Methods and implications of canopy base height characterization for modeling crown fire potential

SOUTHERN ROCKIES FIRE SCIENCE NETWORK

Research Brief · September 2026

Background

Fire behavior models serve as important management tools for responding to active wildfires and planning prescribed fires for wildfire risk mitigation and restoration. These models depend in part on user supplied metrics of fuel structure. One of the most important variables for modeling fire behavior in forest systems is canopy base height (CaBH), which describes how close flammable canopy fuels are to the ground. This helps determine whether and under what conditions fires can spread from the forest floor to the canopy and was originally defined in even-aged forests as the mean crown base height (CrBH) within a stand.

However, as fire behavior models have been applied to an increasing variety of forest conditions, and as new models have been developed that cover increasing spatial extents, new definitions and data sources for calculating CaBH have emerged. New definitions attempt to better capture the importance of lower canopy fuels and datatypes used to characterize CaBH now span field observations, laser scanning, radar, and spectral imagery, with observations made from terrestrial, airborne, and satellite platforms (Figure 1). Yet the importance of characterization approach in determining CaBH and resulting fire behavior remains poorly understood.

This study reviews the different approaches used to characterizing CaBH and assesses differences in CaBH across methods and forest types in northern New Mexico. Differences in predicted torching index, the 6.1 m (20 ft) wind speed at which fire spreads from the surface into the canopy, were also quantified to provide researchers and forest managers with a better understanding of how CaBH characterization approach affects predicted crown fire hazard.

Research Overview

Researchers analyzed field measured crown base heights, airborne lidar, and satellite imagery (spectral and radar) collected across 93 field plots in northern New Mexico between 2016 and 2023 to characterize CaBH and predict torching index using a Rothermel-Van Wagner crown fire model.

Objectives:

1. Assess differences in CaBH across data sources and analytical methods and quantify how these differences vary across forest types.
2. Quantify the implications for modeled crown fire initiation.
3. Evaluate the relationship between vertical stand complexity and among-method variability in CaBH and torching index.

Results were used to identify approaches that provide conservative estimates of CaBH and torching index relevant for risk adverse screening and approaches that better represent characterizing typical conditions across trees.

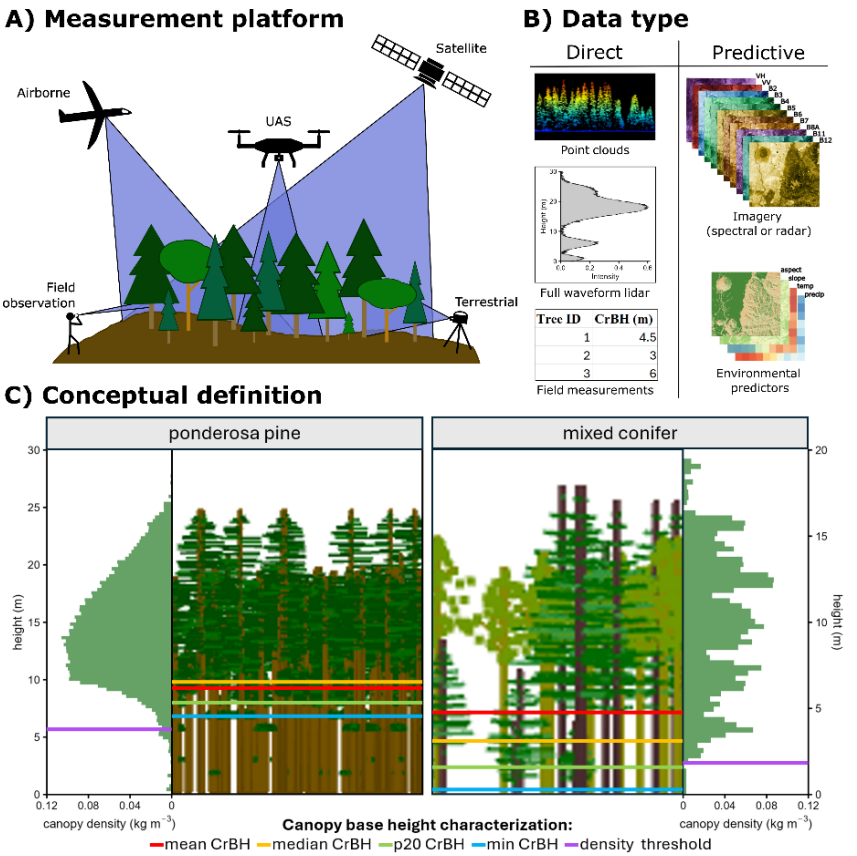


Figure 1: Overview of approaches used to characterize CaBH. **A)** Measurement platforms, including field observation, terrestrial, UAS, airborne, and satellite remote sensing. **B)** Data types used to directly estimate and predict CaBH **C)** Conceptual definitions for characterizing CaBH including CrBH aggregation and canopy fuel density thresholding.

