

extraction of tree crowns and heights using lidar

michael swamer | pj houser | geog 4/593 | fall 2012

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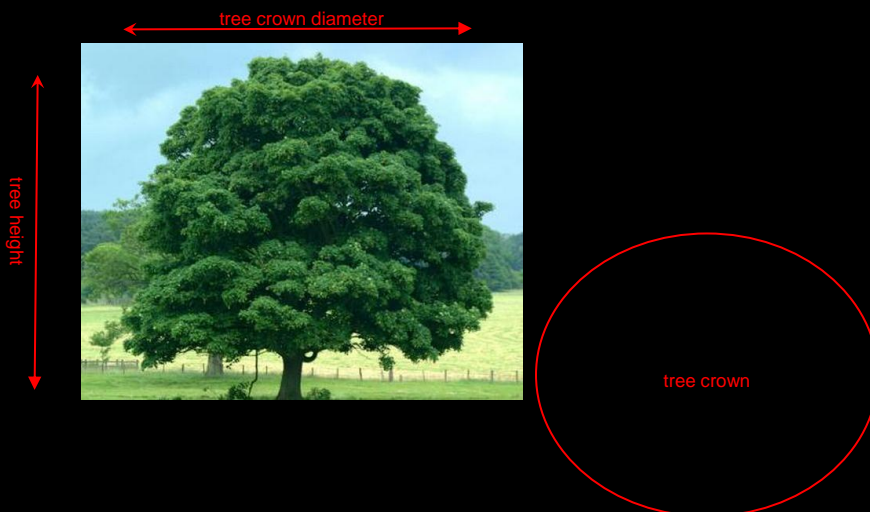
introduction

**objective: extract tree crowns
and heights from LiDAR**

study area: Mt Tabor park

**purpose: tree crowns & heights
can be used to extract
species, estimate forest age**

tree structure



study area - Mt Tabor

reasons:

- ground survey for species
- urban area

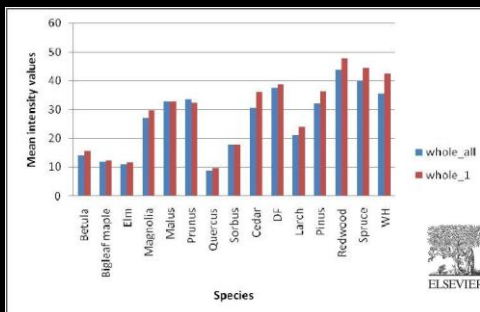
problems:

- buildings
- reservoirs
- low lying vegetation
- roads



background - previous studies

- tree crowns & heights:
 - species determination



Computers & Geosciences 31 (2005) 253–262

COMPUTERS
GEOSCIENCES

www.elsevier.com/locate/cageo

Kim, Sooyoung (2007) Individual tree species identification using LIDAR- derived crown structures and intensity data, *University of Washington*

Use of airborne LiDAR and aerial photography in the estimation of individual tree heights in forestry

Juan C. Suárez^{a,*}, Carlos Ontiveros^a, Steve Smith^b, Stewart Snape^c

^aSilviculture North, Forest Research, Northern Research Station, Roslin, Midlothian EH26 9SY, UK

^bBroadland Surveys, Forest Research, Northern Research Station, Roslin, Midlothian, EH26 9SY, UK

^cOperational Support Unit, Forest Enterprise, 251 Caerislephrie Road, Edinburgh EH12 7AT, UK

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previous work with tree crowns

- other reasons:
 - biomass estimation
 - forest age and health
 - reduce fieldwork for:
 - forest inventory
 - fire damage assessment
 - monitoring forest regeneration

