Automated Wildfire Risk Assessment

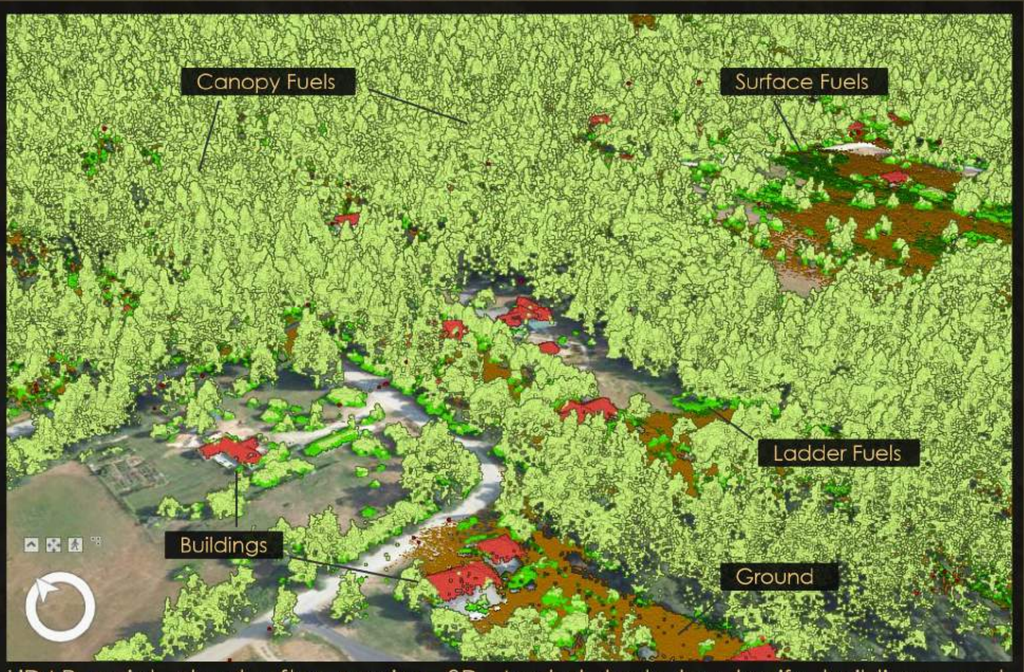
Utilizing LiDAR to Assess Wildfire Threat Posed to Individual Buildings in the British Columbia Wildland Urban Interface

esri Canada

Patrick Droste
Selkirk College
Castlegar, BC
2021

Selkirk College

Each year, wildfires in British Columbia have a devastating economic impact while threatening homes and infrastructure.[1] A proactive approach to wildfire mitigation has been adopted, emphasizing at-risk communities in the wildland-urban interface (WUI) and proactively applying mitigation strategies to these areas.[1] Site assessments currently follow guidelines constructed by the collaboration of several forest consulting companies, and approved by the Ministry of Forests, Lands, Natural Resource Operations, and Rural Development.[2,3] Once properties have been identified within high fire danger areas in the WUI, professionals conduct site level, in-person assessment of properties, following the standardized handbook. Properties are scored based on 20 factors such as slope, topography, position of the structure, canopy closure, and forest health.



LiDAR point cloud after running 3D Analyst tools to classify buildings, and vegetation classes by height; Surface (1-3m), Ladder (3-10m), Canopy (10m+)

LiDAR technology has been demonstrated as a very effective means of creating highly accurate forest structure models.[4] These models could be effectively utilized to quantify fuel metrics over large areas.[5] Combined with LiDAR-derived topography and land classification models, the potential exists for large area, semi-automated individual property-specific risk assessments.

This study aimed to test for five risk metrics surrounding individual properties, identified by LiDAR:

Slope | Aspect | Surface Fuel Coverage | Ladder Fuel Coverage | Canopy Closure

A 15km^2 area east of Nelson, BC was chosen for the study, encompassing a variety of aspects, slopes and forest structures. 160,353,125 LiDAR points were available for analysis in the study area.

