

Multi-Cohort Forest Structure Classifier

a Plug-in Application for
MapWindow GIS

**Multi-Cohort Stand Structural Classification Using
Lidar Workshop**

**Hosted By
Faculty of Forestry, University of Toronto**

March 24, 2010

OCE Project Objective

To explore the utility of LiDAR to re-construct, and possibly improve upon, a ground-based forest stand structural classification that separates relatively uniform even-aged forests from increasingly complex uneven-aged multi-cohort forests

To develop and deliver a software package that automates the multi-cohort forest structure classification process using LiDAR and FRI data and make it available to project partners for integration in a comprehensive forest inventory management system

Multi-Cohort Forest Structure Classifier

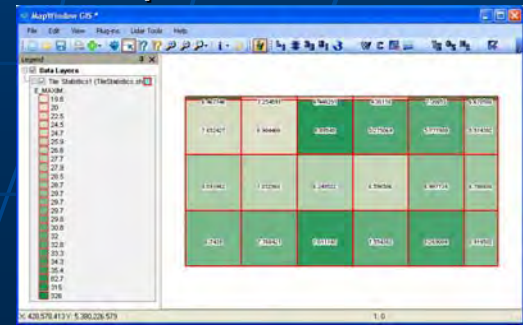
■ What is it?

- A tool to support forest practitioner and researchers in the practice of multi-cohort forest management.
 - **Aids in the managing, viewing and processing of lidar point cloud data,**
 - **Deriving landscape and stand level descriptive statistics from Lidar point cloud data, and**
 - **Performing stand structure classifications**

Development Platform (1 of 2)

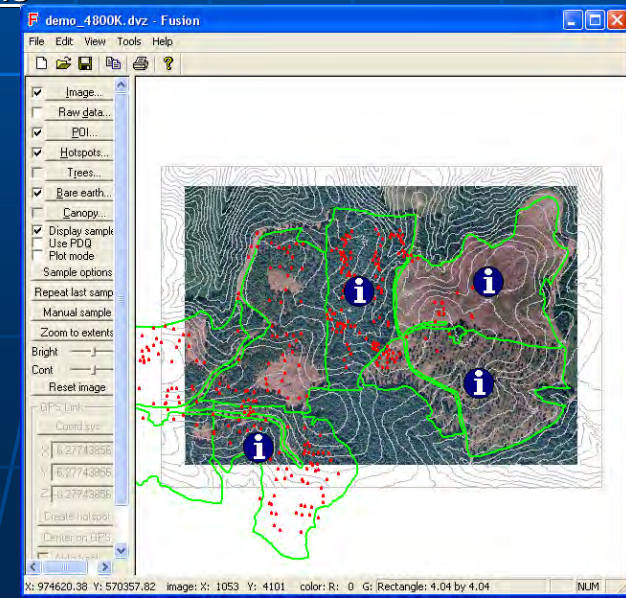
- Developed as a plug-in within MapWindow GIS*
 - A free open source Geographical Information System (GIS)
 - Includes viewing, editing and geospatial analytical tools
 - Provides an easy-to-use interface for use by non-GIS experts
 - Eliminates the need for end users from purchasing a complete GIS system
 - Active user community
 - International users and developers conference
 - Orlando, Florida 31 March - 2 April 2010
 - Plug-ins are fully integrated within MapWindow allowing users access to additional data manipulation and spatial tools.
 - This approach allows for the development of specific tasks related to viewing, processing and analyzing Lidar point cloud data for stand structure classification.

* <http://www.mapwindow.org>



Development Platform (2 of 2)

- Processing and 3D viewing of Lidar Point Cloud data
 - FUSION/LDV package (Version 2.7)
 - Available at no cost from the USDA Forest Service
 - <http://forsys.cfr.washington.edu/fusion/fusionlatest.html>
 - Command line programs from the Fusion Lidar Toolkit (LTK)
 - Importing Las files
 - Tiling
 - Point cloud classification (ground \ non-ground)
 - Generates bare-earth digital elevation models
 - Point cloud summary statistics
 - Version 2.8 was released in March, 2010 and contains many new enhancements including
 - Additional statistics
 - More efficient memory management
 - Better handling of tile edges
 - Lasview
 - A free program for visualizing LAS data.
 - <http://www.cs.unc.edu/~isenburg/lstools>

