

Team LumberHack



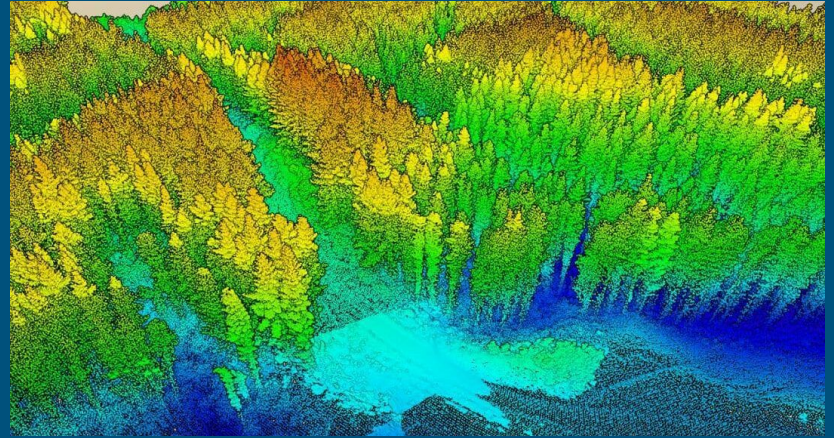
Team: Colin Wood, Jenna Pedro, Thomas Whitney, & Matthew Flanders

Client: Andrew J. Sanchez Meador, Ph.D

Mentor: Melissa D. Rose

Introduction

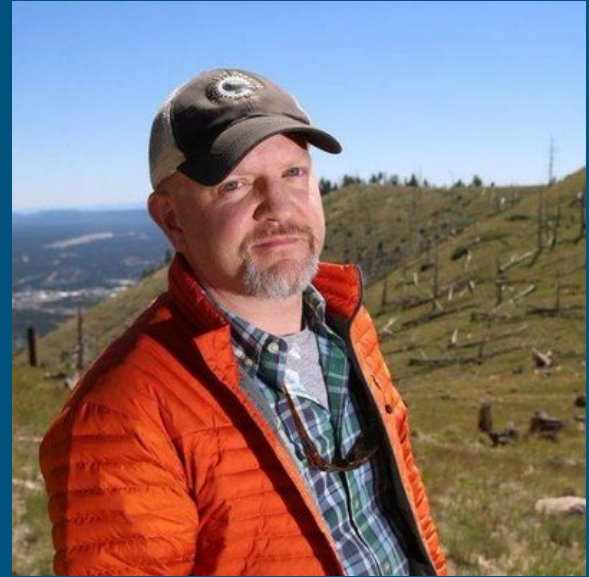
- Climate change
- Forests are denser than ever before
- Large scale restoration projects



Point cloud of a
dense forest

Our Client

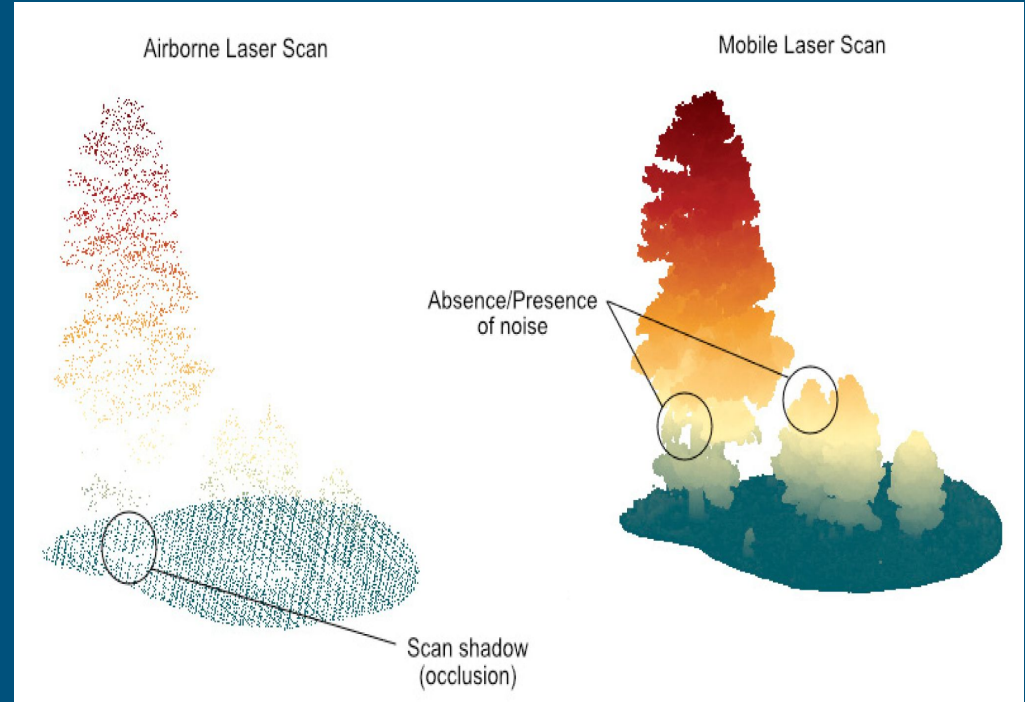
- Forest Ecology Researcher
- What is LiDAR?
 - Light Detection and Ranging
 - Airborne and Mobile
 - Create point clouds for modeling data
- LiDAR assists in restoration efforts