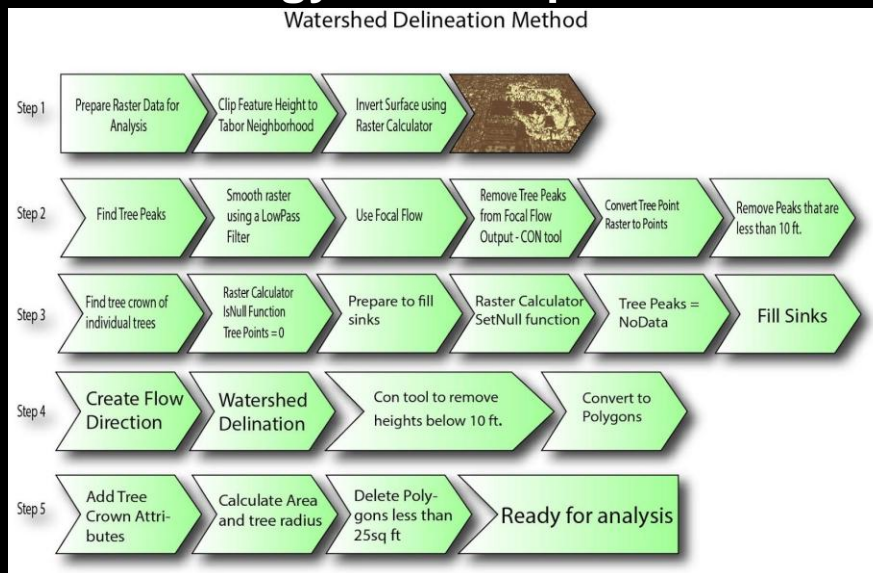
data

- **PSU's geography server**
 - FeatureHeight - raster of Tabor area features
- **Watershed Sciences**
 - points.las - point cloud of Tabor area all returns
 - DEM - bare earth raster based on point cloud
- **RLIS**
 - TaborPark.shp - Mt Tabor outline
 - TaborHood.shp - Tabor neighborhood
- **Parks and Recreation**
 - TaborVeg.shp - areas on Mt Tabor used for vegetation surveys, i.e. areas covered with vegetation

Methods

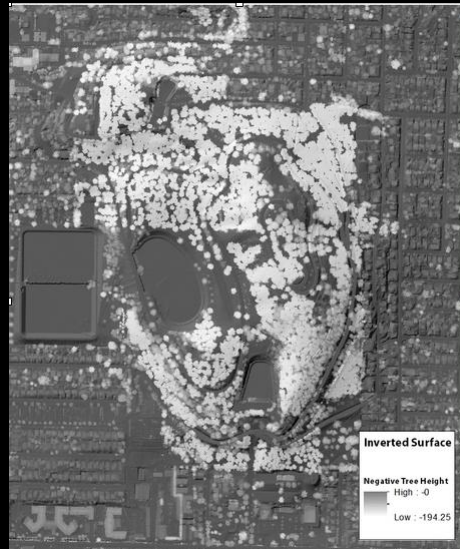
- **ArcMap**
 - treat raster like a watershed
 - focal flow to determine local maxima (tree heights)
 - watershed delineation (tree crowns)
- **FUSION**
 - US Forest Service program to analyze LiDAR data and derive canopy models, tree metrics, and other
 - find canopy maxima of LiDAR point cloud, derive crown sizes and tree heights

methodology in arcmap



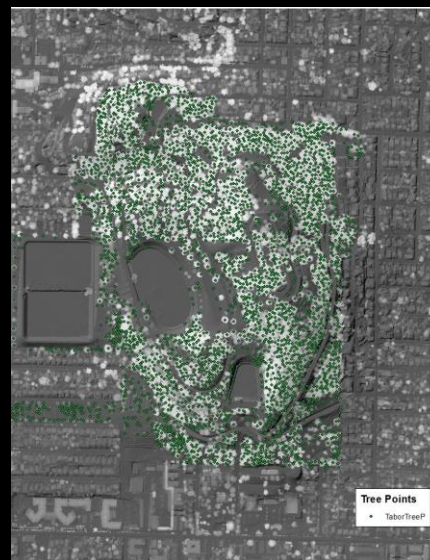
step 1 - prepare feature height raster

- make data size manageable
 - clip to tabor neighborhood
- imitate a watershed
 - invert surface
 - tree peaks become "ponds"
 - tree branches/crowns become watersheds
 - raster calculator:
FeatureHeight * -1



