency and species persistence. The condition should either be maintained (i.e. a resistance-oriented strategy) or restored (i.e. a resilience-oriented strategy) if it is departed from reference conditions. Desired conditions should reflect the forest's distinctive roles and contributions; it is therefore likely that many forests will have desired conditions for areas that are expected to provide future climate refugia conditions not found on the surrounding landscape.

Desired conditions for ecosystem integrity should be specific enough so that progress toward their achievement can be evaluated. Note that the climate analysis underpinning the desired condition should be in the assessment; there may be no explicit indication in the plan that the desired condition is targeted as a climate adaptation strategy. The Forest Service should nonetheless provide clarity on which forest plan strategies are important for climate response and adaptation.

The Draft Revised Land Management Plan for the Sequoia National Forest included the following desired condition for fire regimes in the Upper Montane ecosystem (note the reference to ecological scale and ranges in desired conditions):

> At the landscape scale, fire is a key ecological process, restoring and maintaining patchy fuel loads and increasing heterogeneity and understory plant vigor. Fires occur irregularly, generally every 15 to 100 years, with frequency averaging about 40 years. Fires in this vegetation type burn with low, moderate or mixed severity, with minimal patches of very high severity (greater than 90 percent basal area mortality), rarely greater than 300 acres in size. The proportion of areas burned at high severity within a fire is generally less than 10 to 15 percent. Due to existing high levels of fuels and weather variability, greater proportions of areas of high severity burn (up to 50 percent) may be unavoidable during large landscape prescribed fires or wildfires managed to meet resource objectives. Some patches of high severity burn reach 1,000 acres in size.

Objectives

Objectives are meant to make progress toward the desired conditions, and should be used to prioritize the most important adaptation and climate response actions, for example, those cases where the assessment documented clear vulnerability to climate change impacts and noted projects or activities that could restore the characteristic or condition or alleviate threats that compound the magnitude of the climate impact.

Here is a typical objective that supports implementation of the desired condition; this assists implementation of the desired condition referenced above from the Draft Revised Land Management Plan for the Sequoia National Forest:

> Increase forest heterogeneity, reduce forest density and surface fuels, and restore species composition (i.e. increase black oak and pine) on 9,000 to 15,000 acres of the montane, upper montane, and portions of the foothill landscape, using mechanical treatment, often in combination with prescribed fire, within 10 to 15 years following plan approval.

Note that objectives should be used within forest plans to drive budgetary and other investments in adaptation actions and to communicate adaptation and climate response priorities to other audiences.

Standards and Guidelines

Standards and guidelines constrain projects and activities and should be employed to maintain or restore the desired condition for ecosystem characteristics and conditions for at-risk species. Standards and guidelines will be particularly useful in maintaining desired conditions by avoiding effects that may threaten key characteristics or ecological conditions for at-risk species. 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 in riparian areas that provide a key characteristic or condition (e.g. shade or sediment retention).

For example, water howellia (*Howellia aquatilis*) is a plant species listed under the ESA that occurs on the Flathead National Forest; it is threatened by management activities (timber harvest, livestock use, non-native plants, conversion of wetland habitat) and climate change, which is affecting wetland inundation processes. The Draft Revised Forest Plan for the Flathead included the following standard to avoid stresses to the plant's wetland habitat:

> Retain a buffer of a minimum width of 300 feet from the margins of ponds (occupied and unoccupied) that provide *Howellia aquatilis* habitat, for the purpose of maintaining or creating a favorable physical environment in and around the ponds, protecting against adverse hydrological changes, and maintaining the structural and floristic diversity of the vegetation. (p. 49)

Priority Areas

The application of plan components within specific areas (e.g. management or geographic areas) will be used to concentrate climate change response and adaptation strategies within specific areas of the forest. For example, the Francis Marion revised forest plan designated two management areas to maintain ecological integrity across the nine ecosystems found in the plan area. One of the management areas emphasized desired conditions for the "use of landscape-level, frequent prescribed fire, a primary driver for maintaining and restoring fire-adapted ecosystems and habitats."

The other management area emphasized the reduction of hazardous fuels in areas not feasible for prescribed burning (Francis Marion National Forest, 2016).

Connectivity

Connectivity is a dimension of ecological integrity, as well as a condition necessary to support many at-risk species. Connectivity is especially important for enabling adaptation to changing stressors, including climate change. 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). The forest plan assessment should describe the relationship between connectivity and the distribution of species necessary for persistence with regard to climate change and the forest plan should emphasize the role of ecological connectivity in providing for adaptation to climate.

For example, the Francis Marion included a desired condition that "(b)lackwater rivers and streams and their associated floodplains are maintained and restored. These ecosystems provide corridors that meander across the landscape and connect habitats that facilitate movement of species" (Francis Marion National Forest, p.15). Articulating this connectivity strategy is particularly important given the impact of sea level rise on habitats within the coastal Francis Marion National Forest. This desired condition could be supported by an objective to prioritize areas for restoration of connectivity and possibly standards or guidelines to constrain management actions that may impede achievement of the desired connected condition.