Dr. Andrew J. Sanchez Meador

Problem Statement

- Current tools are not mobile laser scanning (MLS) focused
- Lack of automation / steep learning curve with current software
- Visualizing and generating useful statistics is difficult with current methods

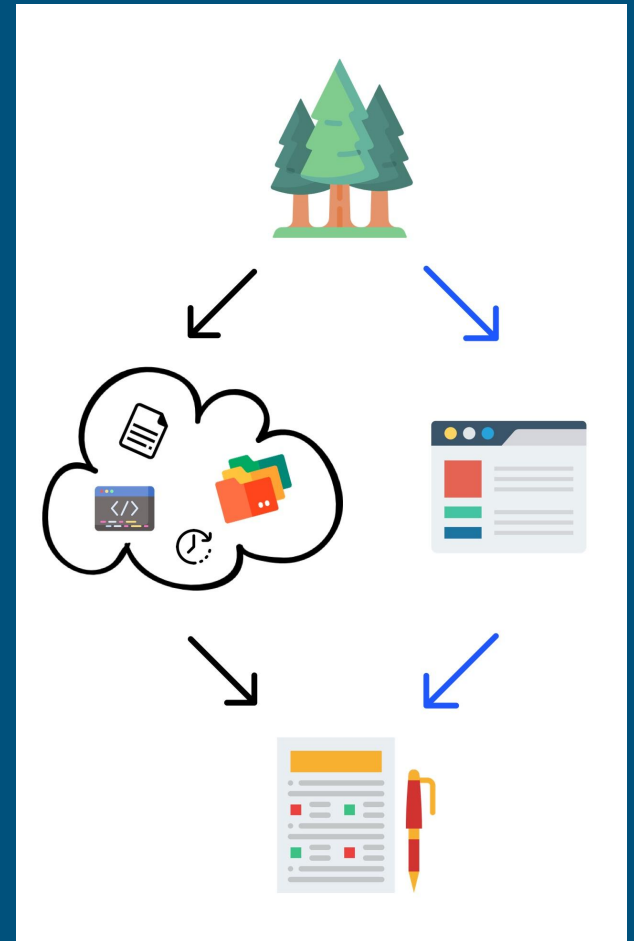


Solution Overview

- Shiny R web app
- Mobile lidar focused
- Performs all major lidar workflow steps in one place



Mobile Lidar Scanner



Solution Overview Cont.