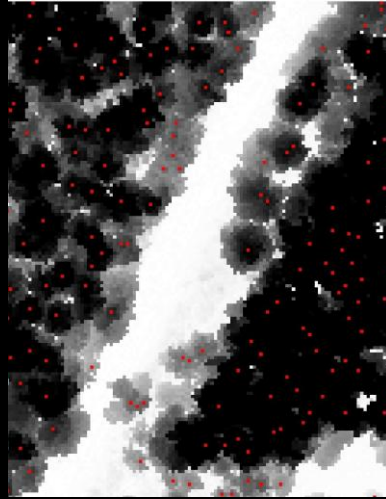
step 2 - find tree peaks

- smooth inverted raster
 - low filter
- determine local minima
 - focal flow
- extract tree peaks
 - con tool
VALUE = "255"
 - if true, return
InvertSurface - negative elevation of the tree peaks
- remove low lying vegetation
 - con tool
VALUE <= -10
- clip to vegetation layer



step 3 - find tree crowns

- create mask to make tree peaks null data
 - tool: RasterCalculator
 - IsNull("ConTree10")
 - 1 means NoData, 0 values are where the tree peaks are
- mask the inverted raster to prepare to fill sinks
 - RasterCalculator
 - SetNull("contreemask"==0, "InvertSurface")
 - inv_null now has noData where there are tree peaks



step 3 - find tree crowns (cont.)

- fill sinks to prepare for watershed delineation
- create flow direction surface
 - Flow Direction
- create watersheds
 - input Flow Direction: NullDirection
 - input pour points: TreeP10



step 3 - find tree crowns (cont.)

- remove low lying watersheds
 - con tool
 - VALUE \geq 10
- convert to polygons
- clip to vegetated area, include trees that overhang roads



step 4 - tree crown attributes

- calculate area
- remove polygons less than 25 sq feet
- calculate radii



tree crowns



Table

TaborTreeCrown25

FID	Shape *	ID	GRIDCODE	Area	Radius	Height
0	Polygon	1931	-107	832.495	16.2827	107
1	Polygon	1931	-35	213.273	8.24144	35
2	Polygon	1938	-118	1152.16	19.1554	118
3	Polygon	1938	-38	201.866	8.01801	38
4	Polygon	1943	-44	506.952	12.7083	44
5	Polygon	1945	-110	1578.59	22.4218	110
6	Polygon	1945	-36	241.779	8.77495	36
7	Polygon	1948	-25	227.928	8.51989	25
8	Polygon	1948	-72	92.4157	5.4251	72
9	Polygon	1948	-84	461.541	12.1238	84
10	Polygon	1952	-138	1933.17	24.8125	138
11	Polygon	1952	-133	3719.26	34.4162	133
12	Polygon	1952	-99	1892.5	24.5501	99
13	Polygon	1952	-121	577.651	13.5634	121
14	Polygon	1955	-131	571.432	13.4902	131
15	Polygon	1960	-18	138.119	6.63227	18
16	Polygon	1962	-123	523.376	12.9105	123
17	Polygon	1963	-131	1359.53	20.808	131
18	Polygon	1964	-119	1260.42	20.0352	119
19	Polygon	1964	-97	1000.26	17.8481	97
20	Polygon	1967	-122	1363.84	20.8409	122
21	Polygon	1968	-98	198	7.94086	98
22	Polygon	1968	-134	893.31	16.8699	134
23	Polygon	1968	-122	745.54	15.4089	122
24	Polygon	1969	-125	478.795	12.3484	125
25	Polygon	1972	-123	1108.14	18.7859	123
26	Polygon	1972	-119	595.209	13.768	119
27	Polygon	1972	-131	1700.75	23.2732	131
28	Polygon	1972	-112	343.049	10.4523	112
29	Polygon	1975	-113	2436.03	27.6533	113
30	Polygon	1975	-129	738.237	15.3332	129
31	Polygon	1975	-123	388.072	11.2594	123
32	Polygon	1977	-151	1168.02	19.2703	151

(0 out of 4343 Selected)

TaborTreeCrown25

FUSION


Untitled - Fusion

File Edit View Tools Help

Image... Raw data... POI... Hotspots... Trees... Bare... Cal... Displa... Use P... Plot m... Sample... Repeat li... Manual... Zoom to... Bright... Cont... Reset... GPS Lin... Coord... X: 6.27 Y: 6.27 Z: 6.27743856... Create hotspot... Center on GPS... Auto-track...