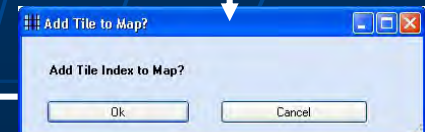
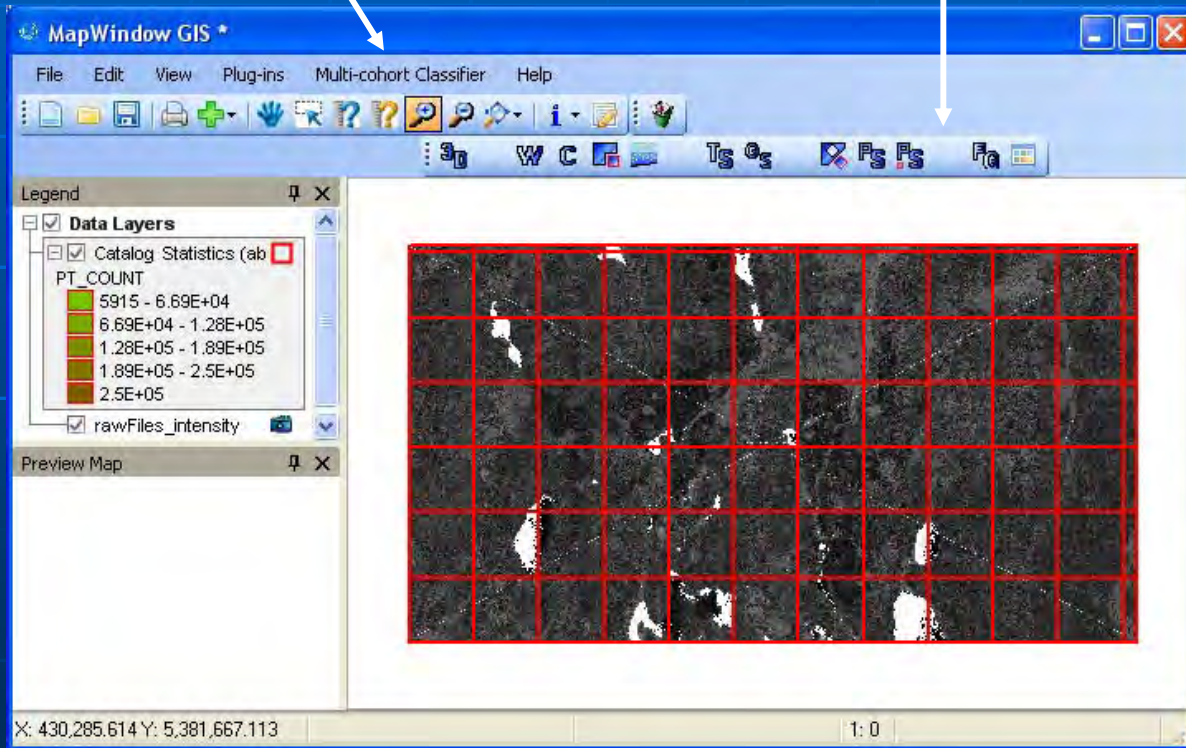
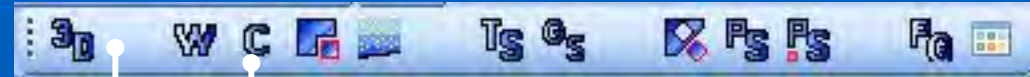
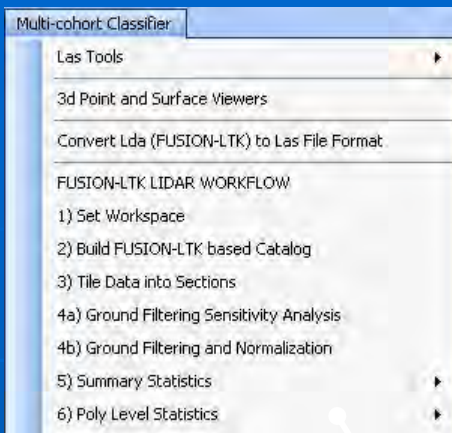


