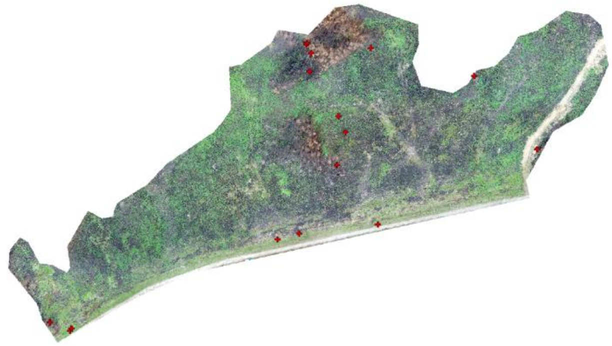

Assessing Remote Sensing Estimations for Burn Area and Tree Mortality.

by

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ABSTRACT

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Remote sensing tools will increase the ability of land managers to visually sample large areas more feasibly. This increase in applications of remote sensing such as UAV aerial LiDAR may require an assessment of algorithm accuracy while utilizing LiDAR data versus ground collected data to ensure these applications are appropriate. One such application included within this study is the detection of trees utilizing the LidR package which allows a cost-effective and quick survey estimating trees contained, and providing their estimated heights. The aim of this paper is to compare these detection results to a traditional ground tree stocking survey, exploring the viability of applying tree detection algorithms on post-burn forestry blocks to assess the surviving trees allowing an indication of future stocking allowing the forest manager to create a more accurate re-planting schedule. The results derived from this assessment deviated significantly from ground surveys with the aerial analysis providing an estimate of 2.20 WSP/ha and the ground survey estimating 70.18 WSP/ha (Well spaced stems per hectare) within block 525_19C. Although stocking results were inconclusive the analysis resulted in several useful outputs such as a combination of orthomosaic imagery alongside the tree detection points. These

outputs resulted in an effective visual aid allowing a more detailed visualization of the spatial extent severe burns included within the forested blocks.

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INTRODUCTION

Recent developments in remote sensing capabilities and consumer accessibility have now allowed drones to become a possible alternative to full-size manned fixed-wing and rotary-winged aircraft in collecting aerial sensing data. Modern aerial drones now feature high-resolution sensors capable of recording accurate georeferenced imagery (Tang & Shao 2015). This development allows drones to position themselves as a cost effective solution due to their low-energy and low-personnel requirements while capturing forestry related aerial data (Banu et al 2016; Tang & Shao 2015). Comparing drones to satellite imagery the key considerations are the ability to produce a higher spectral resolution without the need for comparatively coarse scanning frequency interval some satellite solutions require (Chen et al 2022; Gao et al 2020). This provides managers the ability to receive high resolution data immediately and frequently which is useful in applications such as wildlife monitoring, fire detection, fire monitoring and forest operations monitoring (Banu et al 2016; Chen et al 2022). As drone's capabilities have increased their adoption may require assessments into the viability of implementing such data collection and how their accuracy compares to traditional data collection methods. The drone utilized in this study is a consumer grade DJI Phantom 4 Pro featuring a 1" CMOS sensor collecting 4k images used to produce the ortho-mosaic visualization. The drone is also capable of capturing aerial LiDAR data. The data was collected from the Tumbler Ridge area of northern interior British

Columbia immediately following the West Kiskatinaw River fire discovered on June 6, 2023. Studies such as this are necessary to further the field of remote sensing and provide insight into how drone programs should be implemented and further developed. Quantifying the accuracy of drone collected data will help future managers adjust their use cases and hopefully further the field of remote sensing in the Natural Resources field.

OBJECTIVES

The objective of this study was to determine how much variance there is between estimating tree mortality within a burned forestry block using UAV collected LiDAR versus random ground sampling plots.

HYPOTHESIS

Aerial block mortality estimations from drone collected data will have no variance from random ground sampling plots.

Literature Review

Boreal Forest of Interior British Columbia

The boreal forest represents close to 30% of the earths forested area, with one third being located in North America alone (Whitman et al 2019). The boreal forest also represents approximately half of the stored carbon in global forest ecosystems (Chen et al. 2017). The forests of northern interior British Columbia within the Peace River district are mainly classified as both Boreal plains and sub-Boreal interior ecoregions (Demarchi 2011). These ecoregions are typically defined by their cold winters, warm summers and equal distribution of precipitation throughout the seasons (Demarchi 2011). The main commercial species found within these ecoregions include white spruce (*Picea glauca*), black spruce (*Picea mariana*), engelmann spruce (*Picea* engelmannii), lodgepole pine (*Pinus contorta*), and subalpine fir (*Abies lasiocarpa*). Other common tree species include trembling aspen (*Populus tremuloides*), balsam popular (*Populus balsamifera*), and paper birch (*Betula papyrifera*).

Western boreal forests have been under immense pressure in recent years as disturbance such as fire, insects, and drought have increased under climate change (Baltzer et al. 2021; Brown et al. 2010). Species such as lodgepole pine have suffered immense mortality with mountain pine beetle epidemics killing a large section of the provinces mature pine volume (Brown et al. 2010). This drastic increase in mortality has caused a shift of lodgepole stands from net carbon sinks into potential future carbon sources (Brown et al.