FUSION

Providing fast, efficient, and flexible access to LIDAR, IF3AR and terrain datasets

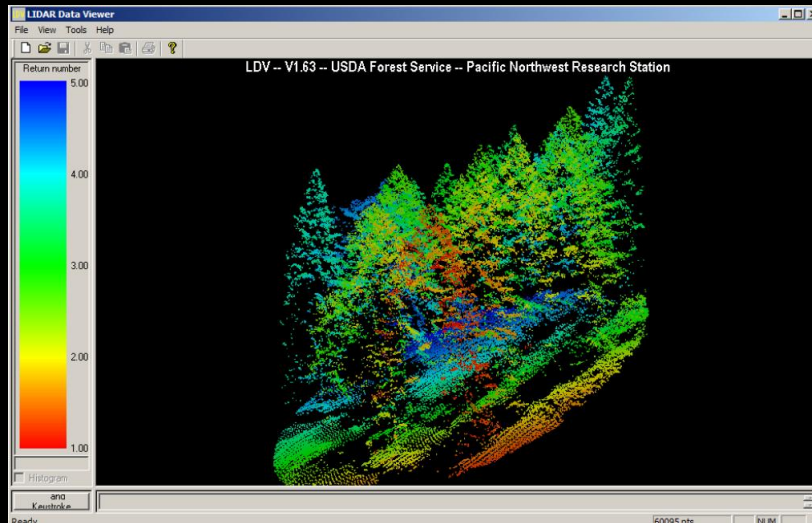


Version 3.21
Build date Oct 15 2012

Robert J. McGaughey
Pacific Northwest Research Station

Ready Rectangle 123456.12 by 123456.12 NUM

viewer



command line for tools

- polyclipdata.exe
- canopymodel.exe
- canopymaxima.exe
- dtm2xyz.exe
- ...

```

Administrator: C:\Windows\system32\cmd.exe
noindex Do not use the data index files to access the data files
index Create FUSION index files for the SampleFile
lda Write sample files using FUSION's LDA format when using LAS input
files. The default behavior of ClipData (after version 2.35) is
to write data in LAS format when the input data are in LAS
format. When using input data in a format other than LAS, sample
files are written in LDA format.
nooffset Removes the offset value in the output LAS file making it
difficult to pinpoint the location of the point cloud. This is
typically used when the location of a sample cannot be known.

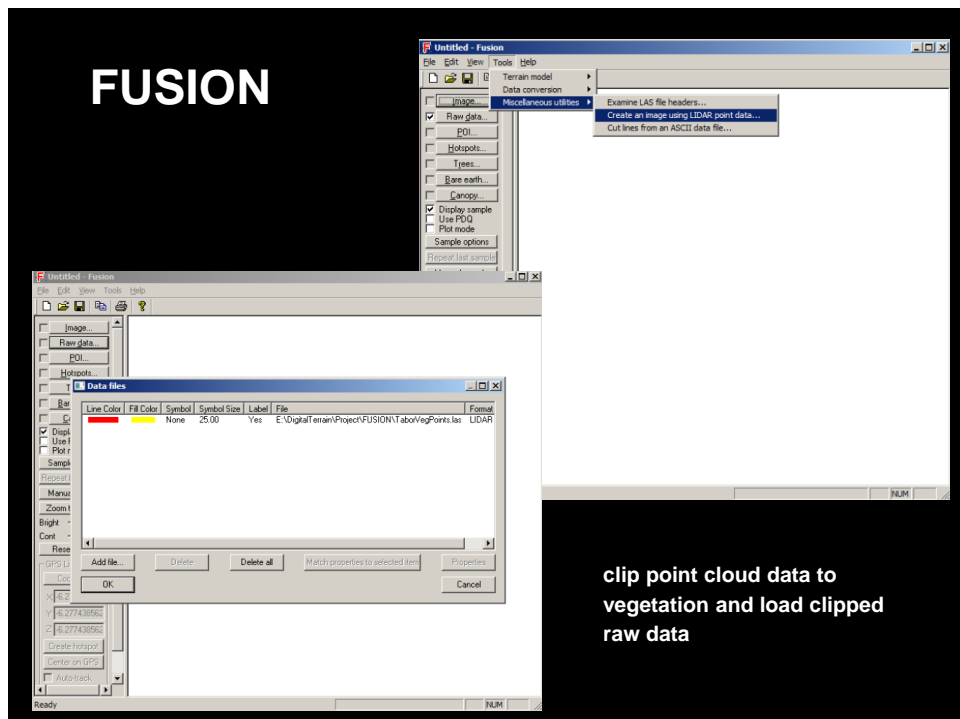
C:\FUSION>PolyClipData.exe
