Fire Management for Climate Change Refugia

Kate Wilkin1*, David Ackerly2, & Scott Stephens1
1 Department of Environmental Science, Policy, & Management at University of California, Berkeley, CA.
2 Department of Integrative Biology at University of California, Berkeley, CA. *Corresponding author: Kate.Wilkin@berkeley.edu

Introduction

Early climate change predictions were for catastrophic species extinctions. As scientists investigated species response to climate change further, a more nuanced perspective emerged indicating species may be able to persist in climate refugia. This phenomenon is especially apparent in complex terrain such as the mixed conifer zone of the Sierra Nevada which has cold-refugia.

Cold-refugia (refugia) form at the intersection of relatively mesic areas with cold-air pools (Figure 1) and/or north-facing slopes.

Figure 1. Cold-air pool landscape position & physics.

Here, many species exist at their southern range extent and do not exist outside of refugia at this latitude (Figure 2). Climate change’s predicted increased warmth and amplified disturbances may cause local extirpation of some refugia species. Concomitantly, these regions may become refugia for other species which are currently common in the region but may become rare and/or restricted to refugia with climate changes. Refugia not only have distinct communities, but they may also exhibit distinct ecological processes from surrounding areas, such as fire frequency or severity.

Goals

(1) Examine published data for insights and limitations of refugia fire ecology. Specifically, do refugia have similar fire occurrence and severity to the adjacent forest?

(2) Infer the vulnerability of refugia to fire.

Materials

Within Yosemite National Park’s mixed conifer forests (Figure 3):

• Cold-pool (CAP) model as proxy for climate change refugia (Figure 4; Lunquist, 2008)
• Fire history polygons from 1930 to 2012 (Figure 5)
• Fire severity delimited with Relative differenced Normalized Burn Ratio (RdNBR) from 1984 to 2012 (Miller 2012)

Results

Data was randomly subsampled from a 100 m point grid to reduce spatial autocorrelation and equal samples sizes from all levels of CAPs (absent, marginal, present) were randomly sampled for both fire occurrence and severity.

We constructed statistical models to test if cold-air pools are related to fire occurrence or severity:

\[ \gamma - \text{Cold air pool} \]

Where \( \gamma \) is the response variable, either fire occurrence (absent: 0, present: 1) or fire severity (ordered classes where very low: 1, low: 2, moderate: 3, high: 4). Cold-air pool categories include absent, marginal, and present.

We used GLMs with binomial distribution for fire occurrence and Gaussian distribution for fire severity the ordered fire severity classes.

Figure 3. Study area

Figure 4. Cold-air pool model (Lunquist, 2008)

Discussion

Fire extent and severity may be moderated by direct and indirect effects of CAP and land management (Figure 9). The factors critical to fire behavior (weather, fuel, and topography) vary spatially and temporally.

Conclusions

• CAPs have less frequent and lower severity fires.
• Prescribed burns are one of the best tools to prepare healthy forests that harbor biodiversity as habitats for species.
• However, refugia may need special management techniques because of their historical ecology.
• Short term:
  • Fire may be a direct threat to refugia inhabitants.
• Long term:
  • Fire may be an indirect benefit to refugia inhabitants by preventing severe wildfires.
  • Lack of fire may exacerbate climate change’s increasing disturbance threats to biodiversity, including increased fire frequency & severity.