Components

Plug-in Menu

Plug-in Tool Bar

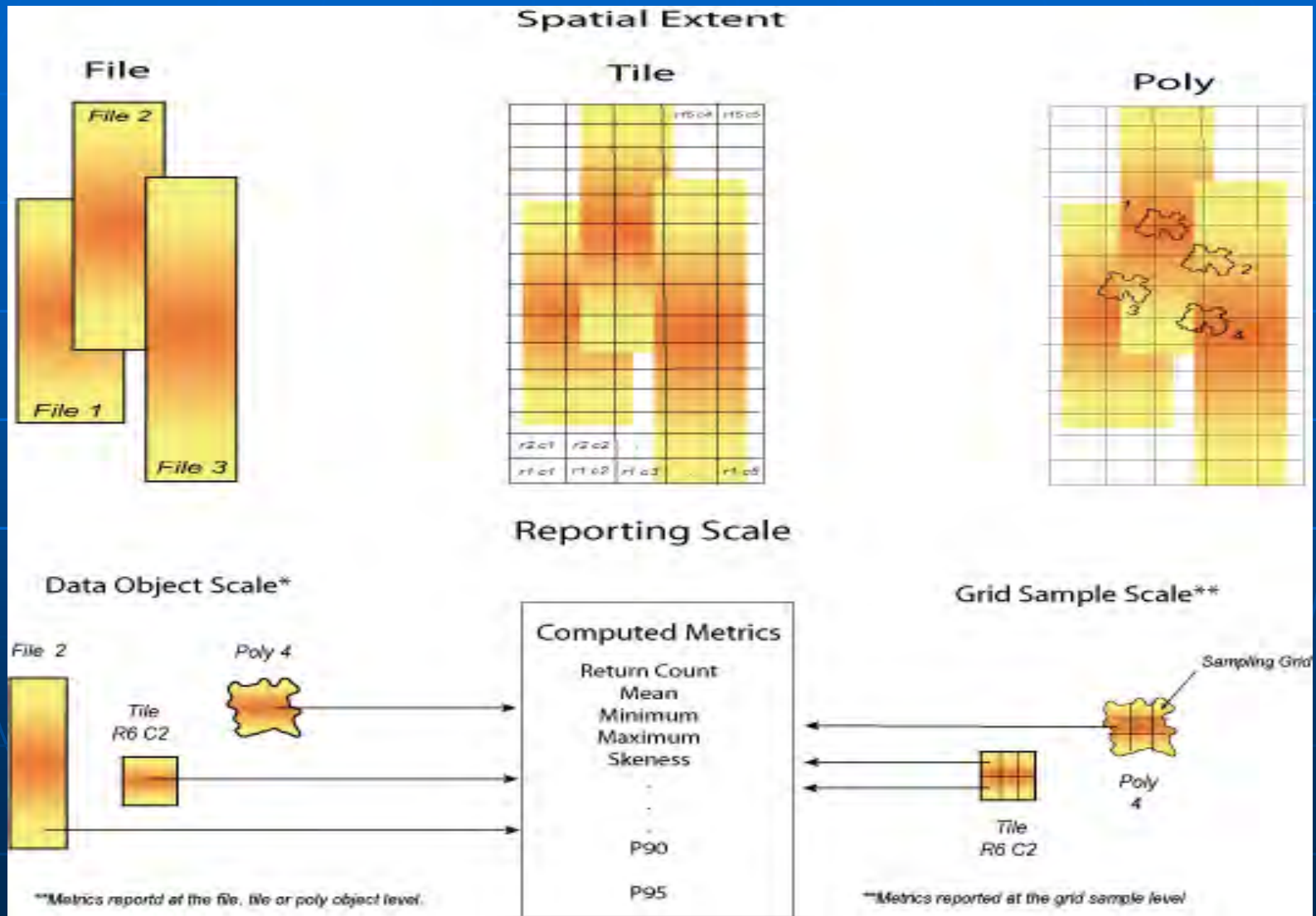
Tool Input Form



MapWindow GIS Application

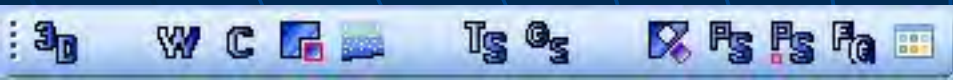
Output Display

Spatial and Reporting Scales



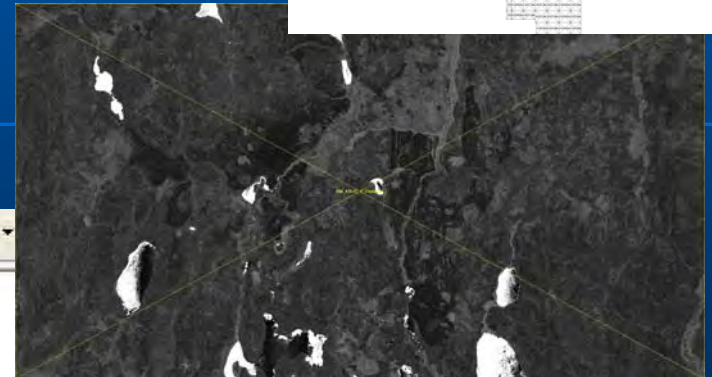
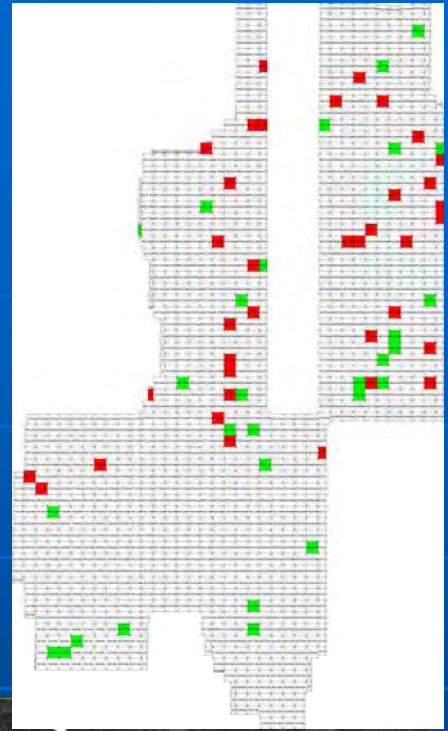
Work Flow

- Process
- Check
- Output\Input



Outputs: Catalog Reports (1 of 2)

Outlier



↑ Intensity Image

← Report

■ *Catalog* produces descriptive reports

- used to evaluate a new acquisition for internal quality, completeness of data coverage and return or pulse density.
- primary output is a web page containing a summary of each file for the entire data set.
- produces images representing the coverage area, pulse and return densities, and intensity values for the entire acquisition.
- images have associated world files

LIDAR Data Coverage Report

LIDAR Data Coverage Report

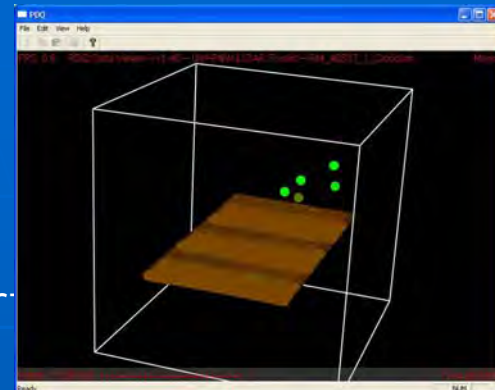
Catalog version 1.80 (FUSION version 2.70) (Built on Mar 3 2009 13:43:07)
Report created on Wed Feb 24 15:57:15 2010
Command line: Catalog Files (x36)
MapWindow/Plugins/mw/LidarTools/Fusion_Lk/Catalog.exe /verbose /drawfiles /semlog /coverage /outlier /intensity /index /log C:\a\FusionTestFolder/mw/Catalog/rawFiles_log.txt
C:\FusionWorkflow\SourceData_North\las\RM_43537_1_Cloud.las

File Summary

Filename	Minimum X	Minimum Y	Minimum Elevation	Maximum X	Maximum Y	Maximum Elevation	Total Returns	Nominal Return Density
C:\FusionWorkflow\SourceData_North\las\RM_43537_1_Cloud.las	429400.00	5374300.00	229.72	440599.99	5380599.99	3121.58	7,291,335	0.25

