Using Terrestrial LiDAR to Model Forest Structure Following the KNP Complex Fire

Hazel Mebius[1], Katelyn Woolfrey[1], Grace Parrott[2]

[1]KBR Inc., contractor to the U.S. Geological Survey (USGS) Earth Resources Observation and Science (EROS) Center, Sioux Falls, SD 57198, USA. Work performed under USGS contract 140G0121D0001. [2]USGS EROS Center, Sioux Falls, SD 57198, USA.

Introduction

- The KNP Complex Fire was formed on September 9, 2021, when the Cabin, Colony, and Paradise Fires converged, and declared contained December 16, 2021, burning nearly 90,000 acres[6]
- A majority of the fire occurred in Sequoia and Kings Canyon National Parks, where it killed thousands of mature giant sequoias[4]
- Terrestrial LiDAR scanning (TLS) has shown to be an efficient and non-biased method of measuring vegetation and fuels metrics for fire research[3]
- Efficient and accurate data on changes in post-wildfire forest structure helps land managers with recovery efforts and thus the public through prevention of future severe wildfires

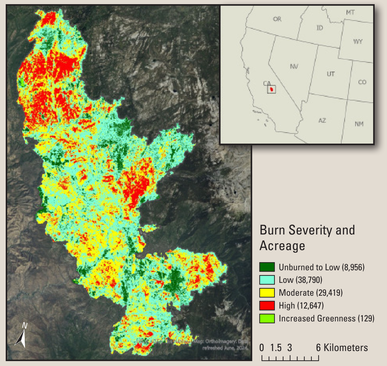


Figure 1. Map showing burn severity of the KNP Complex fire as mapped by the Monitoring Trends in Burn Severity program[5].

Research Question

How well can canopy bulk density (CBD), as an indicator of canopy fuel load, be measured using a combination of TLS and traditional field measurements?

Methods

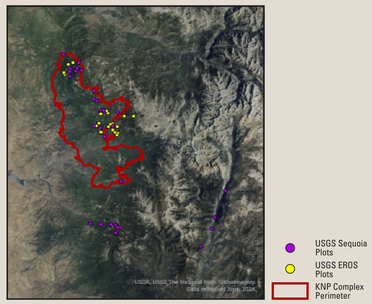


Figure 2. Map showing KNP Complex fire perimeter and plot locations for the USGS Earth Resources Observation and Science Center TLS data and USGS Sequoia and Kings Canyon Field Station collected field data.

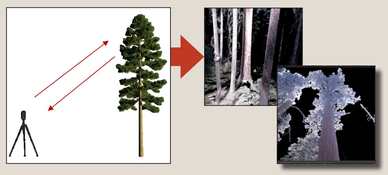
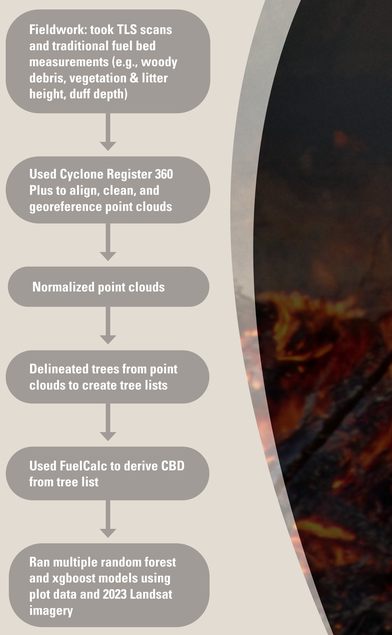


Figure 3. Diagram showing the in-field TLS setup and the point cloud outputs. The TLS system used for this project is the Leica BLK360. It is single return and collects 680,000 points per second.



Results

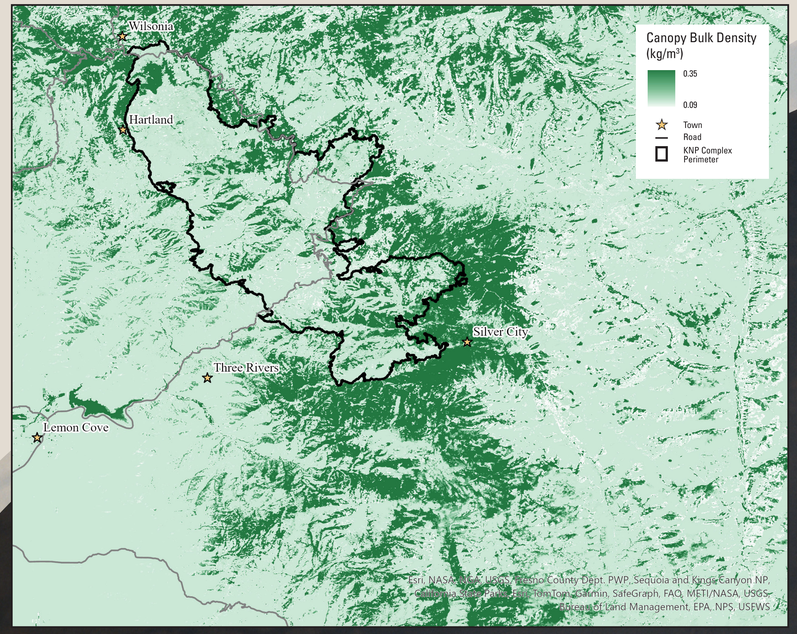


Figure 4. Map of CBD values for the area of interest. 2023 Landsat imagery used for model base data.

