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USDA California Climate Hub

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Climate Change Primer for Forest Managers in the Sierra Nevada

Contents

Forest Resilience in the 21st Century

Climate Change Impacts

Framework for Addressing Climate Change

Climate Change Adaptation Strategies: Options

Landscape Heterogeneity

Priority Considerations

What to Expect from Adaptation Strategies

Key Themes in Contemporary Landscape Management

Forest Resilience in the 21st Century

Forest health has never been a more urgent concern in California. In the past 100+ years some significant changes have occurred in Sierra Nevada forests. Multiple factors, including fire exclusion, historic logging practices, and climate change, have intersected to create significant risks of high severity fire, drought linked mortality, beetle infestation, and disease in the Sierra Nevada.

This summary is aimed at Line Officers and other people responsible for managing large tracts of forest in the Sierra. It suggests a landscape view of forest management as well as ways to cope with changing conditions.

Large, high severity fire

Drought stress and large-scale insect infestation

Climate Change Impacts

Sugar pine on the STEF E. Knapp

Graphic courtesy of Pacific Forest Trust.

The evidence is clear and compelling: climate conditions in the Sierra Nevada have changed and temperatures and precipitation patterns will continue to transform in the foreseeable future.

Forest growing conditions (tree species and density) are strongly influenced by the seasonal interactions of energy (temperature) and water (rain and snow). Projected climatic trends suggest there will be large-scale changes to current forests. Longer summer periods of higher evapotranspiration demands coupled with extended periods of low soil moisture leads to a "Climatic Water Deficit" (CWD). Anticipated increases in the CWD will further stress trees and shrubs and ultimately drive changes in forests through various forms of disturbance.

Modeling scenarios suggest average annual temperatures could increase by 3 to 9 degrees F by the end of the century. Seasonal and geographic variability may be more pronounced. Future precipitation is less certain, but modeling suggests slightly increased overall precipitation with a higher proportion coming as rain vs. snow, and possible patterns of multi-year droughts with occasional years of extreme precipitation.

We are in an era of extreme variability, which compels us to try innovative tactics in forest management guided by the best available science. Forming partnerships with research and learning from inventive silviculture, fire management, and other resource management approaches will accelerate our ability to learn as we apply new management ideas.

Framework for Addressing Climate Change

Historic photo, Eldorado County in 1899

Management Options - Sufficient scientific insight has been developed in recent years to provide managers with guidance to reorient forest management direction to better cope with anticipated climate changes.

A simple stepwise approach for developing adaptation options was devised by scientists at the Northern Research Station, USFS. (*Figure 1.*)

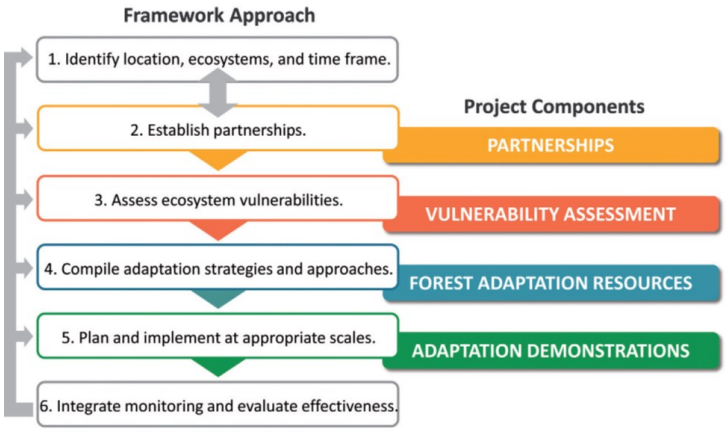
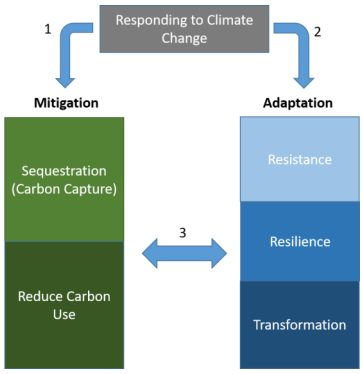


Figure 1. From Chris Swanston and colleagues at the Northern Research Station; an iterative approach to help natural resource professionals integrate climate change considerations into management planning and activities, and the resulting four project components.