Outputs: Catalog Reports (2 of 2)

- Plug-in enhancements
 - Creates a spatial index layer from the catalog report
 - Contains catalog report summary statistics
 - Links to source dataset for 3D viewing



MapWindow GIS *

File Edit View Plug-ins Lidar Tools Help

Legend

Data Layers

Catalog Statistics (rawTiles.shp)

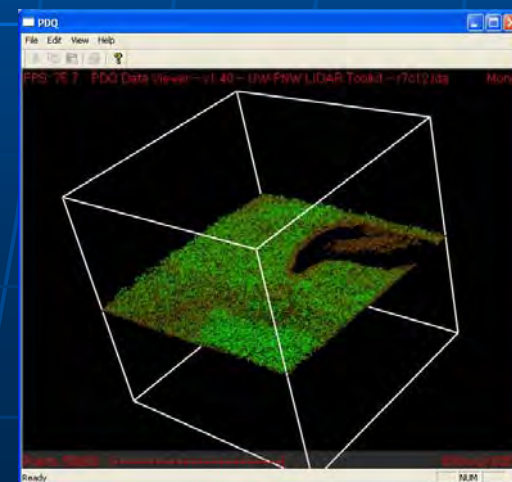
Title Name: r1c1 Density Count: 0.2156	Title Name: r1c2 Density Count: 0.213	Title Name: r1c3 Density Count: 0.2347	Title Name: r1c4 Density Count: 0.2152	Title Name: r1c5 Density Count: 0.2489	Title Name: r1c6 Density Count: 0.2519
Title Name: r2c1 Density Count: 0.2272	Title Name: r2c2 Density Count: 0.242	Title Name: r2c3 Density Count: 0.2506	Title Name: r2c4 Density Count: 0.2295	Title Name: r2c5 Density Count: 0.2436	Title Name: r2c6 Density Count: 0.312
Title Name: r3c1 Density Count: 0.2419	Title Name: r3c2 Density Count: 0.2519	Title Name: r3c3 Density Count: 0.247	Title Name: r3c4 Density Count: 0.2573	Title Name: r3c5 Density Count: 0.2591	Title Name: r3c6 Density Count: 0.3875
Title Name: r4c1 Density Count: 0.214	Title Name: r4c2 Density Count: 0.2357	Title Name: r4c3 Density Count: 0.2282	Title Name: r4c4 Density Count: 0.2223	Title Name: r4c5 Density Count: 0.2564	Title Name: r4c6 Density Count: 0.3861