Figure 5. Box and whisker plot showing CBD distributions for plot data and modeled map data. Plot data is observed data, or data collected in the field at specific plots using both traditional field methods and TLS. Modeled map data is predicted data by the model. The distribution of model output CBD is significantly different than the CBD of data collected in field, indicated by the asterisk.

Table 1. Metrics of model, trained with plot data. Accuracy based on subset of training data. Map, predicted by the model, tested with test data accuracy.

	Root Mean Squared ERROR (kg/m³)	r^2
Model	**0.158**	**0.366**
Map	**0.120**	**0.618**

Accessed October 18, 2024[7]

Accessed October 18, 2024[8]

Discussion

- Used manually collected and TLS derived tree list data to calculate CBD using FuelCalc and then created a model to predict CBD values within the burned area (n = 72; 90% training data (65), 10% test data (7); Fig. 4)
- The model significantly overestimates CBD, as compared to the collected field plots (Fig. 5)
- The model fit was relatively low which indicates that our model accuracy is poor, while our map accuracy was higher, which can possibly be attributed to the small sample size and potential for spatial autocorrelation (Table 1)
- There are multiple sources of error that are contributing to low model accuracy
  1. Total sample size is small, with there only being 7 test plots
  2. Some data used in the model does not have the same geographical characteristics (outside burn boundary, elevation, and vegetation type)
  3. Error in point cloud derived tree metrics for tree lists used as FuelCalc inputs, as the process of tree delineation from TLS point clouds at times inaccurately calculated tree height, canopy base height (CBH), and diameter at breast height (DBH), which are metrics used to calculate CBD
  4. Only one independent variable was incorporated in the model
  5. Landsat surface reflectance may not have a strong correlation with CBD

Future Directions

- We are currently working to improve this model to achieve and higher map and model accuracy within KNP Complex fire
  1. Adding more variables to model, such as topography and climate parameters
  2. Increasing sample size by including all the data within similar elevations and vegetation types collected by the USGS Sequoia and Kings Canyon Field Station
- Use this modeling process, along with local field data, to build additional models for other fires of interest, such as the Jasper fire and Legion lake fire in the South Dakota Black Hills
- Develop models to obtain other useful tree metrics, such as CBH, DBH, and tree height
- Merge TLS data with other remote sensing technology data such as airborne laser scanning (ALS) and the Global Ecosystem Dynamics Investigation (GEDI) data to obtain a more efficient and accurate understanding of wildfire impact and recovery

Acknowledgments

- Funding provided by the USGS National Land Imaging/Land Change Science and the Wildfire Disaster Supplemental Appropriated Funds
- TSSC Contract number ---140G0121D0001
- Thank you to Ellie Broadman for collecting and providing field data for which we used in conjunction with our own data for this model
- Thank you to Adrian Das, Nick Ampersee, and Anne Pfaff from the USGS Sequoia and Kings Canyon Field Station
- Thank you to Josh Picotte and Birgit Peterson for their continued guidance throughout this project

References

[1]Loudermilk, E.L., Pokswinski, S., Hawley, C.M., Maxwell, A., Gallagher, M.R., Skowronski, N.S., Hudak, A.T., Hoffman, C. and Hiers, J.K., 2023. Terrestrial laser scan metrics predict surface vegetation biomass and consumption in a frequently burned southeastern US ecosystem. *Fire*, 6(4), p.151.

[2]Shive, K., Brigham, C., Caprio, T. and Hardwick, P., 2021. *Fire Season Impacts to Giant Sequoias*. National Park Service, Sequoia and Kings Canyon National Parks.

[3]U.S. Geological Survey, 2005. *Monitoring Trends in Burn Severity (MTBSI) Data: Jasper Fire*. U.S. Geological Survey. Available at https://mtbs.gov/direct-download. (Accessed: 26 August 2024).

[4]U.S. National Park Service, no date. *KNP Complex Fire - Sequoia & Kings Canyon National Parks*. Available at: https://www.nps.gov/seki/learn/nature/knp-complex-fire.htm (Accessed: 21 October 2024).

[5]https://www.nps.gov/media/photo/gallery-item.htm?pg=70327334&id=06ce5453-4b17-408f-9805-d168791fbed2&gid=2CDC85DF-EBE0-4B25-84C3-9DC95FABF4F6

[6]https://www.nps.gov/media/photo/gallery-item.htm?pg=70327334&id=0c58fd17-f4fe-4f43-a4d0-83cae4980159&gid=2CDC85DF-EBE0-4B25-84C3-9DC95FABF4F6

U.S. Department of the Interior
U.S. Geological Survey

November 2024