PolyClipData v1.42 (FUSION v3.21) (Built on Oct 15 2012 11:44:05) DEBUG
Clips point data using polygons stored in shapefiles

Syntax: PolyClipData [switches] PolyFile OutputFile DataFile
PolyFile Name of the polygon file used for clipping. Format should be Arc
shapefile.
OutputFile Base name for output data files. Default behavior is to create
one output file for all polygons in PolyFile. See below for use
of /outside, /shape, and /multifile switches to modify this
behavior.
DataFile LIDAR data file template, list of data files, or name of a text
file containing a list of file names (must have .txt extension)

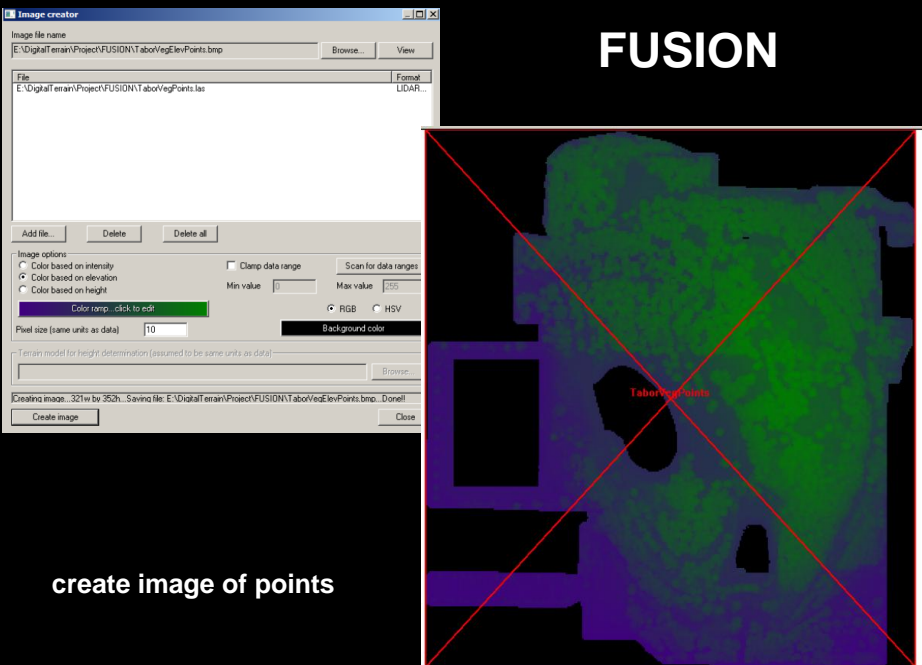
Switches:
Switches are preceded by a "/". If a switch has multiple parameters after
the ":", they should be separated by a single comma with no spaces before
or after the comma.
  
```

FUSION methodology

- load raw point data
- create image from LiDAR
- run canopymodel.exe to derive canopy.dtm
- run canopymaxima.exe to extract tree heights and tree crown diameters
 - output - xy point table
- export to ArcMap
- buffer points with tree crown radius for visual display