Climate Change Adaptation Strategies: Options



*Hypothetical management approaches to address climate change. It is widely accepted that actions that result in (1) **mitigation** are highly desirable but that (2) **adaptation** actions are necessary. Often there are (3) **co-benefits** where actions deemed critical to realize adaptation goals also meet mitigation interests as well, hence the term co-benefits.*

Responding to Climate Change - Coping with climate change must be a backdrop for every proposed forest management project in the coming decades. The changes that are anticipated in the composition and spatial structure of forests and ecological responses suggest that management goals ought to emphasize ecological processes, rather than solely managing structure and composition.

Three Basic Options - There are three basic approaches ranging along a continuum of minor to major efforts and/or changes in tree communities before and after treatments.

The appropriate choices depend on many factors; current site conditions across the Sierra vary significantly. Each site will likely have its own unique blend of treatments.

1. Create Resistance to change- manage forests so they are able to resist the influence of climate change. This may require intensive intervention. For example maintaining suitable spotted owl habitat in areas that are inevitably subject to various disturbances may require management actions to sustain key owl habitat that will be vulnerable under a changing climate.

2.Promote Resilience to change- resilient forests accommodate changes resulting from periodic disturbances and return to a prior condition naturally or with some management assistance. For example variable density thinning in a mixed conifer stand will temporarily restructure forest conditions but will also allow remaining trees to be resilient to subsequent disturbances.

3. Transition to a new forest community type- this approach essentially concedes that the existing forest is unable to adapt to expected climatic changes. In this case managers actively facilitate change to realign the forest community (species composition and forest structure) to better match future environmental conditions. For example it may be necessary to facilitate the regrowth of tree and shrub species that can adapt better to future conditions on a given site.

Landscape Heterogeneity

The most feasible approach among the treatment options to consider, and one that is likely to garner immediate benefits, is a combination of variable density thinning with prescribed fire. This approach has been developed over the last ten years at multiple locations in the Sierra and holds strong promise for restoring forest resilience across much of the wildland mixed conifer region. Management in the wildland/urban interface will of course require specific care to safeguard human communities.

This combination of silvicultural methods will help restore the desired overstory and fuel conditions as well as address the climatic water deficit of the forest. Reducing stand density will allow the remaining trees to better cope with the changing climate.

The degree to which density should be reduced depends on a variety of factors. Forest managers should consider site specific factors such as topography and aspect, as illustrated in Figure 2. Drainage bottoms and north-facing slopes, for example, can sustain denser stands with larger trees and may persist as refugia for such stand conditions in the face of warming conditions.

By contrast, ridgetops or south-facing slopes will likely be more exposed to stressful temperature and climatic water deficits, particularly in later summer and fall. Thus some locations may require little to no reduction in density while other locations may require reductions even below historical levels to cope with foreseeable drought stress. Careful site-specific evaluations will guide appropriate and necessary treatment strategies.

