Conservation of Yellow Pine Mixed Conifer Forests: A Look Into the Past, Present, and Future

– Executive summary –

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Yellow pine mixed conifer (YPMC) forests, which provide important ecological, economic, and social benefits, are the most abundant conifer forest habitat type in Southern California.[1] However, anthropogenic impacts like fire suppression, cessation of Native American burning, and climate change threaten the health and continued persistence of these forests and the benefits they provide by increasing fire severity, habitat loss, and bark beetle mortality. YPMC forests in Southern California are "sky islands" that are geographically isolated among many different mountain ranges.[2] This makes these forests sensitive to severe perturbations as there are no nearby seed sources to assist in regeneration following disturbance events, nor can the forests shift upward in latitude to escape from stressors. Therefore, it is essential to protect existing YPMC habitat by managing for resilience to disturbances. Understanding past, present, and likely future conditions of YPMC forests will allow managers to make informed decisions to better preserve these forests for future generations.

Our work provides valuable insight into the shifting structure and composition of YPMC forests in Southern California. We analyzed how contemporary Southern California YPMC forests differ from historical conditions using qualitative and quantitative data, projected suitable locations for yellow pines saplings under likely future climates using MaxEnt, and demonstrated how to identify YPMC forests that are a high priority for forest conservation.

We found significant increases in tree density, canopy cover, and basal area across Southern California YPMC forests since the early 1900s, which has broad implications for ecosystem resilience. More destructive wildfires are expected to occur as climate change is projected to result in more frequent and severe droughts and alter precipitation patterns.[3-5] Increases in tree density and drought conditions can have disastrous consequences on the health and persistence of forests, as denser and drier forests facilitate the spread and severity of wildfire.[6] Additionally, higher tree density and basal area increase competition for water which makes trees more susceptible to bark beetle attacks and mortality during droughts. Similarly, increases in canopy cover can also have negative consequences for ecosystem resilience. For example, forests with larger canopies can facilitate the spread of crown fires.[7]

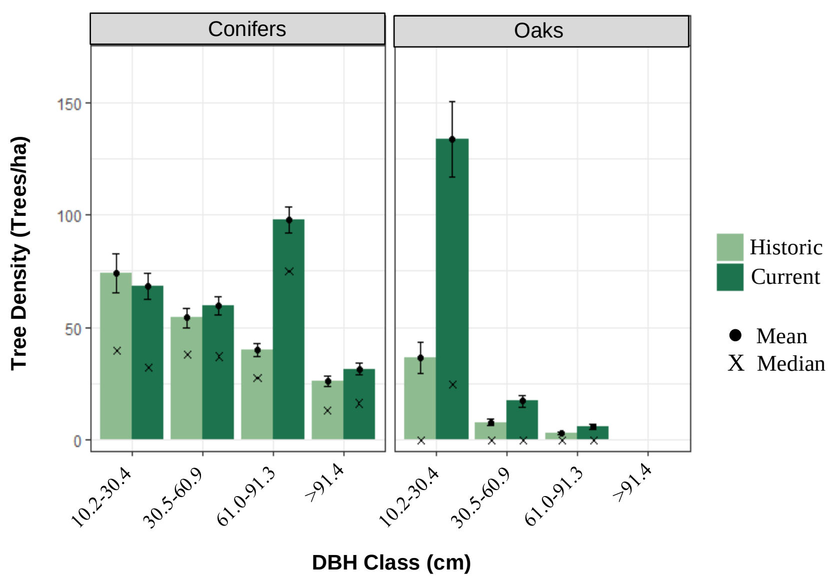

Figure 1. Tree density of conifers and oaks by size class. Conifers and oaks included in the analysis include: *Abies concolor* (white fir), *Calocedrus decurrens* (incense cedar), *Pinus coulteri* (Coulter pine), *Pseudotsuga macrocarpa* (Bigcone douglas-fir), *Pinus lambertiana* (sugar pine), *Pinus jeffreyi* (Jeffrey pine), and *Pinus ponderosa* (Ponderosa pine), *Quercus chrysolepis* (canyon live oak) and *Quercus kelloggii* (black oak).