2010). Other insect attacks have also increased in prevalence as drought promotes insect epidemics by promoting physiological stresses amongst trees increasing their vulnerability to insect attack (Chen et al. 2017). These increases in disturbance have created a shift in boreal ecology, changing the successional directions of regenerated stands by excluding species, reducing regeneration capabilities, and reducing forest health overall (Brown et al 2010; Chen et al. 2017; Whitman et al. 2019).

Boreal Forest Fire

Forest fire plays an integral part in the boreal forests natural ecology, and is typically a key disturbance responsible for stand replacing events (Ferster et al 2016). Currently boreal fire regimes and characteristics appear to be differing from historical norms likely due to climate change (Whitman et al 2019). Although climate change is a key driver of increasing fire severity, a history of fire exclusion has also lead to high fuel loads within forested areas further promoting extreme fire conditions (Stephens et al. 2009).

Historically boreal fires had an observed interval typically between 30 to several hundred years for a stand replacing events (Whitman et al 2019). Typically, boreal stands have difficulty burning within 30 years of the last fire, this is mainly due to the reduction in fuels preventing fire ignition and spread (Whitman et al 2019). Increases in climate changes such as increasing drought severity and occurrence have decreased fire intervals (Whitman et al. 2019). Increases in droughts have also decreased the control fuel reduction has had on reducing fire risk, this has lead to previously burned stands experiencing burning events sooner then expected (Whitman et al 2019). One issue facing current boreal forests is the effects anthropogenic fire exclusion has had on boreal stands (Stephens et al. 2009). Fuel levels have increased overall on the landscape leading to more extreme fire events and less tree survival from these burns (Stephens et al. 2009). Controlling fuel levels has proven to reduce fire severity reducing tree mortality and preserving canopy cover (Stephens et al. 2009).

Depending on the wildfires characteristics vegetation mortality can vary greatly (Ferster et al 2016). Two effective indicators of increased survival included low fuel continuity within the fire and fires in regions with non-drought conditions (Ferster et al 2016). Surviving residuals may play a key part in boreal ecology, surviving residuals may effectively influence future stand composition, residuals may also play a role in facilitating regeneration (Ferster et al 2016). Post-fire residual patches also play a key role in facilitating re-colonization by animals, fungi, insects, and birds (Perera & Buse 2014). Residual patches can act as a refuge for these species within the burned area allowing quicker recolonization post-fire as the patch may act as a source (Perera & Buse 2014).

LiDAR and Remote Sensing

Remote sensing is an emerging field in natural resources management allowing managers the ability to collect information which would previously be cost prohibited. Remote sensing can have many applications allowing managers the ability to observe large landscape changes or small intensively measured stand characteristics depending on the objectives and method utilized (Tang & Shao 2015). Recent developments in drones, sensors, software, and batteries have allowed consumer grade fixed-wing and rotary-winged drones to become viable options for cost effective, high quality aerial visualizations (Tang & Shao 2015). Previous studies have utilized drones in various applications including: mapping, biodiversity studies, precision stand mensuration's, and canopy dynamics (Banu et al 2016). Aerial drones may also have effective application for fire detection, fire extent mapping, and fire behavior studies (Chen et al 2022). Drones also provide a higher level of precision when compared to satellite imagery, the benefits of drones include low-latency data streams, higher spatial resolutions, and the ability to have more reactive visualizations (Banu et al 2016; Chen et al 2022).

LiDAR (Laser Imaging Detection and Ranging) has become a standard tool utilized in the field of remote sensing. LiDAR has many applications from creating digital terrain models utilized in mapping, to collecting forest canopy measurements such as tree differentiation and canopy cover (Yadav et al., 2023). LiDAR has been used previously to detect forest stand conditions, allowing forest managers a cheaper alternative to physical surveying (Chisholm et al., 2013). Drones' ability to navigate freely also allows them to address niche applications such as below-canopy surveys (Chisholm et al 2013). This low altitude capability and maneuverability also allows drones to be fire monitors as they can fly low enough to detect fire spread in conditions which other methods might be adversely affected by smoke or lack spatial resolution (Chen et al 2022).

Methods and Materials

Area of Study

Aerial photography, LIDAR and ground plots were collected from previously harvested forest blocks in the Tumbler Ridge area of Northern British Columbia. All three blocks have a similar locality and are located at 55°07'58.39"N -120°39'45.58"W (Block 525-19c), 55°08'73"N -120°42'59.9"W (Block 139-4) and, 55°21'45.35"N -120°9'19.6"W (Block 664-111). Fire was previously active in June 2023, blocks were aerially scanned from approximately late July 2023 to September 2023, scanning did not commence immediately following fire event as low level burns continued and the risk from standing deadwood was present. Aerial Surveys and ground plots commenced as soon as ground personnel were permitted entry.

Aerial Drone Scanning

Aerial scanning was completed with a DJI phantom 4 pro using a 1-inch CMOS sensor to collect 4k RGB aerial photography, aerial LIDAR used in this assessment was also derived from the same flights. Flight paths were created using the *Sitescan for ArcGIS* application created by Esri. Within the application flight paths were created by utilizing a shape files of the previously harvested block extents and allowing the automated processing to create a flight path from the area survey option. To optimize the flights and data collection these shape files were modified from their originals by adding a 10-meter buffer to the entire exterior extent allowing better visualization of the surrounding residuals and mature stands from the imagery captured. Flights were conducted at an above-ground-level of 100 meters, the *Terrain Follow* feature was enabled allowing the drone to automatically adjust as terrain elevation changed over the site. Post flight data was then processed by the desktop *sitescan* application, this post-processing resulted in the orthomosaics, laz, and las files used in this assessment.

