Cold and drought tolerances of 5 planted conifer species in the 2020 Cameron Peak Fire

Chambers, M.E., Barrett, K.J., Stevens-Rumann, C.S., Wilson, M.A.
Colorado Forest Restoration Institute,
Department of Forest and Rangeland Stewardship, Colorado State University, Fort Collins, CO

Introduction: Wildfires are increasing in size and severity across the western USA, and as this trend continues to grow, managers are increasingly looking for information about reforestation in a changing climate. Our study focuses on post-fire climate-informed reforestation as a potentially critical management tool for sustaining resilience in our forests. Our long-term goal is to understand the ecological limitations of adapting post-fire reforestation efforts to a changing climate through changed management practices to inform more effective post-fire restoration. By examining the winter and summer sensitivity/mortality of five native conifer species planted across elevations & forest types in the 2020 Cameron Peak Fire, CO, our results will inform climate-informed reforestation in our region. Our specific research objectives are to**: 1) understand post-fire seedling survival of five native planted conifer species; 2) understand mortality dynamics following winter and summer seasons of five native conifer planted species post-fire;** 3) identify if any abiotic, biotic, or microsite factors (e.g., nurse objects) may be influencing planted seedling survival of native planted conifer species.

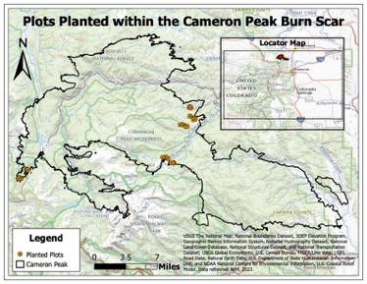


Figure 1 (left): map of planted areas in the 2020 Cameron Peak Fire. Figure 2 (bottom left):CRI technician planting a tree in gridded quadrat. Figure 3 (bottom right); CFRI technician performing data collection.

Methods: Field sites within the 2020 Cameron Peak Fire (Fig. 1) were selected based on accessible terrain (i.e., within 1.5 mi of roads, no deep stream crossings, and on slopes <40% grade). We planted 34 plots equally within low- and high-severity burn areas. High severity is defined as 100% overstory mortality, with at least 150 ft to nearest living tree.

We established plots in four forest types: ponderosa pine, mixed conifer, lodgepole pine, and spruce/fir. Plots are based on the Colorado Forest Restoration Institute "mothership" protocol (Fig. 4), which includes a full botanical survey within a 1/10th ac area. Planted plots are placed just outside the CFRI mothership plots at the N, NE, E, S, SW and W aspects in 1m^2 quadrat frames that are split into 16 cell grids (see Fig. 5d) for planting 5 native coniferous tree species randomly within each quadrat (Fig. 2). Plots were monitored in Spring and Fall of 2022 and 2023 (Fig. 3, except Spruce fir plots in Spring 2023 due to snowpack). For analysis, we used a linear mixed effect model to evaluate survival and winter/summer mortality using the latest available dataset.

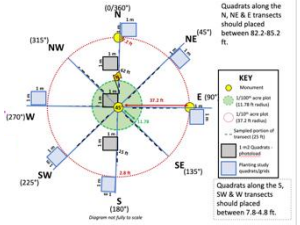
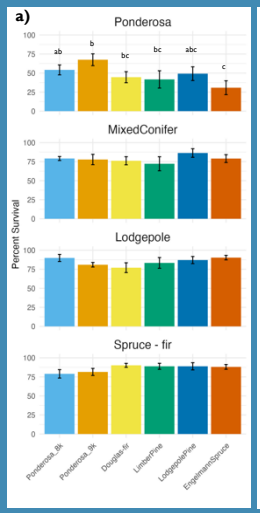
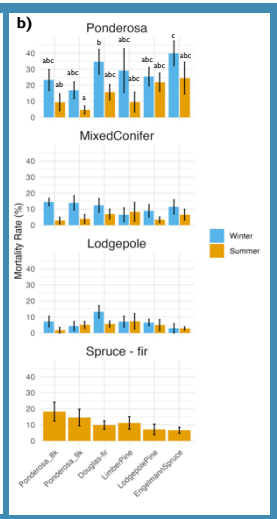


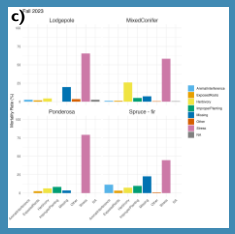
Figure 4: Depiction of CFRI mothership plot (circular area) with planting plots (blue squares) added for planting study.