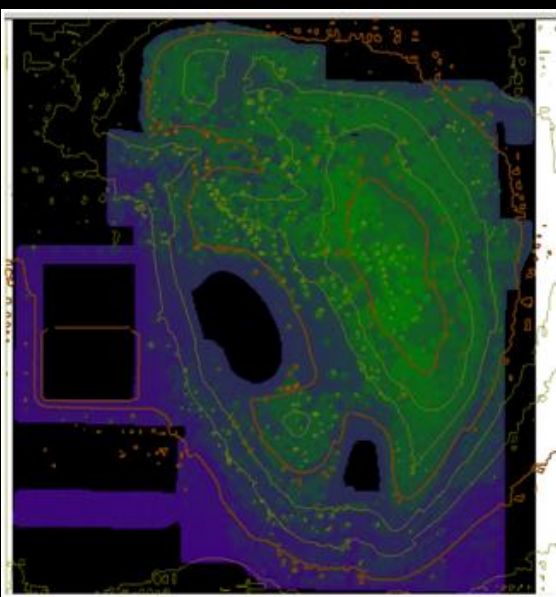
FUSION



create image of points

FUSION

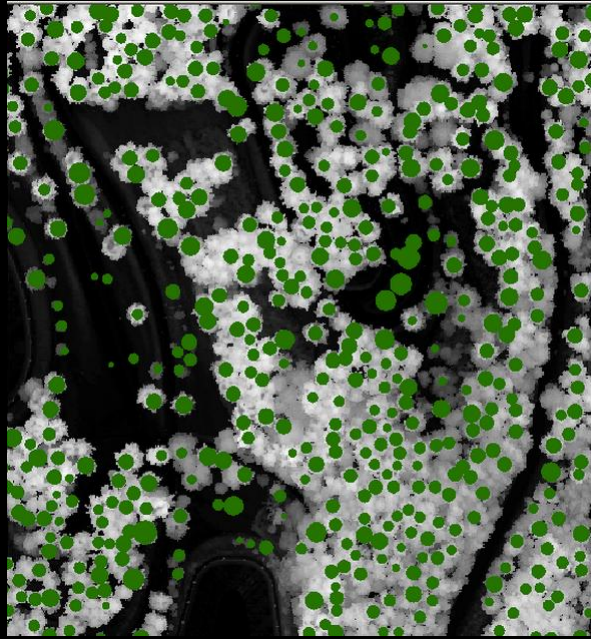
insert bare earth surface (derived from point cloud by Watershed Sciences)