Workflow:

1. Extract Buildings & Create Buffers
2. Isolate Fuel Classes
3. Find Slope / Aspect
4. Calculate Risk Factors within Buffers
5. Assign Buildings Risk Score

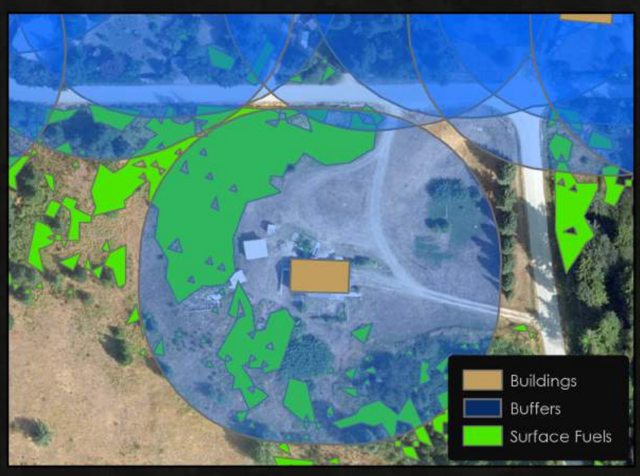
1. Extract Building Features & Create Buffers

Building features extracted and buffers created

After building points were classified using ArcGIS 3D Analyst tools, building points were converted to a raster on their elevation value, and the raster was then converted to polygon features. This process output polygons for each building with unique Object IDs. Building footprints were regularized, and small holes were eliminated to better represent building features. With building footprints generated, buffers were created for each, at a radius of 50m, and excluding the building itself from the output polygon. 50m was chosen to encompass each Firesmart zone outlined by the B.C Government.[6] As surrounding vegetation would be calculated as a percentage of surrounding area, excluding buildings was necessary for accurate calculation.

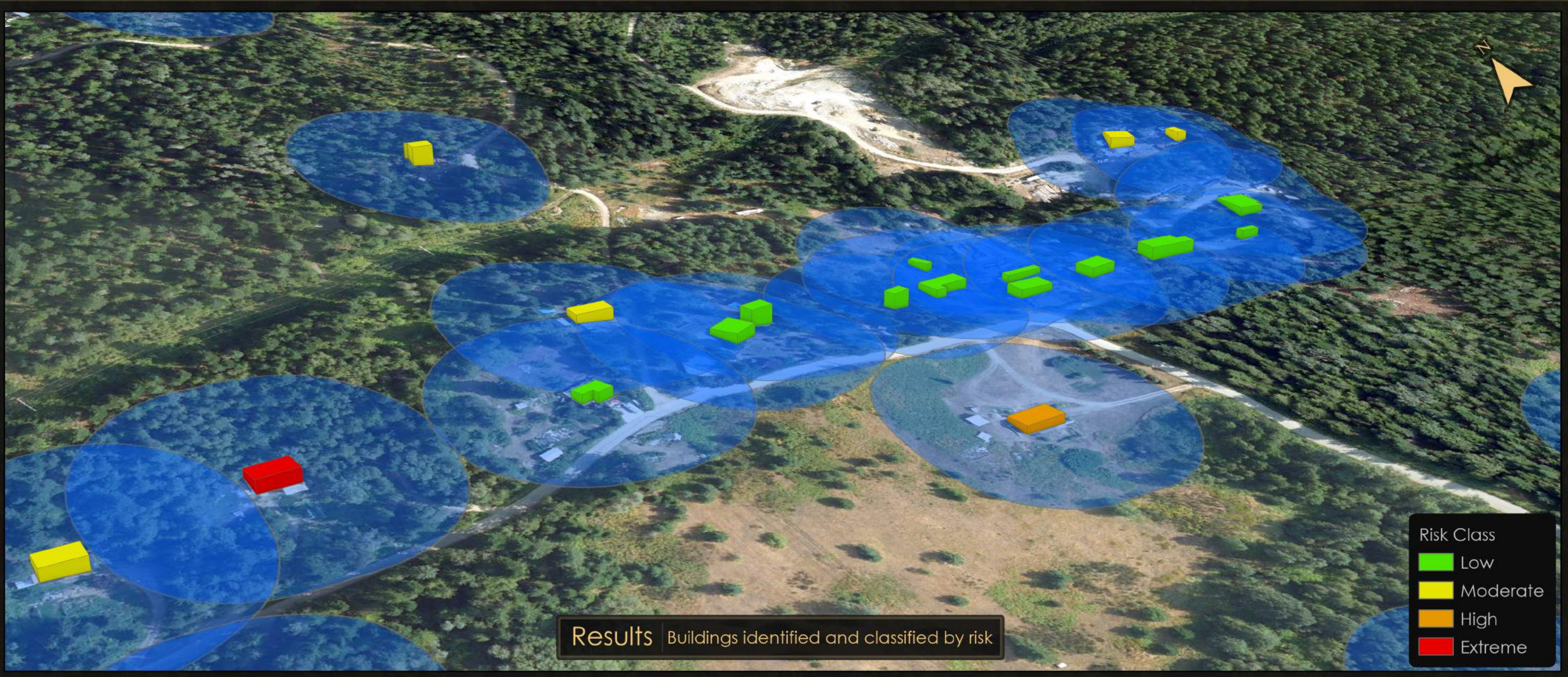
2. Isolate Fuel Classes & Find Percent Coverage