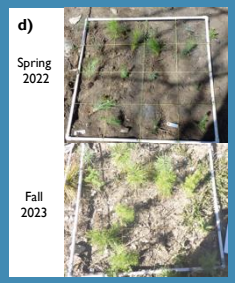
Species planted in this study:
Ponderosa pine (*Pinus ponderosa*, sourced from 8,000 ft.)
Ponderosa pine (*Pinus ponderosa*, sourced from 9,000 ft.)
Douglas-fir (*Pseudotsuga menziesii*)
Limber pine (*Pinus flexilis*)
Lodgepole pine (*Pinus contorta*)
Engelmann spruce (*Picea engelmannii*)

Figure 5 (a-d): a) percent survival of the five coniferous tree species planted within the four forest types that burned in the 2020 Cameron Peak Fire, b) percent mortality of the five coniferous tree species planted within the four forest types that burned based on winter and summer monitoring c) percent mortality by mortality cause, and d) examples of gridded quadrats with planted species in Spring 2022 and Fall 2023 from the same plot and aspect in a mixed conifer forest type. Ponderosa_8K indicates ponderosa pine sourced from 8,000 ft and Ponderosa_9k indicates ponderosa pine sourced from 9,000 ft.









Discussion:

Planted seedling survival: By Fall 2023, ~75% of seedlings survived. Ponderosa pine sites had the lowest overall survival for all species ($p<0.01$) and was the only forest type with significant differences between planted species survival. In this forest type, Engelmann spruce had the lowest survival rate. No other significant differences between species survival within respective forest types was observed. However, a trend of higher survival for all species at mid- and higher-elevation forest types was observed.

Post-winter and post-summer mortality:

By Fall 2023, 19%of planted seedlings had died because of observed post-winter or post-summer season desiccation or stress. Within the ponderosa pine forest type, the average mortality rate for all species combined was higher in winter than in summer ($p<0.01$). Additionally, a significant difference between species mortality was observed ($p=0.02$), where mortality rates were highest for Engelmann spruce and Douglas-fir and were lowest for ponderosa pine sourced from 9,000 ft. Within the mixed-conifer forest type, average mortality rates for all species combined was higher following winter than summer ($p=0.002$), but no significant differences between species mortality was found. No significant differences between post-winter or post-summer mortality or between species survival was found in lodgepole pine or spruce-fir forest types.

Causes of mortality:

Post-winter and post-summer "stress" was the highest observed cause of planted seedling mortality across all forest types. Other causes of mortality that were observed at higher rates included "missing" seedlings (unknown cause) in the ponderosa pine forest type, herbivory in mixed conifer, and animal interference or "missing" in spruce-fir.

Future findings from this study will help to illuminate climate-informed reforestation information and strategies of coniferous species in CO and across the Western US.

Next Steps:

Monitoring will continue Spring and Fall 2024 and into the future. This study will be expanded in two additional fires in 2025 (2020 Calwood Fires and East Troublesome Fires, CO). Analysis of additional data will address whether abiotic, biotic, or microsite factors (e.g., nurse objects) may be influencing planted seedling survival and growth of native planted conifer species. Future analyses will continue to illuminate survival and growth of each species and across a range of elevations & forest types. Results will be shared widely with managers, researchers and other interested parties.

Acknowledgements: We are grateful to the Arapaho-Roosevelt National Forest for supporting this project and providing access to fire closure areas, Allie Rhea and Stephanie Mueller for spatial analytical support, and to our CFRI field technicians for help planting seedlings and monitoring in the field.

Want more information? Click the QR code at the top lright of this poster or contact Marin Chambers at marin.chambers@colostate.edu.