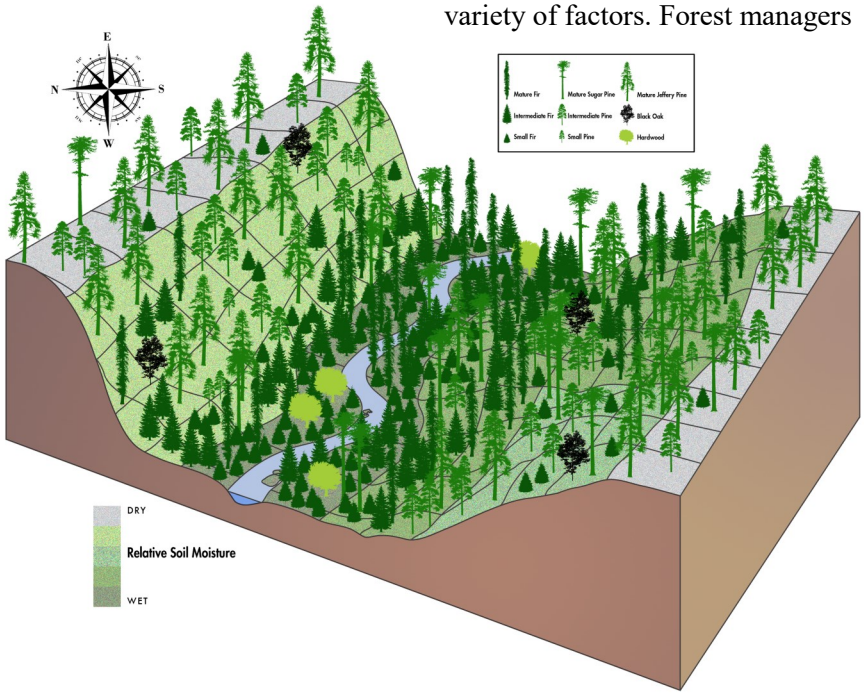


Figure 2. Landscape schematic of variable forest conditions influenced by topography; e.g. slope, aspect, slope positions. From PSW GTR-220 Malcolm North et al.

Priority Considerations

1. ***Think outside the box***: seek innovative actions that will move toward resiliency.
2. ***Think about the future***: practice ad-hoc scenario planning by evaluating every project through the lens of what conditions could be in 25-50 yrs.
3. ***Take actions that are feasible to implement****:* ensure adequate funds, staff, resources, and community support to successfully conduct selected projects.
4. ***Keep options open*****:** ensure that a proposed action augments future opportunities.
5. ***Prioritize****:* among multiple potential projects determine which is the most important to complete.
6. ***Prepare for change***: plan for increases in the amplitude and frequency of extreme weather-related events.

What to Expect from Adaptation Strategies

Forest managers may be understandably overwhelmed with this large and complex challenge. We will not solve all our concerns immediately but we can make incremental progress to shift the trajectory of our forests toward a more resilient condition.

Some adaptation measures may be novel but they can provide critical lessons to help managers create sustainable forests.

Managers should plan and conduct treatments as experiments and learn from them. This will allow managers and their stakeholders to move forward in the face of uncertainty with structured experiments based on clearly defined objectives.

Under this approach, well-designed monitoring will be necessary. We need to provide the data to evaluate outcomes and improve subsequent decision-making.

The general consensus among scientists is that we have ample information with which to move forward with treatments to increase resilience in the Sierra Nevada *(see attached bibliography)*.

What is less clear is how to garner support from a diverse public to proceed with novel tactics and strategies. Creating partnerships with research and stakeholders can be an effective way to explore difficult challenges that carry inevitable uncertainty.

Stanislaus Tuolomne Exp Forest where large trees dominate after treatment with both fire and thinning. This is an example of the inherent structural and compositional variability we are striving to create in the Sierra Nevada

Key Themes in Contemporary Landscape Management

Fisher using a black oak cavity on the Sierra National Forest
R. Green

There are some overarching management themes and directions that have emerged in the last few decades. One of the most important changes is the trend toward management at a landscape scale. The following considerations are key to advancing effective management and addressing changing climates at a landscape scale.

Ecological Resilience – capacity of a forest system to absorb disturbance and return to the pre-condition function and structure.

Ecosystem Services - benefits people obtain from ecosystems: food, fresh water, fuel, fiber; climate, water, and disease regulation; pollination; soil formation and nutrient cycling; educational, aesthetic, recreational and, cultural heritage values.

Incorporating Fire as a Functional Ecological Process—the absence of fire over the last ~100 years has profoundly impacted forest structure and composition and contributed to subsequent uncontrolled wildfire.

Landscape Heterogeneity- management techniques to recreate the inherently complex forest structure that results from periodic disturbances (e.g. fire) to increase ecological resilience.

Addressing the Needs of Wildlife Species at risk— One of the most contentious issues a land manager may confront is how to reconcile treatments, which are typically intended to improve forest resiliency, with the impacts to selected wildlife species deemed at risk.

This primer was produced through a partnership of the USDA California Climate Hub, USFS Region 5 State and Private Forestry, and USFS-Pacific Southwest Research Station, synthesizing the latest scientific guidance that will enable climate-informed and science-based decision making for forest management in the Sierra Nevada region.