Tree Detection in R-Studio

The tree detection analysis was completed utilizing the “lidR: Airborne LiDAR data manipulation and Visualization for Forestry Applications” package for R-studio developed by *Jean-Romain Roussel, Tristan R.H. Goodbody and, Piotr Tompalski*. Within the package a digital terrain model with a 1 metre resolution was created for each block utilizing the triangular irregular network (TIN) method. The resulting digital terrain model (DTM) was then used to create a normalized LiDAR model resulting in our canopy height model. LiDAR normalisation was again achieved within the LidR package inputting the raw .las files and our corresponding DTM previously created.

Tree detection was also completed within the LidR package, using the canopy height model the tree detection algorithm was applied outputting the final shape-files containing point xyz coordinates. The model was run using the local maximum filter with a fixed window size of 3.2 metres, the diameter was chosen as it corresponded with the minimum inter tree distance of 1.6 metres that the planting prescriptions required for a well-spaced tree. The default minimum tree detection height of 2 metres was also used. The last setting modified was utilizing the bitmerge classification method for ascribing identifiers to the attribute table representing the trees detected. Utilizing the bitmerge method was especially important for the larger blocks which required the LidR process to be completed with the catalog file structures. The completed tree detection shapefiles and canopy height model lidar files were then visualized in ArcGIS pro alongside the orthomosaic, allowing the data to be visualized simultaneously.

Post Fire Mortality Ground Surveys

Randomized sample plots were also collected post-fire during the same period as the aerial drone scanning. Plot sizes were standardized at 3.98m radius representing 50m^2. Data collected from plots includes total tree counts, species type, how many of these trees are considered well spaced for restocking purposes, average heights of all trees counted, average height of only well spaced trees, observations on ground vegetation species, %cover, average height within the plot, and observational notes from the data collectors. Notes included observations such as ground burn observations, recommendations for restocking, and observations on surviving trees status.

Surveys were then transformed to represent WSP/ha (well-spaced-stems per hectare) and Stems/ha.

RESULTS

Comparison of Aerial Analysis versus Ground Plots

A final summary table for the raw counts of detected trees was provided, table also includes stems per hectare, stems per hectare minus the wildlife tree retention patches, stems per hectare for the ground plots, and well-spaced stems per hectare for the ground plots. Outputs were chosen as they best reflect the stand conditions relevant to the forest manager, trees included within the wildlife tree retention patches represent a differing age cohort of post harvest trees in which their inclusion removes descriptive capabilities on the previously planted cohort. Well spaced stems per hectare are also a key comparison as the work window was set at 3.2 metres in the LIDAR analysis resulting in a minimum inter-tree distance of 1.6m reflecting the definition of a well spaced tree. Outputs deviated significantly, block 525_19C had 31.9 times less WSP/ha then the ground plots, block 139_4 had 3.54 times less WSP/ha then ground plots, and block 664_111 had 9.75 times less WSP/ha then ground plots.

Table 1. Results from the LIDAR analysis, and the ground plots represented in stems/ha.

Block	Block Size (ha)	Aerial Stems	Aerial Stems Excluding WTP	Aerial Analysis Stems/ha	Aerial Analysis – WTP Stems/ha	Ground Plots Stems/ha	Ground Plots Well Spaced Stems/ha
525_19C	5.7	16	11	2.81	2.20	56.34	70.18
139_4	28.1	812	769	28.90	32.18	854.09	113.88
664_111	37.7	414	304	10.98	8.71	663.13	84.88

Point density below represents the average point density included within the raw las files, point densities were extremely variable over the entire extent of the block, with the centre section containing a high density due to the flight plans overlap and the exteriors a significantly lesser value.

Table 2. Average Point Densities derived from blocks raw las files.

Block	Average point density
525_19C	83.36
139_4	152.71
664_111	198.31

Visualisation of Spatial distribution

Figure 1,2,3 represent the final output combining orthomosaic imagery and the resulting tree detection shapefile. This images are useful for evaluating the spatial distribution of trees detected from the final end products. Wildlife retentions patches are also included to act as a removal filter as original analysis was completed to determine the extent of restocking efforts for the original plant. Overall spatial trends show detected trees were distributed thoroughly throughout the block with some trends such as large patches of standing timbers (Figure 664_111, wildlife retention patch), large concentrations near roadsides (figure 139_4), and increases near cut-block edges from surrounding timbers.