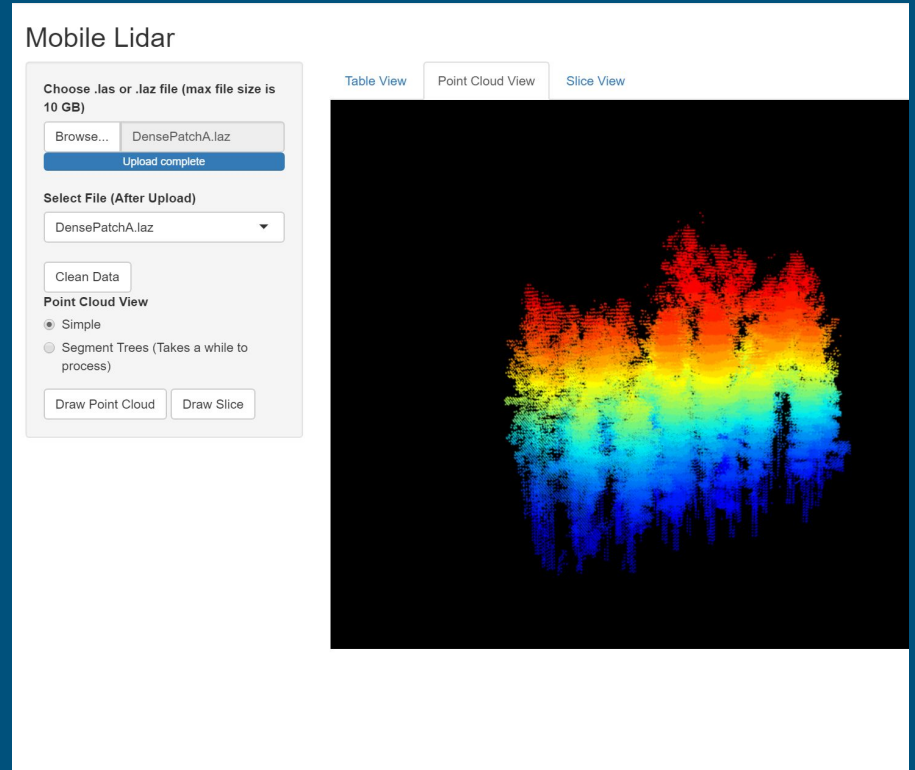
- Data upload and cleaning
- Point cloud visualization
- Backend C++ processing
- Tabular view of tree attributes

tree_id	x_pos	y_pos	radius	lean
1	102.141024	240.474007	10.978300	0.725947896
2	224.412968	322.904605	16.704138	8.191627970
3	11.188016	40.960714	16.417722	5.414638863
4	306.837726	295.461786	9.618238	3.404597676
5	307.961702	313.393133	8.281876	0.942195308
6	208.713118	85.571764	6.726003	6.960635563
7	56.904400	63.982972	18.295235	2.579895211
8	326.348538	258.060020	6.703865	1.557860044
9	305.605233	207.754606	9.778736	8.765013345
10	56.976276	227.372297	5.175110	6.665619377

User Interface Requirements

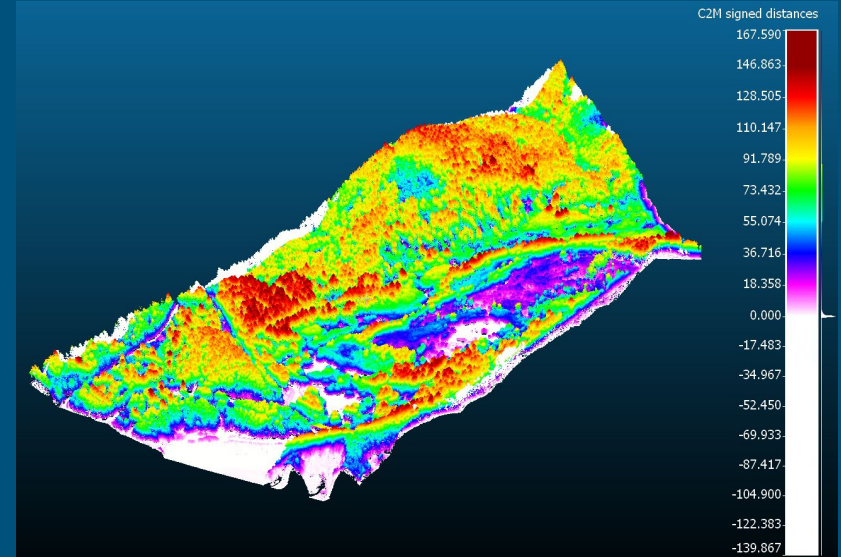
R Shiny

- Easy to use graphical user interface through R shiny
- Reduce technical knowledge required to work with lidar data
- 3d visualizations of point cloud data



Lidar Data Requirements

- Upload one or multiple .laz or .las data files
- Denoise the lidar point cloud
- Normalize the lidar point cloud
- Classify points within the point cloud