Key Findings

Finding 1: CaBH varies by characterization approach

CaBH estimates varied based on characterization approach with the lowest estimates coming from field-measured minimum CrBH and LANDFIRE, and the highest estimates from Sentinel-based models (Figure 2). Airborne lidar produced similar estimates to field observations but were on average 1.1 m higher and Forest Vegetation Simulator (FVS) predictions that utilized internally predicted crown ratios overpredicted CaBH by 1.2 m relative to models that included observed crown ratios. Finally, forests with lower canopies, such as pinyon-juniper, exhibited greater variability among methods.

Finding 2: Method selection strongly impacts predicted crown fire hazard

Patterns in predicted torching index among approaches were similar to those seen in CaBH, but with greater variability among approaches due to the nonlinear relationship between CaBH and torching index. These patterns were consistent across different surface fuel models, but torching index values changed significantly with different surface fuel conditions, highlighting the importance of accurately characterizing both canopy and surface fuels.

Finding 3: Method selection matters more in structurally complex forests

Plots with greater vertical canopy complexity, measured using tree height variability, generally had greater variability in both CaBH and torching index among methods. These findings are due to conceptual definitions having different sensitivities to lower canopy fuels and remote sensors differing in their ability to penetrate the main canopy.

Management Implications

- Airborne lidar is broadly available across much of the U.S. and provides similar estimates of CaBH as traditional field-based methods, allowing for measurement across larger geographic extents.
- Characterization choice matters more in multi-canopy stands due to the wider CrBH distributions and occlusion of smaller trees below the main canopy.
- When possible, managers should consider multiple characterizations to produce a range of potential outcomes as opposed to a single prediction of fire behavior.

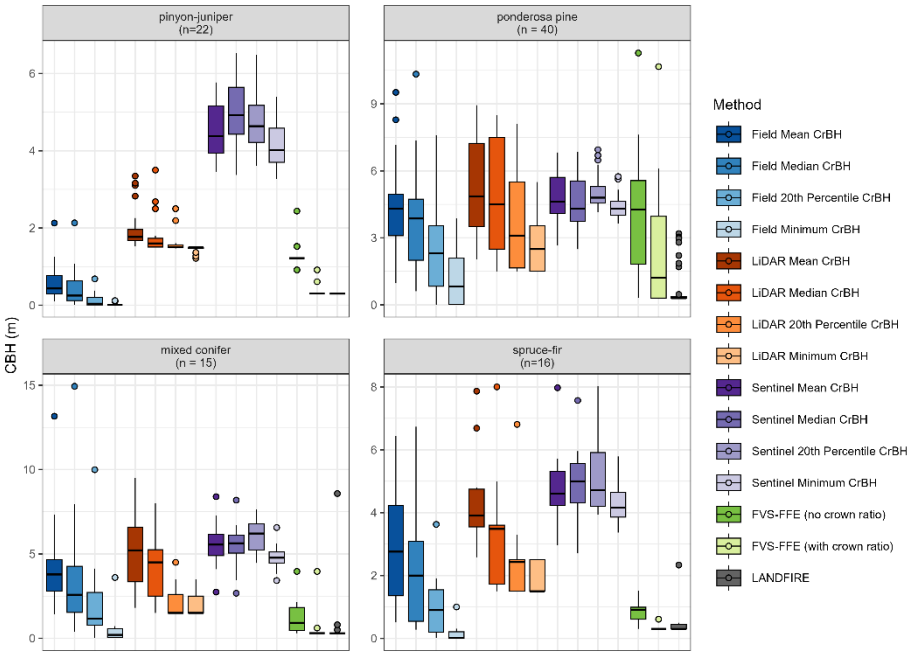


Figure 2: Boxplot comparison of canopy base height estimates across characterization approaches and forest types in northern New Mexico.

Additional Information

This brief is based on the following article:

Mast, C.N., Vallet, L., Hurteau, M.D., Zald H.S.J., Jones G.M., Woolsey G.A., Tinkham W.T., Hoffman C.H., Francis E.J. Methods and implications of canopy base height characterization for modeling crown fire potential. *Fire Ecology* (2026). https://doi.org/10.1186/s42408-026-00567-4

This brief was written by Colin Nystrom Mast and produced for review by the Southern Rockies Fire Science Network.

For additional information, contact: ColinNMast@gmail.com

READ THE FULL PAPER HERE!