Surface fuel point density raster



Surface fuel polygons in building buffer

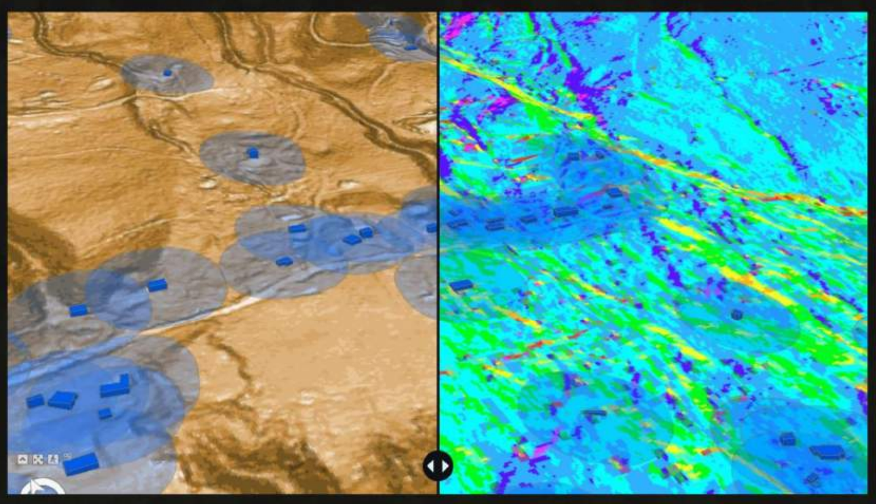
Once classified, each vegetation (fuel) class was isolated, and converted to rasters with 2x2m cell size using point count. These rasters were then reclassified to '1' or 'nodata' based on a cell value of 'equal to or greater than 16' = 1, and 'less than 16' = 'nodata'. The threshold 16 was chosen as function of point spacing and cell size, where it was estimated that for every 2x2m cell, there would be approximately 16 pulses, as vegetation would typically have multiple returns per pulse, it would be expected that the presence of significant vegetation in this cell would have a point density of at least 17, filtering out sparse vegetation and solid objects. Reclassified rasters were then converted to polygon features for the purpose of coverage analysis. Once polygons were created for each vegetation class, pairwise intersect was used to create new polygons for each vegetation class, uniquely tied to each buffer in which they intersected. This allowed for vegetation polygons that existed in the overlap between two or more buffers, to be duplicated, with each version being uniquely attributed to one buffer. Summary statistics were calculated for each vegetation class as the sum of vegetation area per buffer ID. These statistics were joined to the buffer features, and a percent coverage calculation could then be performed on each vegetation class, per building buffer.



Results Buildings identified and classified by risk

3. Mean Slope & Aspect

LiDAR points were filtered to ground, and converted to a DTM raster. A cell size of 2m was chosen as the resolution. This decision was based on the average point spacing, as discussed in the previous step. The DTM was converted to both a Slope (deg) and Aspect raster, which were then converted to vector point features based on their values. In order to find the average slope and average aspect, slope and aspect points were spatially joined to building buffer polygons, using 'merge' by mean value, the result was building buffer features, with attributes for mean slope, and mean aspect. The circular nature of aspect point values required further processing to attribute an accurate mean aspect to buffers.