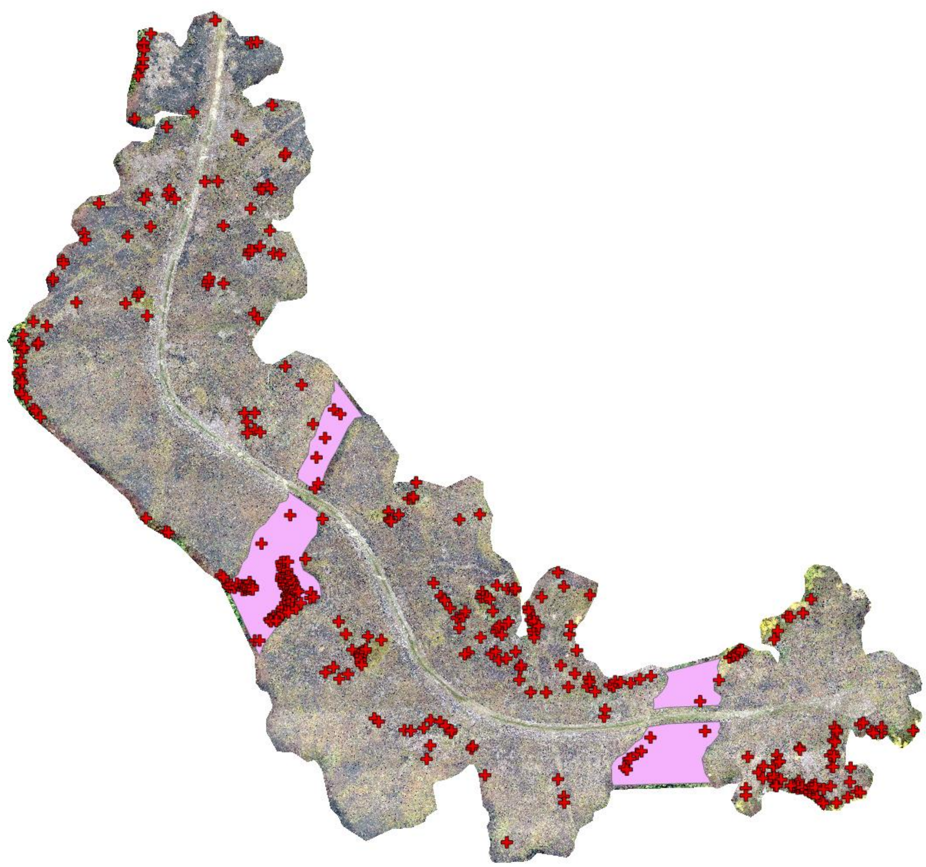

Figure 1. Block 664_111, wildlife tree patches are highlighted by the pink polygons, tree detection was extremely dense within these areas resulting in a large increase in detected stems/ha.

Figure 2. Block 525_19C, Red crosses represent the distribution of tree's detected, pink polygons represent wildlife tree retention patches.

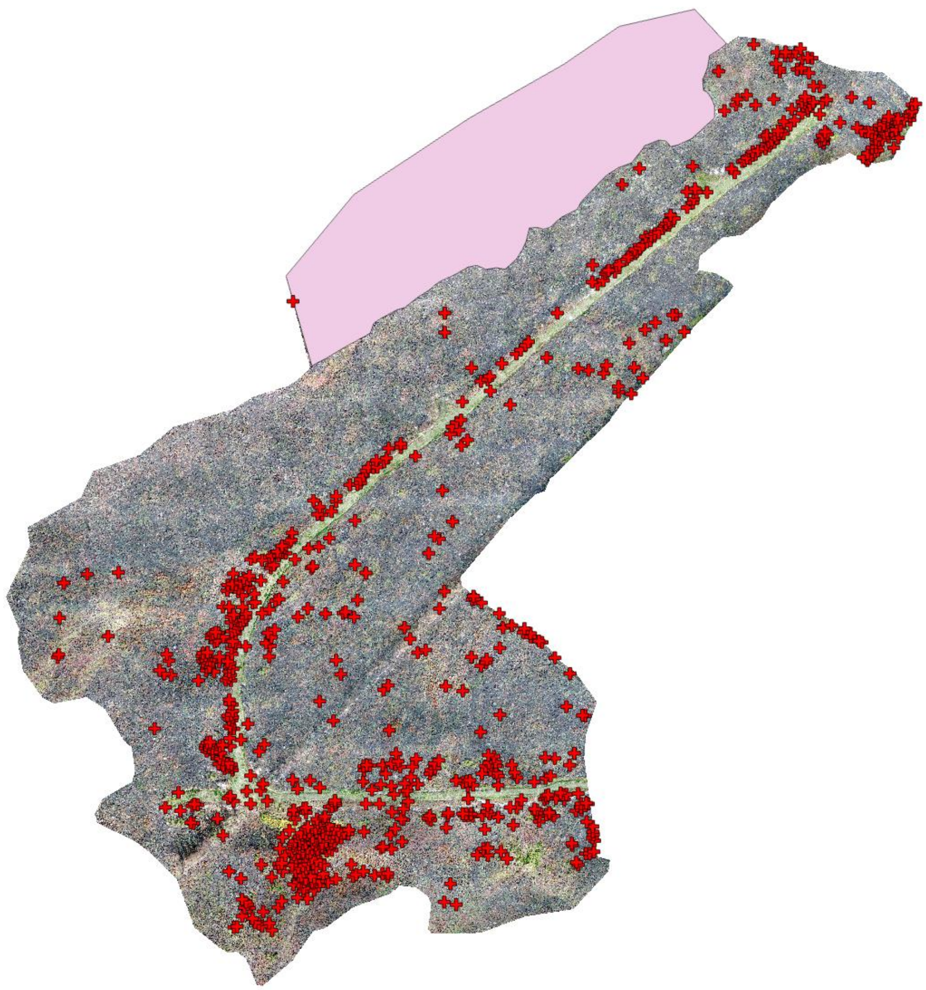

Figure 3. Block 139_4, red crosses represent the distribution of tree's detected, pink polygons represent wildlife tree rentention patches.