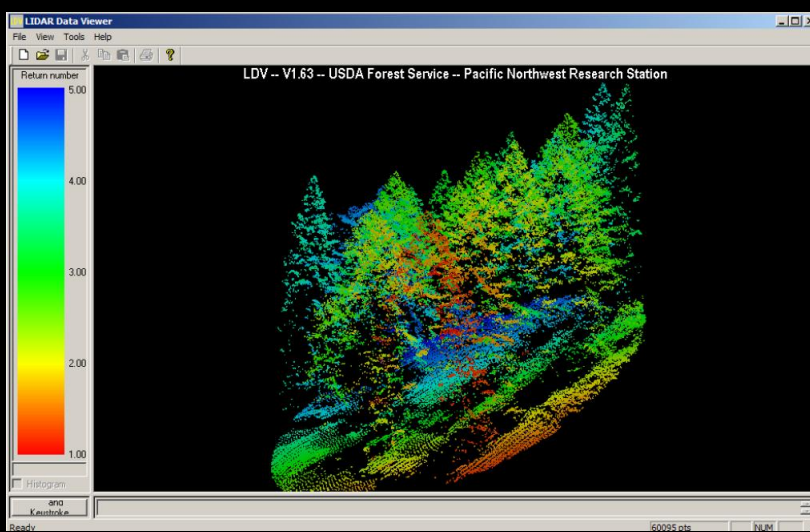
FUSION

load
CanopyMaxima xy
data into ArcMap
and export as
multipoints

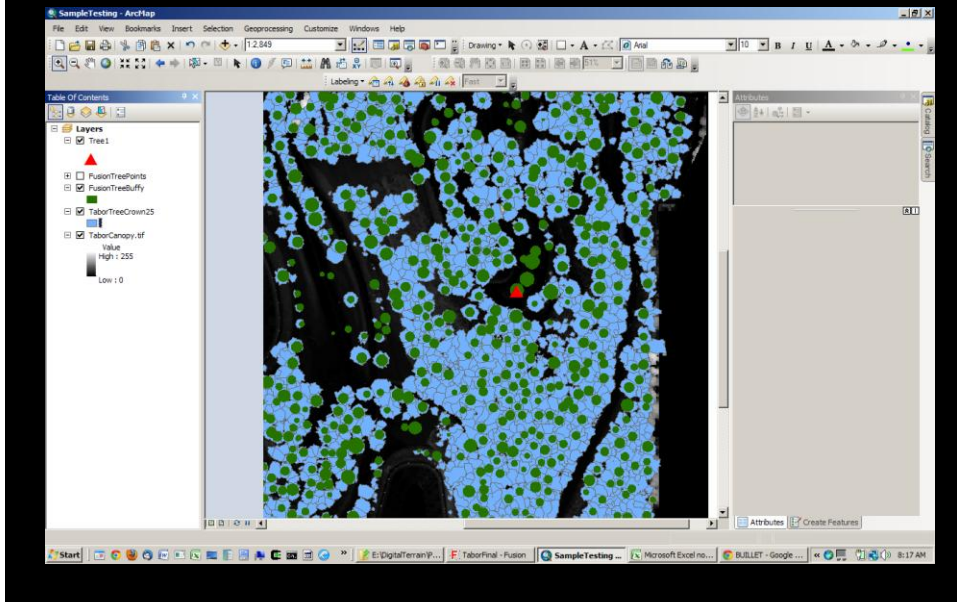
buffer points to
create illusion of
tree crowns