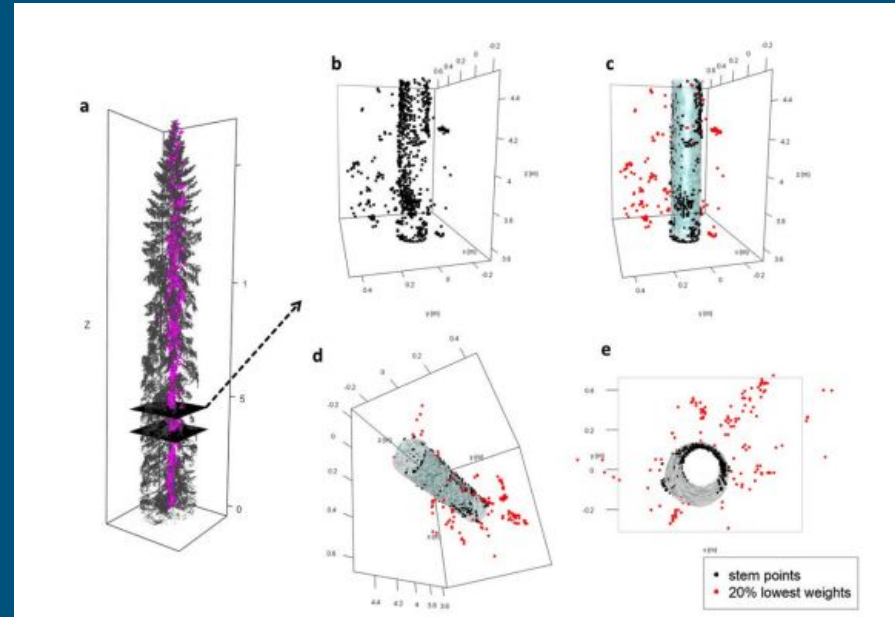
RANSAC Cylinder Fit Requirements

Parameter modification for:

- Number of iterations to preform
- Minimum threshold for a point to be considered an inlier
- Desired inlier percentage

Return:

- Cylinder fit
- Mean squared errors
- Percent of inclusion



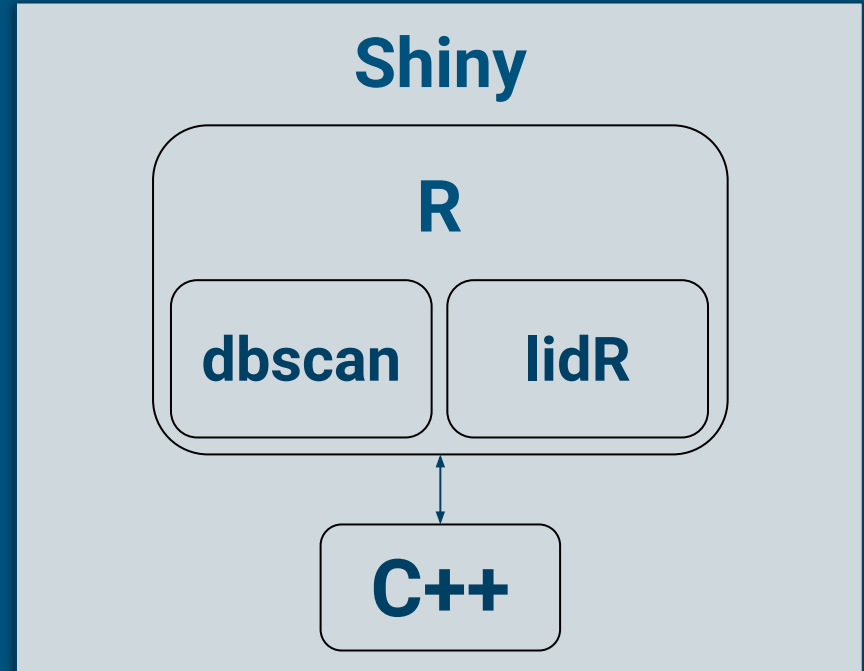
Requirements Overview

- Easy to use GUI
- Load and clean data
- Classify points and segment trees
- RANSAC Cylinder fit at 1.37 m for tree boles
- Display results with error reporting



Architecture and Implementation Overview

- R shiny user interface
- R manages data and supporting packages
- C++ handles fast processing of data



Prototype: Data Upload and Cleaning

Mobile Lidar

Choose .las or .laz file (max file size is 10 GB)

Browse... No file selected

Select File (After Upload)

Clean Data

Point Cloud View

- Simple
- Segment Trees (Takes a while to process)

Draw Point Cloud

Draw Slice

Table View

Point Cloud View

Slice View

Prototype: Plotting Point Cloud

Mobile Lidar

Choose .las or .laz file (max file size is 10 GB)

Browse... DensePatchA.laz

Upload complete

Select File (After Upload)

DensePatchA.laz

Clean Data

Point Cloud View

- Simple
 Segment Trees (Takes a while to process)