Figure 4 highlights the combination of orthomosaic imagery, LiDAR points filtered to represent non-ground classification, and the crosses representing trees detected. This combination output is an ideal product of such an analysis for aiding forest managers. Figure 5 represent the same visualization with LiDAR points removed allowing better visualisation of the RGB orthomosaic underneath.

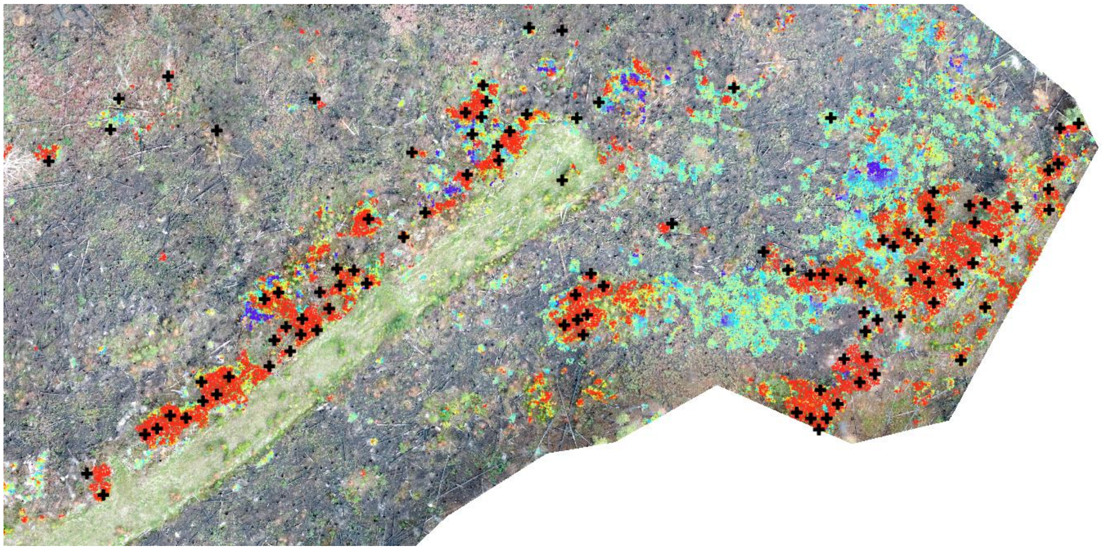

Figure 4. Block 139_4, LiDAR overlayed filtering for non-ground points, crosses represent the estimated trees detected, orthomosaic included for visualization.

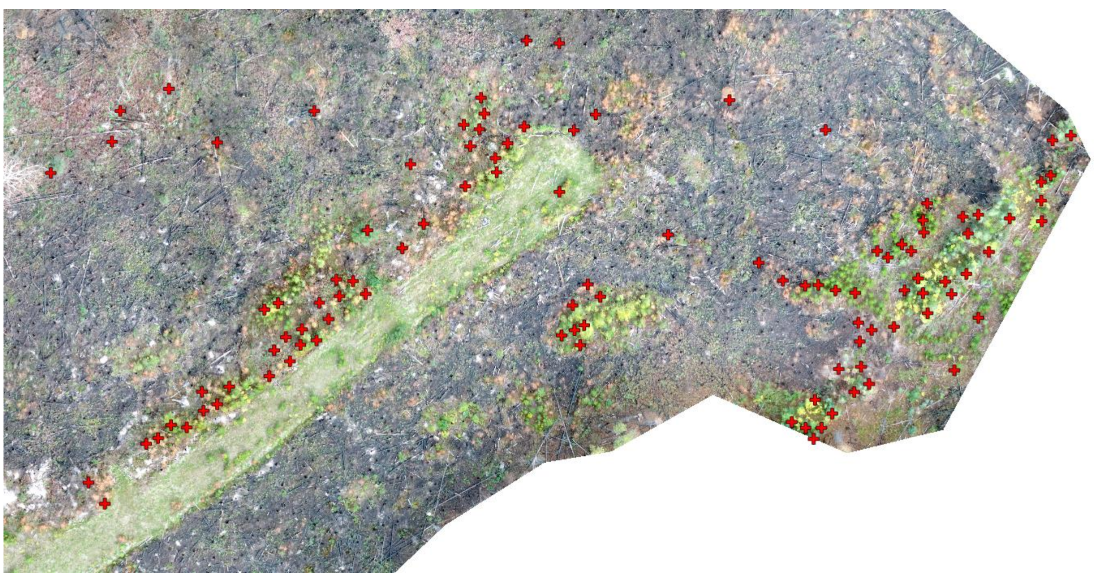

Figure 5. Block 139_4 without LiDAR overlay, allowing better visualization of orthomosaic.

Histogram of Height Captures.

Histograms were produced of the raw tree counts for each block, this data could be useful for visualizing age classification of the differing forest stand conditions within the blocks (wildlife retention patches vs later planted seedlings). Histograms minimum height was 2 metres as the LIDAR analysis did not detect trees below this, the overwhelming majority of trees detected were within the < 3m age category with block 664_111 representing 51.32%, block 525_19C representing 60%, and block 139_4 representing 79.16% of trees detected.