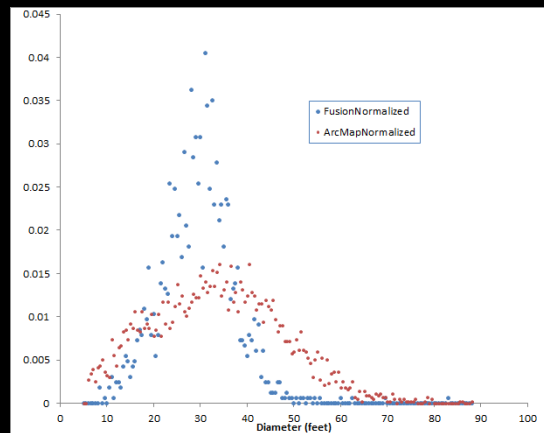
FUSION



visual results FUSION vs ArcMap

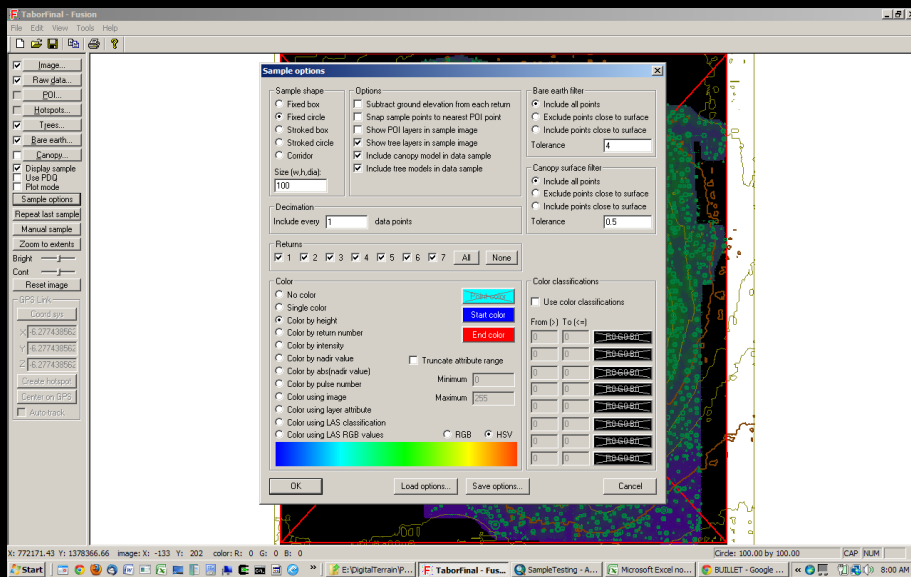


statistical results

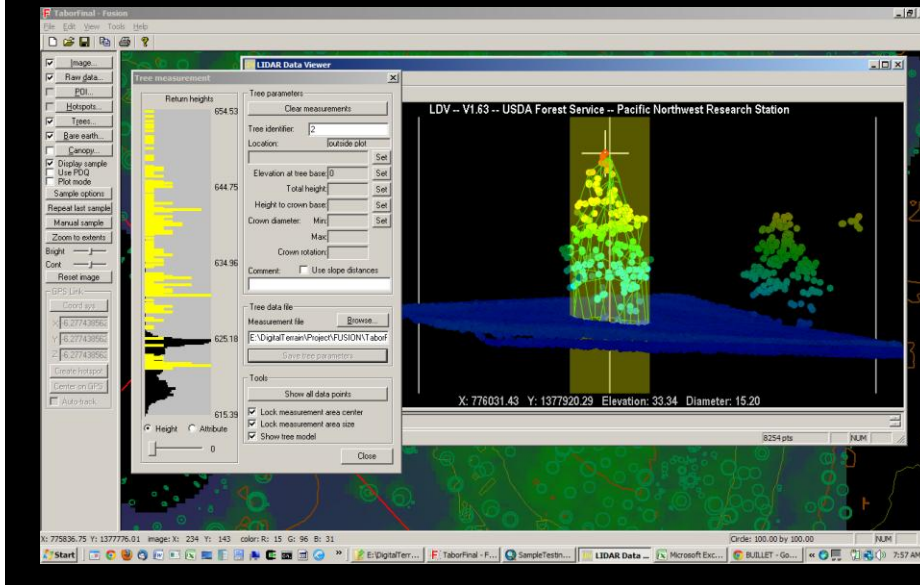


	ArcMap	FUSION
Mean	33.32	29.20
Median	33.08	29.39
Standard Deviation	13.79	7.56
Skewness	0.26	0.34
Minimum	5.72	8.16
Maximum	87.58	82.55

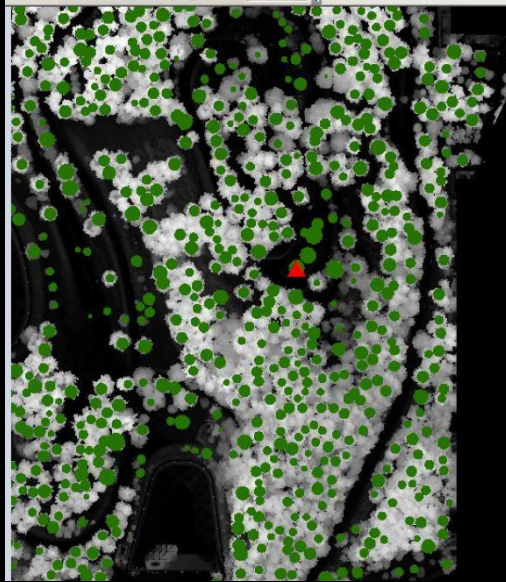
FUSION - individual tree sample



individual tree - manually measure



FUSION results vs sample tree



individual tree vs arcmap vs FUSION

Manual tree measure

X	Y	Elevation	Total height	Ht_to_crown	Crown
776031.43	1377920	621.19	33.34	4.5966	16.72

FUSION results

X	Y	Elevation	Height	Ht_to_crown	Crown
776031	1377924	0	654.53	327.27	47.81

ArcMap results

X	Y	Elevation	Height	Ht_to_crown	Crown
			30	-	17.21486

individual vs. group comparisons

- ideally, this would be done to multiple random trees
- ArcMap results need x and y values appended
- FUSION results need to show feature height instead of just elevation + feature height

conclusions

- methodology:
 - ArcMap - complicated, too many intermediate files
 - FUSION - simple once the interface and command line are understood
- results:
 - similar mean, median, skew, distribution
 - ArcMap
 - too many tree crowns
 - 4 times as many tree crowns
 - FUSION
 - smaller tree crowns
 - possibly too fewer trees
 - tighter distribution
- currently unknown:
 - accuracy of each model

future research

- **compare to manual analysis of sample plots**
 - using point cloud data, randomly assign circular plots
 - manual delineate tree crowns and tree heights
 - within circular plots, compare ArcMap and FUSION tree crowns/heights to manual delineations
- **combine LiDAR intensity or multispectral imagery with tree crown datasets to derive species**