Preview Map

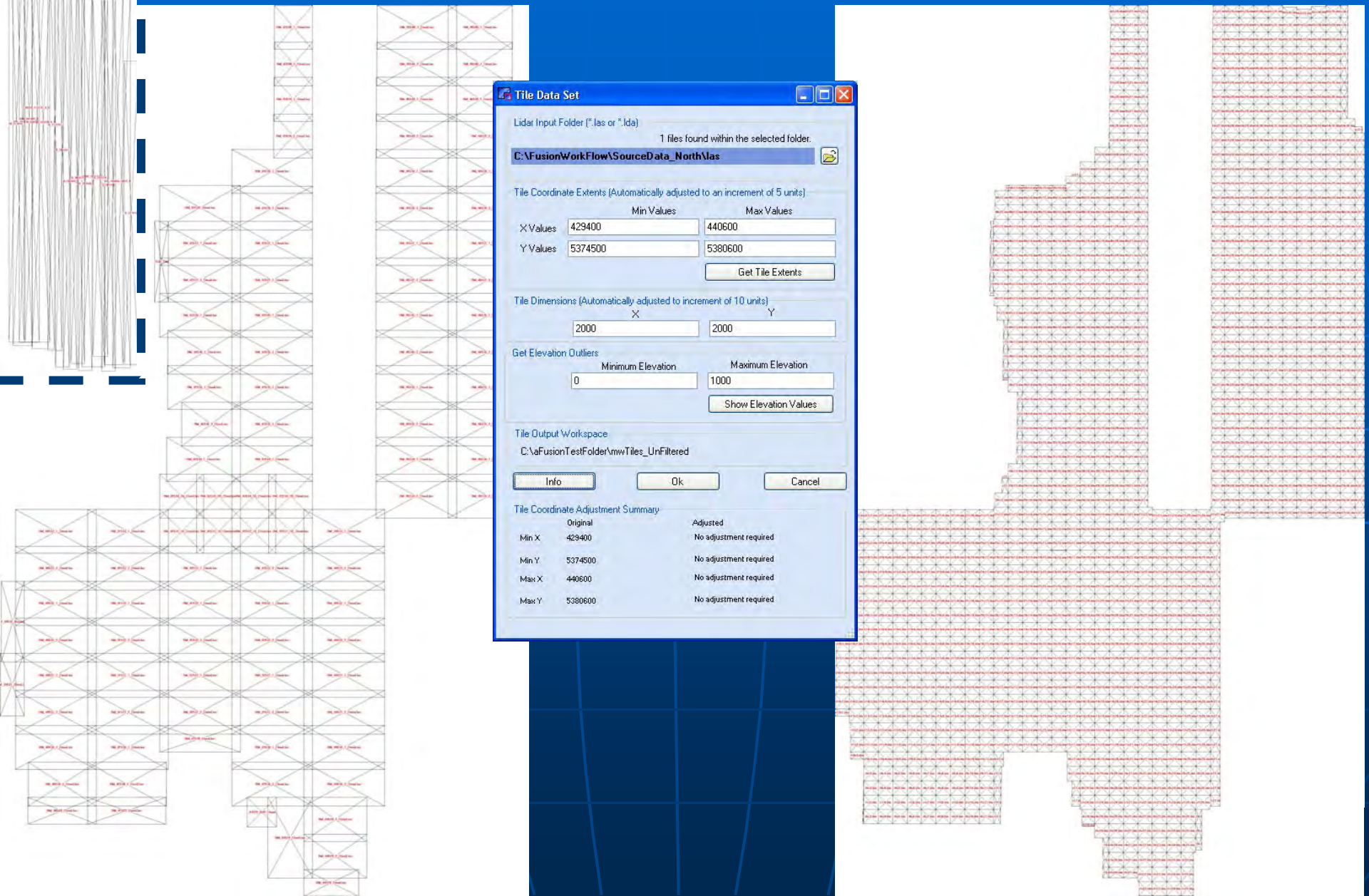
X: 433,838.829 Y: 5,382,702.698 1: 0

Index Map

Point Cloud Viewer



Outputs: Merged and Tiled Datasets



Tile Data Set

Lidar Input Folder (*.las or *.lax)
 1 files found within the selected folder.
C:\FusionWorkflow\SourceData_NorthMas

Tile Coordinate Extents (Automatically adjusted to an increment of 5 units)

	Min Values	Max Values
X Values	429400	440600
Y Values	5374500	5380600

Get Tile Extents

Tile Dimensions (Automatically adjusted to increment of 10 units)

	X	Y
Dimensions	2000	2000

Get Elevation Outliers

	Minimum Elevation	Maximum Elevation
Values	0	1000

Show Elevation Values

Tile Output Workspace
 C:\aFusionTestFolder\mwTiles_UnFiltered

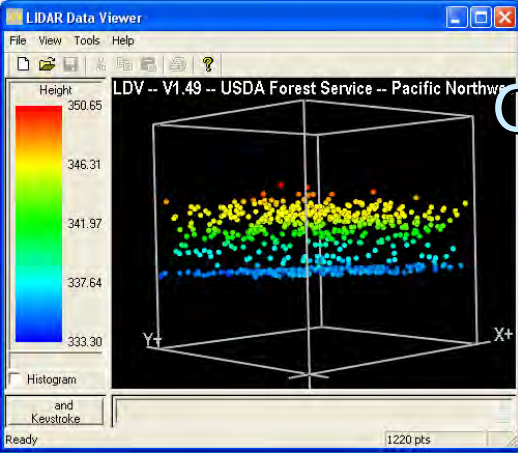
Info Ok Cancel

Tile Coordinate Adjustment Summary

	Original	Adjusted
Min X	429400	No adjustment required
Min Y	5374500	No adjustment required
Max X	440600	No adjustment required
Max Y	5380600	No adjustment required

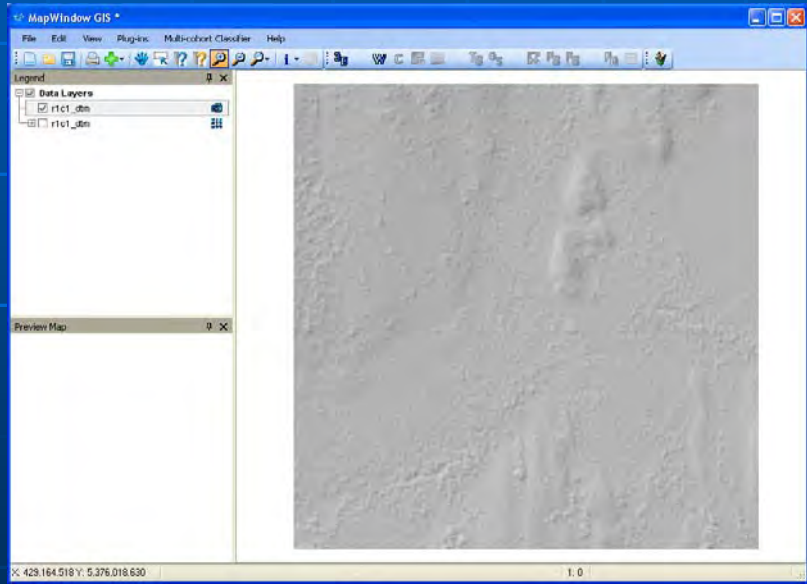
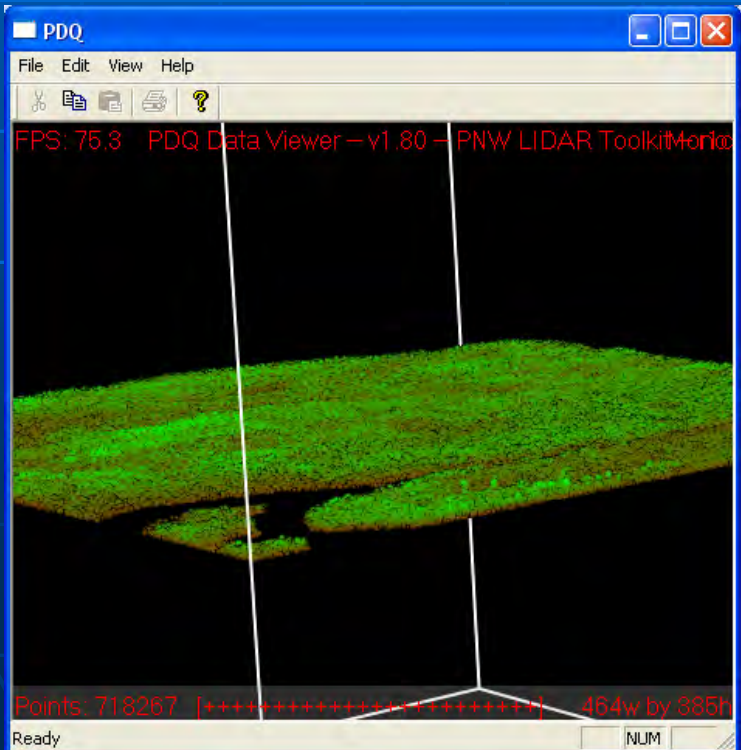
Outputs: DEM and Above Ground Heights