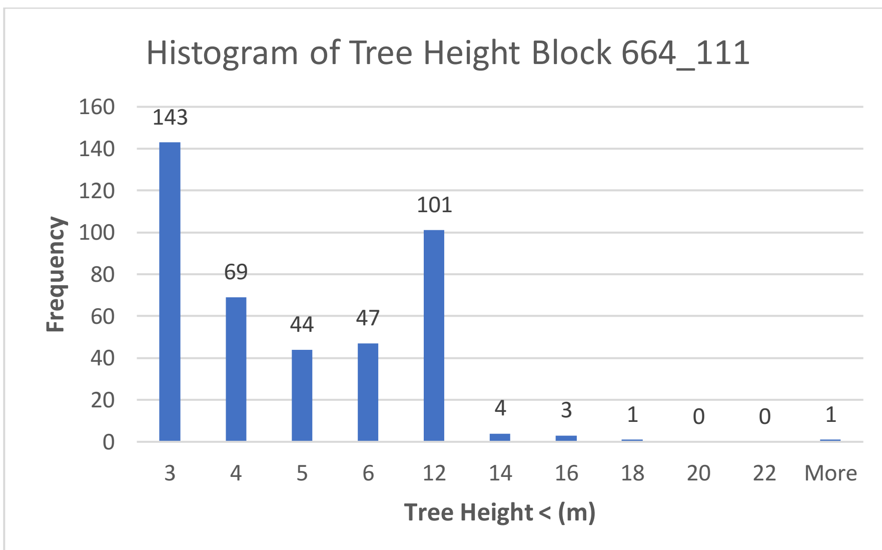

Figure 6. Histogram for block 664_111.

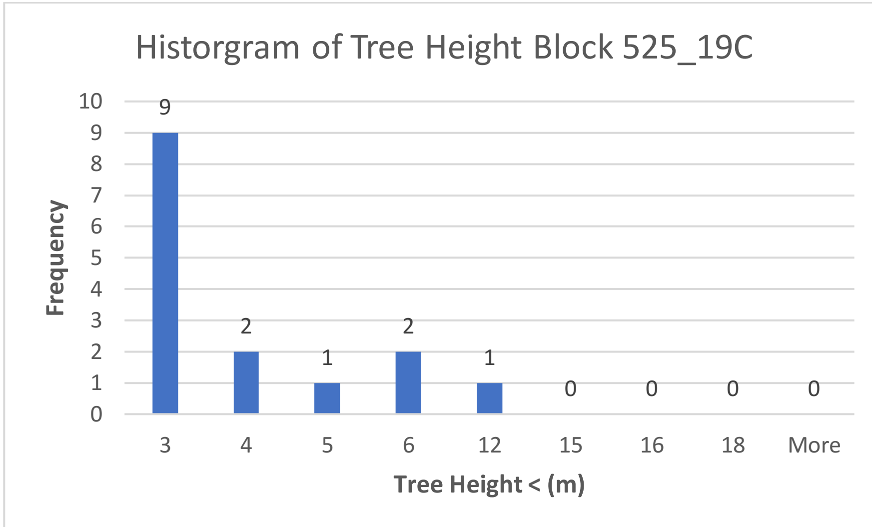

Figure 7. Histogram for block 525_19C.

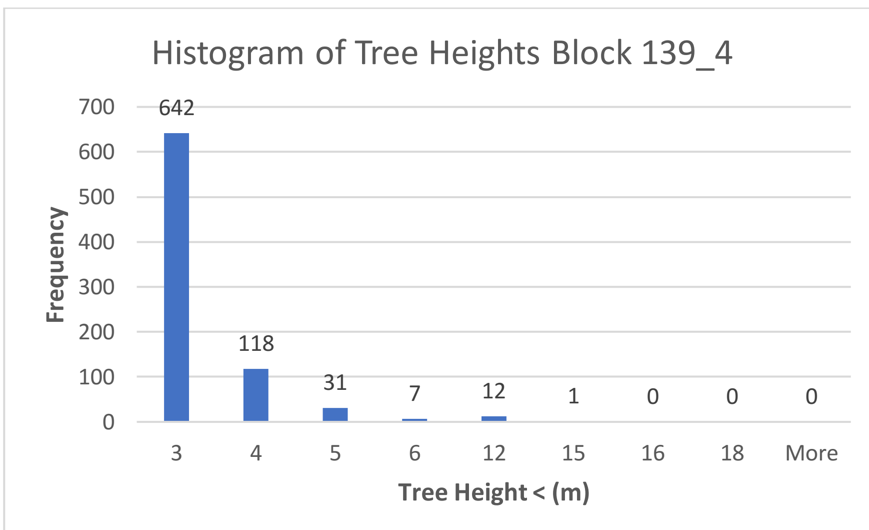

Figure 8. Histogram for block 139_4.

Data from blocks 664_111, 525_19C, and 139_4 is summarized in tables 3,4, and 5, respectively. Cumulative % and proportion represented % were calculated to allow better visualization of heights detected within the analysis.

Table 3. Block 664_111 Tree height Frequency.

Tree Height < (m)	Frequency	Cumulative %	Proportion Represented %
3	273	51.32%	51.32%
4	110	71.99%	20.68%
5	60	83.27%	11.28%
6	49	92.48%	9.21%
12	27	97.56%	5.08%
14	6	98.68%	1.13%
16	4	99.44%	0.75%
18	2	99.81%	0.38%
More	1	100.00%	0.19%

Table 4. Block 525_19C Tree height Frequency.