The observed increase in tree density is primarily due to an increase in large diameter conifers (61-91.3cm) (Figure 1) and increases in shade tolerant species *Abies concolor* (white fir) and *Quercus chrysolepis* (canyon live oak). We believe the increase in large diameter conifers occurred because of a 90-year absence of fire from interior forests and relatively minimal logging activity throughout these forests, which likely allowed trees to grow to a larger size class since the early 1900s. Consequently, shade tolerant species are likely thriving because of increases in large diameter (61-91.3cm) trees and forest densification that resulted in more closed canopies. Shade tolerant species grow in the understory and contribute to more severe wildfires by acting as ladder fuels, carrying fire from the ground to forest canopies.

Density of *Q. chrysolepis* increased by 510%, particularly at lower elevations (1000-1999m). In contrast, conifer juveniles (10.2-30.4cm) have significantly decreased across the same elevation gradient, which indicates that when adult conifers die at lower elevations, there will not be sufficient juveniles to replace them. Ultimately, these trends signal a potential compositional shift from conifer forests to oak woodlands that will be occurring at low elevations. These results support findings from other studies that indicate California will becoming increasingly oak dominated,[8-11] particularly as the climate warms.[12]

Our MaxEnt models demonstrate that suitable habitat for yellow pine saplings (diameter <12.7cm) is shrinking under climate change (Figure 2). We can expect a greater than 50% loss in suitable sapling habitat by 2039, with even greater losses projected by 2040-2069. Disturbance events, such as severe wildfire, drought, and bark beetle attack, which are increasing under climate change, contribute largely to the mortality of adult yellow pines. The loss of adult yellow pines from areas unsuitable for saplings in the future will result in the net loss of yellow pine forests, as future climates across these areas are predicted to no longer support sapling regeneration.

In conclusion, we found significant changes in forest structure over the past century and expect that forest structure will continue changing into the future as a result of climate change. These changes in forest structure have important consequences for ecosystem services, fire regimes, and overall forest resilience. Our comprehensive work analyzing the 20th century shifts of forest structure and composition, in conjunction with our species distribution model, provides information that land managers need to effectively manage these forests to be more resilient against these threats. Our work is part of a larger internal initiative that will aid the USFS in defining desired ecosystem attributes. Knowing how much contemporary forests have deviated from these desired conditions provides insight into how much effort will be needed to achieve the conditions that promote resilience to stressors. Additionally, by understanding where yellow pine forests will likely thrive under future climates our project will assist the USFS in selecting YPMC forests that will be a high priority for conservation so that future generations can enjoy the ecological, economic, and social benefits of these forests long into the future.

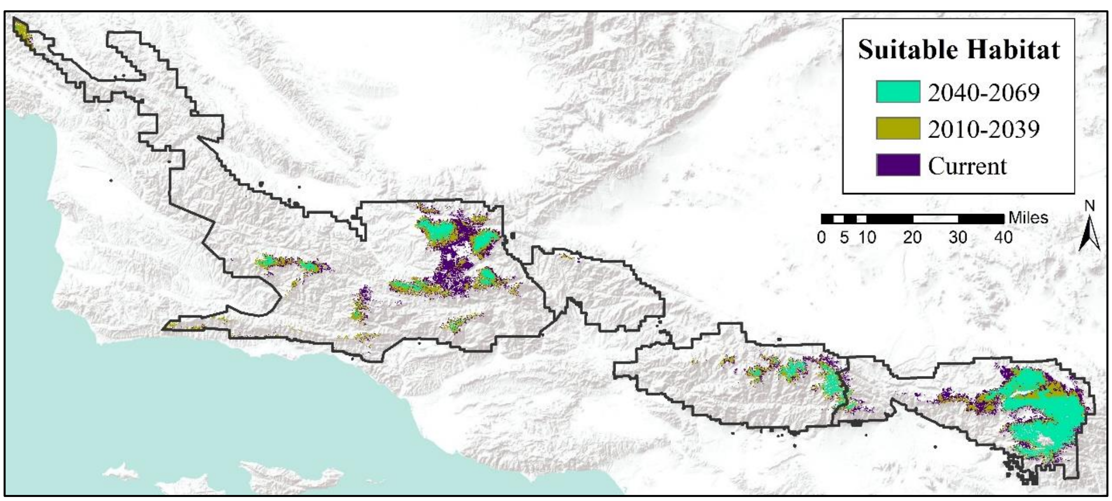

Figure 2. Current and future projected suitable habitat of yellow pine saplings in the Southern California Transverse Ranges. Suitable habitat shrunk from 2010-2039 and 2040-2069 as a result of climate change.

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