- Bare Earth and Above Ground Point Heights
 - Filters a point cloud to identify bare-earth points
 - Derive above ground heights for non-ground points



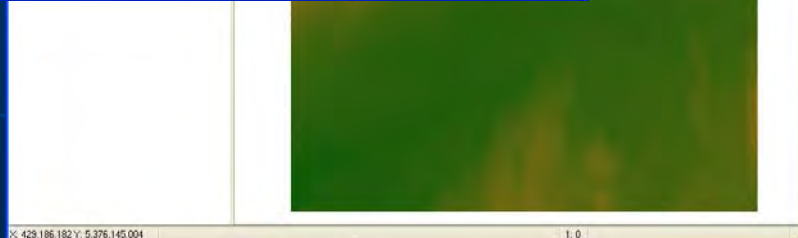
3D Point Cloud Above ground heights

Bare Earth DEM Tile (Elevation)



Color shading

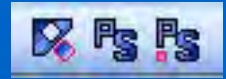
Hillshade



Outputs: Clipped Above Ground Heights

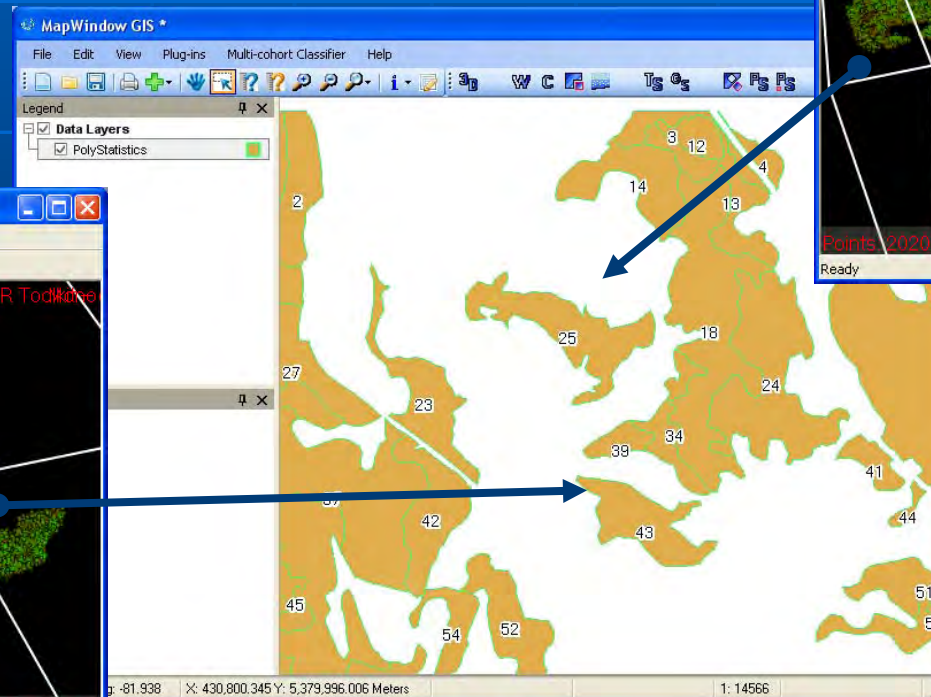
Polygon Clip

Polygon Level Statistics

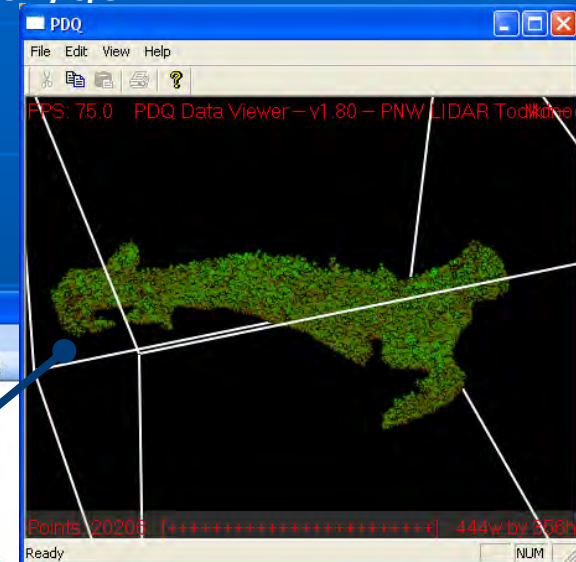
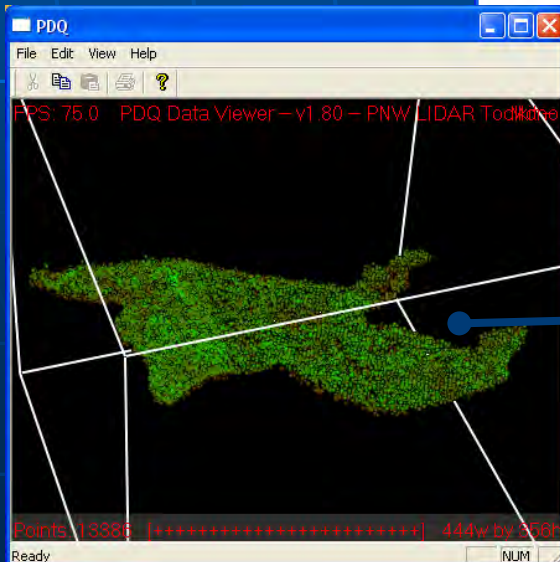