Tree Height < (m)	Frequency	*Cumulative %*	*Proportion Represented %*
3	9	60.00%	60.00%
4	2	73.33%	13.33%

5	1	80.00%	6.67%
6	2	93.33%	13.33%
12	1	100.00%	6.67%

Table 5. Block 139_4 Tree height Frequency.

Tree Height < (m)	*Frequency*	*Cumulative %*	*Proportion Represented %*
3	642	79.16%	79.16%
4	118	93.71%	14.55%
5	31	97.53%	3.82%
6	7	98.40%	0.86%
12	12	99.88%	1.48%
15	1	100.00%	0.12%

DISCUSSION

The results of this paper have shown that the aerial analysis conducted on a post-burn block utilizing LiDAR derived from a consumer drone deviated from ground plots significantly. Previous studies involving UAV's alongside LiDAR detection algorithms have had great success detecting trees with a detection rate of 98% utilizing similar methods (Wallace et al., 2014). Several factors regarding tree heights, ground characteristics, and site conditions may have contributed to a significant exclusion of ground residuals. Ground plots within the analysis contained a large proportion of trees at heights of less then 2 metres (> 40cm, 50cm ext). The tree detection software was set at a 2 m minimum height; this height was selected as the majority of the previously planted cohort would have met this condition. Lowering the minimum detection height also increased the rate of errors drastically, reducing the outputs descriptive capabilities. A lowered detection height had a large increase in detection errors including downed woody debris, re-vegetation (shrubs and wildflowers), and roadside trenches as sources of error.

Another factor affecting the descriptive capabilities of this analysis includes the detection of stems who have suffered mortality. Several points represented in the data include burnt residuals, and trees that have suffered mortality as apparent of vegetation colour from the orthomosaic imagery. Although these data-points represent a minority their inclusion reduces the descriptive capabilities of the outputs produced. Other factors contributing to detection difficulties include the re-vegetation on blocks such as 525_19C which resulted in imagery that were effectively uniformly green creating difficulties for distinguishing trees visually with the RGB alone. Delays in collecting the post-fire aerial data reduced the utility of differentiating between low height vegetative species. Several species were prominent within the blocks and plots, re-vegetation of fireweed (*Chamerion anugustifolium*) at heights ~ 1m, trembling aspen (Populous tremuloides), and balsam popular (Populous balsamifera) were all common during site re-establishment. This re-vegetation resulted in difficulties differentiating trees from ground cover as the point clouds results included dense foliage in some sections.

Recommendations when utilizing consumer drone LIDAR for forest management

LiDAR point densities can be increased by overlapping flight routes as was apparent during processing in ArcGIS Pro, which could result in increased detection accuracy for many detection algorithms (Wallace et al., 2014). Stand heights and stand uniformity are important factors determining the effectiveness of tree detection. Stands whose canopies are mainly composed of similar heights produce the best results as trees within the understories are often the first to be underrepresented in software analysis (Wallace et al., 2014). The selection of blocks is important for producing a viable post-burn mortality assessment. Blocks should be selected when forest mangers are sure that the average height of previously planted cohorts will be enough to be effectively differentiated from other ground species.

The production of histograms from the detected trees may also be a useful output for various applications. The tree detection software also produced an accurate height assessment of all stems detected within the analysis. Forest managers may use this to effectively estimate the age cohorts detected within the analysis simply by comparing these values to a forest site index.

CONCLUSION

The results of this assessment have shown post-burn tree detection utilizing a consumer drone analysis deviated significantly from randomized ground surveys rejecting our null hypothesis. This analysis has shown that significant deviations were indicated in the final data values but that the analysis has still produced outputs such as the orthmosaics and tree detection points which can be used to produce useful visualizations for forest managers. The outputs produced have been combined within the analysis to produce imagery allowing a better visualization of the spatial extent the burns included. Future research should bear in mind the viability of LiDAR detection when working with tree cohorts close to the minimum viable detection range. Future research may also wish to incorporate a statistical analysis of the tree misattributions due to mortality indicators. Overall the analysis was inconclusive whether tree detection software is a viable option for post-burn assessment although many of the potential difficulties when applying such techniques have been discovered.

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APPENDICES

Survey forms for block 525_19C, 664_111 and 139_4 are included below (figures 9, 10, and 11).