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. To improve aquatic ecosystem integrity and provide necessary habitat conditions for at-risk fish and other aquatic species, the Forest Service is embarking on a major effort to improve aquatic organism passage by removing or upgrading the thousands of culverts on national forest lands. All forest plans will likely have plan components similar to this objective within the Flathead's Draft Revised Forest Plan: "Reconnect 10 to 20 miles of habitat in streams disconnected by roads or culverts where aquatic and riparian-associated species' migratory needs are limiting distribution of the species."

Priority Watersheds

The Planning Rule also requires that the forest plans identify priority watersheds for restoration. The identification of such watersheds is tiered to the Forest Service's *Watershed Condition Framework*[15], the objective of which is to improve watershed conditions including their ability to moderate the effects of climate change. Forest plans should therefore identify priority adaptation and conservation actions for these watersheds.

The Flathead National Forest's draft revised forest plan prioritized identified a subset of watersheds, called the *Conservation Watershed Network*, to prioritize conservation of bull trout and pure westslope cutthroat trout. These watersheds received a set of unique plan components to guide management. For example, there is an objective which states that "Conservation Watershed Network are the highest priority for restoration actions for native fish. Stormproof 15 to 30% of the roads in Conservation Watershed Network prioritized for restoration as funding allows to benefit aquatic species, e.g. bull trout" (Flathead draft revised plan, 2016).

Implementation, Monitoring and Evaluation

After the plan has been finalized, projects and activities will be implemented, and the plan will be monitored and evaluated for effectiveness. All projects and activities must be consistent with the plan components. The forest should begin implementing the priority adaptation and climate response strategies to fulfill the desired conditions; most of these will be resiliency-oriented strategies to restore key ecosystem characteristics and conditions for at-risk species. It is important that the forest plan prioritize these actions based on risks to the resources.

The forest will also implement other plan components, including those for multiple-uses, such as timber harvest, grazing and recreation; 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 integrity and conditions supporting at-risk species.

The forest plan includes a monitoring program to determine if the adaptation strategies and plan components are having the intended effect. The program is intended to support adaptive management by indicating whether there is a need to adjust the 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. For example, the Flathead National Forest established a monitoring question to track the status of water howellia (a listed species threatened by climate change, discussed earlier) in areas experiencing both natural

[15] See http://www.fs.fed.us/sites/default/files/Watershed_Condition_Framework.pdf

and human-caused disturbance. Forest-level monitoring programs will operate in conjunction with broader-scale monitoring strategies developed by the regional forester.

Forest plans can also monitor the effects of possible management stressors interacting with climate change effects; for example, the Flathead monitoring program evaluates the status of stream banks within grazing allotments. Management actions that have uncertain effects on climate sensitive resources should be closely monitored.

Focal Species

The rule also requires the identification and monitoring of focal species, defined as:

> A small subset of species whose status permits inference to the integrity of the larger ecological system to which it belongs and provides meaningful information regarding the effectiveness of the plan in maintaining or restoring the ecological conditions to maintain the diversity of plant and animal communities in the plan area. Focal species would be commonly selected on the basis of their functional role in ecosystems.

Forest plans should select focal species sensitive to climate impacts to evaluate whether strategies to maintain or restore ecosystem integrity are effective.

Focal species, while not a required target for evaluation in the forest plan assessment, should be considered during the assessment of characteristics and species sensitive to climate impacts. The planning rule directives advise that focal species should be selected as key compositional characteristics of ecosystems, suggesting that the "presence and distribution of species that have a significant effect on species diversity and ecosystem function (for example, keystone species and ecological engineers) be selected for assessment, planning and monitoring (FSH 2909.12, Chapter 10).

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.

The Flathead National Forest identified western white pine as a focal species. Western white pine (*Pinus monticola*) is a five-needle pine species that is vulnerable to the interacting stressors of climate change, fire suppression, white pine blister rust, and mountain pine beetles (Loehman et al., 2011). The Flathead monitoring program developed the following questions and indicators for western white pine:

- Question: What is the change in ecological conditions within the warm moist and cool moist-mod dry biophysical settings, as indicated by conditions suitable for western white pine?
    - Indicator: Proportion forest-wide and by ecosystem type for western white pine presence, size class and tree canopy cover.
- What management actions are contributing to the restoration of western white pine?
    - Indicator: Acres treated by various methods for the purpose of sustaining or restoring western white pine. Survival of planted western white pine seedlings.

Focal species can be stressors known to interact with climate-induced stressors to impact ecosystem integrity and conditions for at-risk species. For example, the Sequoia National Forest selected cheatgrass and red brome as focal species associated with the integrity of sagebrush ecosystems.