- Clips above ground point data using a polygon shape file
 - creates individual clipped point files for each polygon
 - calculates polygon (stand) level statistics
 - creates a polygon index layer with statistics

Polygon Index layer



Polygon 43



Polygon 25

Stand Structure Classification (1 of 3)

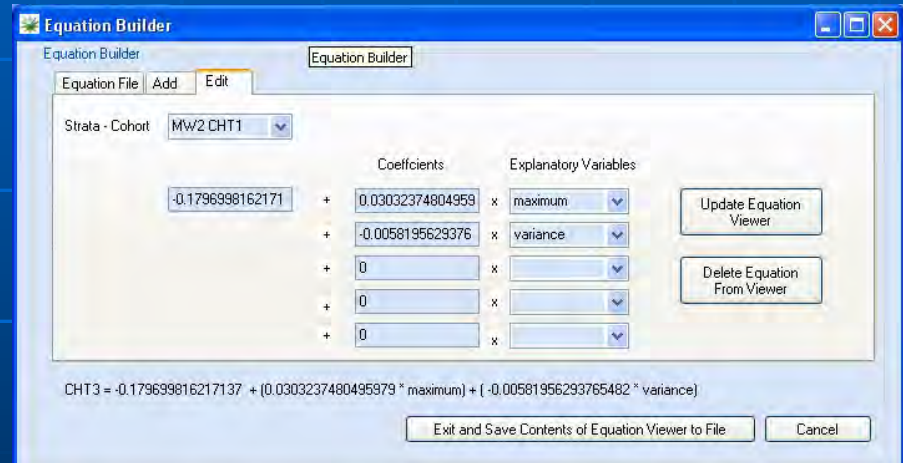
- Clip by Poly Shape
- Join Poly Statistics to Shape File
- Stand Equation Builder
- Stand Structure Classifier

Step 1: Define discriminant classification functions

Sample classification function for a mixed wood cover type (MW2)

$$\begin{aligned} \text{Cohort class 1} &= -0.179699816 + (\text{Max ht} * 0.030323748) + (\text{Ht variance} * -0.005819563) \\ \text{Cohort class 2} &= -0.344478415 + (\text{Max ht} * 0.041700802) + (\text{Ht variance} * -0.007583264) \\ \text{Cohort class 3} &= -0.371830603 + (\text{Max ht} * 0.04293942) + (\text{Ht variance} * -0.007430198) \end{aligned}$$

Equation Builder



CHT3 = -0.179699816217137 + (0.0303237480495979 * maximum) + (-0.00581956293765482 * variance)

Ascii Equation File (csv)

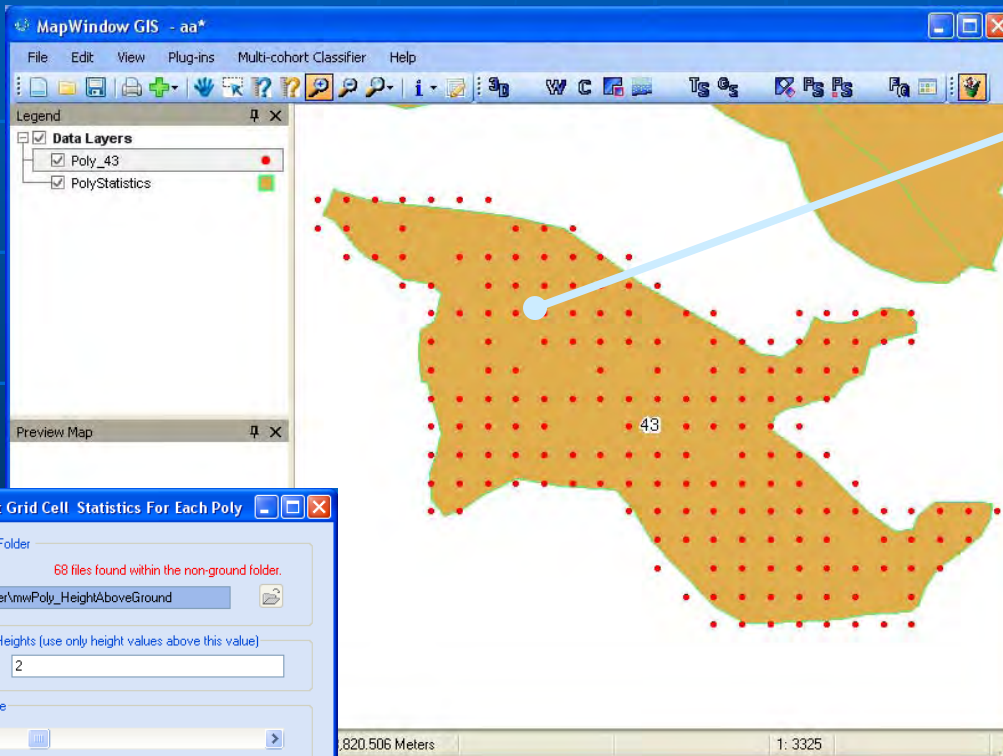
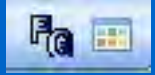