Chetwynd Forest Industries - Walkthrough Survey Form 2023																																	
CP & Block:		**664-111**			**Standard Unit:**				1				**Date of Survey:**					25-09-23				**Surveyor(s):**				Jenny Hammond & Marcus Vander Meulen							
	Preferred Species												**Deciduous Species (acceptable and/or competing)**												**Competing Brush Species**				**Competing Ground Vegetation**				
Plot #	Pli Total	Pli WS	Pli Ave. Height (cm)	Pli WS Height (cm)	Sx Total	Sx WS	Sx Ave. Height (cm)	Sx WS Height (cm)	Bl Total	Bl WS	Bl Ave. Height (cm)	Bl WS Height (cm)	At Total	At WS	At Ave. Height (cm)	At WS Height (cm)	Acb /Act Total	Acb /Act WS	Acb/Act Ave. Height (cm)	Acb/Act WS Height (cm)	Ep Total	Ep WS	Ep Ave. Height (cm)	Ep WS Height (cm)	Willow %	Willow Height	Alder %	Alder Height	Ground Vegetation	% Cover	Ave. Height	**Crown Closure % (all tree species)**	BURN RELATED NOTES
1	14	3	40	40																							5	150	Palmate coltsfoot, grass, fireweed	70	10	3	Partial burn in plot, survival present. Fill plant @ 800sph required.
2	3	1	20	40																									Horsetail, sedge, fireweed	80	5	1	Partial burn in plot, survival present. Fill plant @ 800sph required.
3	52	9	40	40	1		10																						fireweed, creeping snowberry, prickly wildrose, lab tea	50	15	5	Partial burn in plot, survival present. Reforestation efforts not required.
4																	50		15										Fireweed, sedge, palmate coltsfoot, horsetail	20	30	20	100% mortality from the burn, immediate suckering from ABC
5																													Horsetail, sedge, fireweed, dandelion	50	5	0	100% mortality from the burn.
6																											p		Grass, fireweed				Partial burn with patches of conifer survival. None indicated within plot.
7					2	1																							Grass and AT, amount and height not collected.				Complete burn
8	5	2	35	35																									Fireweed and aspen, amount and height not collected				Partial burn
9																																	Complete burn
Comments / Recommendations for the Standard Unit:																																	
Block is a continuous mix of severe and moderate burn. The northermost portion has minimal damage. Block will be classed as a full re-plant, while spacing off acceptable naturals. Assess block in fall 2024 for prescence of cone germinants.																																	

Figure 9. Ground survey form, block 664_111.

Chetwynd Forest Industries - Walkthrough Survey Form 2023																																	
CP & Block:	525	19C			Standard Unit:			1					Date of Survey:				20-09-23					Surveyor(s):			Jenny Hammond & Shaojie Huang								
	Preferred Species												Deciduous Species (acceptable and/or competing)												Competing Brush Species				Competing Ground Vegetation				
Plot #	Pli Total	Pli WS	Pli Ave. Height (cm)	Pli WS Height (cm)	Sx Total	Sx WS	Sx Ave. Height (cm)	Sx WS Height (cm)	Bl Total	Bl WS	Bl Ave. Height (cm)	Bl WS Height (cm)	At Total	At WS	At Ave. Height (cm)	At WS Height (cm)	Acb /Act Total	Acb /Act WS	Acb/Act Ave. Height (cm)	Acb/Act WS Height (cm)	Ep Total	Ep WS	Ep Ave. Height (cm)	Ep WS Height (cm)	Willow %	Willow Height	Alder %	Alder Height	Ground Vegetation	% Cover	Ave. Height	Crown Closure (all tree species)	BURN RELATED COMMENTS
1																													Fireweed, prickly wildrose, palmate coltsfoot, sedge	15	30	0	Severe burn
2													1		80										2%	50			wildrose, palmate coltsfoot, bunchberry, sedge	40	40	0	Severe burn
3													1		25										5%	110			Fireweed, prickly wildrose, palmate coltsfoot, sedge	40	40	0	Severe burn
4																													Fireweed, grass, prickly rose	25	30	0	Severe burn
5																									5	40			Moss, fireweed, grass, prickly rose	10	20	0	Severe burn
6																									3	110			Fireweed, grass, prickly rose	10	30	0	Severe burn
7																																	
8																																	

Comments / Recommendations for the Standard Unit:

There are some cones present. A full replant is required. Assess block in fall 2024 for cone germinants.

Figure 10. Ground survey form, block 525_19C

Chetwynd Forest Industries - Walkthrough Survey Form 2023																																
CP & Block:		**139_4**				**Standard Unit:**			1				**Date of Survey:**			19-09-23					**Surveyor(s):**				Jenny Hammond & Marcus Vander Meulen							
	Preferred Species												**Deciduous Species (acceptable and/or competing)**												**Competing Brush Species**				**Competing Ground Vegetation**			
Plot #	Pli Total	Pli WS	Pli Ave. Height (cm)	Pli WS Height (cm)	Sx Total	Sx WS	Sx Ave. Height (cm)	Sx WS Height (cm)	Bl Total	Bl WS	Bl Ave. Height (cm)	Bl WS Height (cm)	At Total	At WS	At Ave. Height (cm)	At WS Height (cm)	Acb /Act Total	Acb /Act WS	Acb/Act Ave. Height (cm)	Acb/Act WS Height (cm)	Ep Total	Ep WS	Ep Ave. Height (cm)	Ep WS Height (cm)	Willow %	Willow Height	Alder %	Alder Height	Ground Vegetation	% Cover	Ave. Height	**Crown Closure (all tree species)**
1																													Fireweed	10	50	0
2																													Fireweed	5	40	0
3																													Fireweed, aster, raspberries	20	55	0
4													41	8															Fireweed, grass	20	40	5
5	23	4	190	190	14	1	25	110																			5	250	Lab tea, blueberry, moss, huckleberry, grass, fireweed	40	75	25
6																													Fireweed, aster	5	35	0
7	4	3	160	200	4		15						34		50		5		50						2	180			Fireweed, grass	5	60	10
8																																
Comments / Recommendations for the Standard Unit:																																
Some prescence of cones. Majority of block has been burnt with expections of pockets throughout the block. A full replant is required being mindful of the acceptable naturals.																																

Figure 11. Ground survey form, block 139_4.