Slope & Aspect rasters, mean values found within buffers

4. Calculate Risk Factors

The five risk factors measured in this analysis were weighted to a similar degree to the field assessment handbook, adjusted slightly to reflect value ranges found in this dataset. For each building buffer, the five metrics fall within one of the six categories (A-E), and the associated score is added to the building total risk score. Total risk score then falls within one of four risk categories, and this risk class is given to the building being analyzed.

	A	B	C	D	E
Slope	*0-15deg* *0*	*15-25deg* *1*	*25-35deg* *3*	*35-45deg* *4*	*45deg+* *5*
Aspect		*N* *0*	*E* *3*	*S* *5*	*W* *4*
Surface Fuel Coverage	*0%* *0*	*1-10%* *4*	*10-25%* *8*	*25-50%* *12*	*50-100%* *15*
Ladder Fuel Coverage	*0%* *0*	*1-10%* *2*	*10-40%* *5*	*40-60%* *8*	*60-100%* *10*
Canopy Closure	*0-20%* *0*	*20-40%* *1*	*40-60%* *2*	*60-80%* *5*	*80-100%* *4*

Risk Class	Low (1)	Moderate (2)	High (3)	Extreme (4)
Score Total	*0-16*	*17-20*	*21-24*	*25-40*

Weighted risk score tables (value ranges and associated scores)

Conclusion

This study examined the viability of utilizing LiDAR data to automatically extract building footprints, and analyze the surrounding topography and vegetation structure in order to determine its risk to wildfire. Building feature extraction, slope and aspect analysis show highly accurate results. Canopy vegetation density was very accurately captured, however surface and ladder vegetation were sometimes obscured, and therefore underrepresented in areas of thick canopy vegetation, leading to lower risk results than expected. Once refined and exported to a standalone script, this tool will enable regional districts to input any LiDAR dataset, for any location, and quickly perform large area, automated risk assessments. As LiDAR data becomes more prevalent and freely available in British Columbia, this tool could be applied to any community to identify high risk areas in which to prioritize further investigation, and risk reduction strategies.

References

1. BC Wildfire Service. 2020. BC Wildfire Service Mandate & Strategy - Province of British Columbia. [accessed 2020 Oct 18]. https://www2.gov.bc.ca/gov/content/safety/wildfire-status/about-bcws/governance/mandate-strategy.
2. MacIntosh B, Morrow B, Johnston K, Davies J. 2013. Wildland Urban Interface Wildfire Threat Assessments in B.C. [PDF]. Available from: https://www.ubcm.ca/assets/Funding~Programs/LGPS/SWPI/Resources/swpi-WUI-WTA-Guide-2012-Update.pdf
3. Hicks DTF. 2019. Wildfire Threat Assessment Guide and Worksheets [PDF]. Available from: Wildfire Threat Assessment Guide and Worksheets (ubcm.ca).
4. Skowronski NS, Clark KL, Duveneck M, Hom J. 2011. Three-dimensional canopy fuel loading predicted using upward and downward sensing LiDAR systems. Remote Sens Environ. 115(2):703–714. doi:10.1016/j.rse.2010.10.012.
5. Burns J. 2012. Applications of Lidar in Wildfire Management [PDF]. UBC Open Library. Available from: https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwiopOr92uXvAhXHrZ4KHfWpAKYQFjABegQIBBAD&url=https%3A%2F%2Fopen.library.ubc.ca%2Fmedia%2Fdownload%2Fpdf%2F52966%2F1.0075533%2F1&usg=AOvVaw0C2vXG-K6hS3VIZvG0FczJ .
6. Firesmart B.C. Critical Infrastructure Guide FireSmartBC_FireSmartCriticalInfrastructureGuideFINAL.pdf. [accessed 2021 Mar 14]. https://firesmartbc.ca/wp-content/uploads/2020/09/FireSmartBC_FireSmartCriticalInfrastructureGuideFINAL.pdf.

Data

LiDAR dataset provided by the Province of British Columbia for educational use. Collected August 2017. UTM Zone 11N (NAD83), CGVD2013. Point spacing 0.24-0.42m
Ortho photos provided by the Province of British Columbia for educational use, captured simultaneously

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