Strata	Cohort	CoEff 0	CoEff 1	Stat1	
MW2	CHT1	-0.17969981621...	0.030323748049...	maximum	+
MW2	CHT2	-0.34447841535...	0.041700802	maximum	+
MW2	CHT3	-0.37183060278...	0.042939420123...	maximum	+
SF1	CHT1	-0.17969981621...	0.030323748049...	maximum	+
SF1	CHT2	-0.34447841535...	0.041700802	maximum	+
SF1	CHT3	-0.37183060278...	0.042939420123...	maximum	+
SB1	CHT1	-0.05287713663...	0.047363796	lq	+
SB1	CHT2	-0.11279597695...	0.069176621	lq	+
SB1	CHT3	-0.26032792244...	0.105092788	lq	+

Stand Structure Classification (2 of 3)

Step 2: Calculate polygon (stand) grid level statistics

- calculates statistics for sample cell (size is user defined)
- creates a point layer with sampling zone statistics



FUSION-LTK Point Grid Cell Statistics For Each Poly

Clipped Non-Ground Folder
68 files found within the non-ground folder.
C:\vaFusionTestFolder\mw\Poly_HeighAboveGround

Filter Above Ground Heights (use only height values above this value)
Minimum Height: 2

Grid cell Sampling Size
20

Grid Cell Statistics Workspace
C:\vaFusionTestFolder\mw\Poly_GridMetrics

Info OK Cancel

Identifier

Shape Index: 26

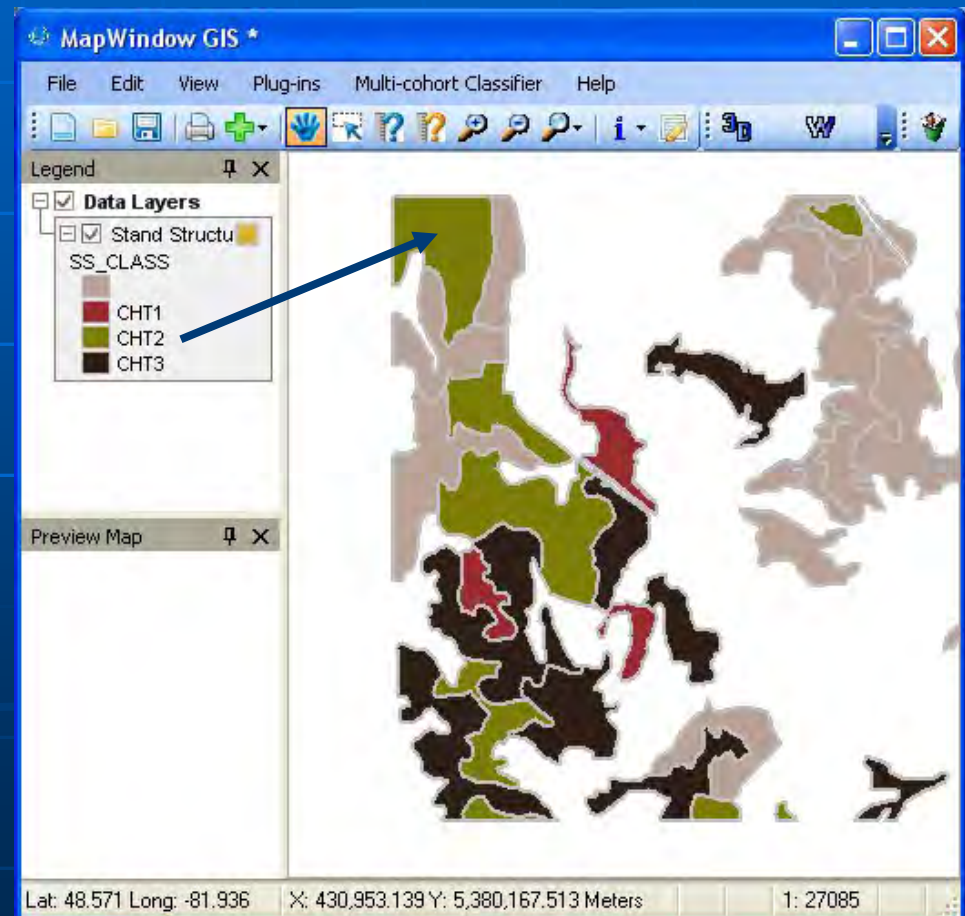
Field Name	Field Value
MWShapelD	26
ROW_COL	12_7
ROW	12
COL	7
PT_COUNT	147
DEN_COUNT	129
MIN	0.7584
MAX	23.602
MEAN	0.2005
MODE	8.3729
STD	5.508
VARIANCE	30.3384
CV	0.5961
SKEWNESS	0.4505
KURTOSIS	2.8417
AAD	4.2936
P05	1.1215
P10	1.4746
P20	3.7228
P25	5.3106
P30	6.6444
P40	7.9789
P50	9.0937
P60	10.1451
P70	11.4084
P75	12.4002
P80	12.9105
P90	16.4851
P95	20.1864
X_COORD	431500
Y_COORD	5378710
lq	7.08960009
P90m10	15.0104999
P95m05	19.0648994
DENSITY	0.8776

Point layer for Polygon 43 with sample zone statistics

Stand Structure Classification (3 of 3)

Step 3: Calculate stand structure class

- Outputs a classified stand structure polygon layer



■ Known issues

- Edge effects with grid metrics (ascii grids)
 - may be resolved in 2.8 with the new buffer switch within the Fusion Gridmetrics program
- Can't create intensity images for large datasets
 - memory issues
- Error trapping issues
- Equation builder needs work

Thank You

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