Draw Point Cloud

Draw Slice

Table View

Point Cloud View

Slice View

name	size	type	datapath
DensePatchA.laz	11779545		C:\Users\matt\AppData\Local\Temp\RtmpAtoEil\bcaedcc35637c197e678ffeb\0.laz

```
class      : LAS (v1.2 format 2)
memory     : 291.5 Mb
extent     : -10.666, 10.685, -14.9995, 14.9995 (xmin, xmax, ymin, ymax)
coord. ref. : WGS 84 / UTM zone 12N
area       : 536 m2
points     : 3.18 million points
density    : 5940.31 points/m2
density    : 5940.31 pulses/m2
File signature:      LASF
File source ID:      0
Global encoding:
- GPS Time Type: GPS Week Time
- Synthetic Return Numbers: no
- Well Know Text: CRS is GeoTIFF
- Aggregate Model: false
Project ID - GUID:   00000000-0000-0000-0000-000000000000
Version:             1.2
System identifier:
Generating software: rlas R package
File creation d/y:   0/2017
header size:         227
Offset to point data: 297
Num. var. length record: 1
Point data format:   2
Point data record length: 26
Num. of point records: 2184005
```

Prototype Tree Segmentation

Mobile Lidar

Choose .las or .laz file (max file size is 10 GB)

Browse... DensePatchA.laz

Upload complete

Select File (After Upload)

DensePatchA.laz

Clean Data

Point Cloud View

- Simple
- Segment Trees (Takes a while to process)

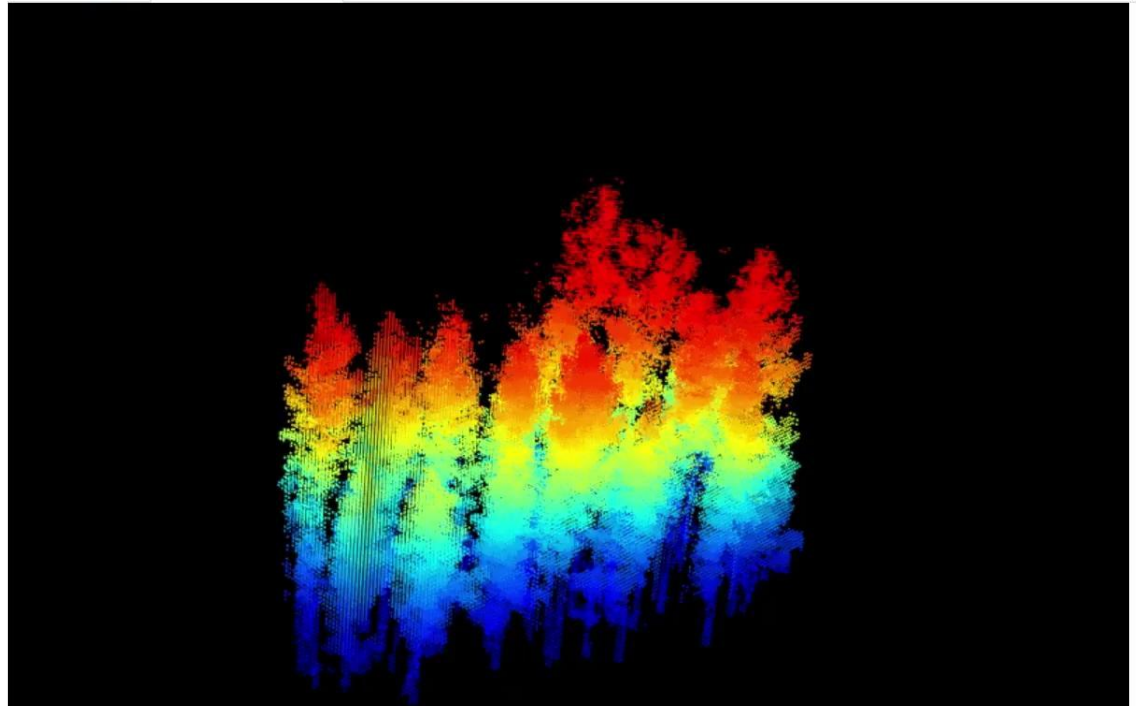
Draw Point Cloud

Draw Slice

Table View

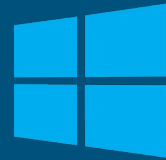
Point Cloud View

Slice View



Challenges and Resolutions

- Windows and Mac compatibility
- R package dependencies
- Point classification



Schedule

NOW

PROJECT TITLE		LumberHack Capstone																																		
TASK TITLE	PCT OF TASK COMPLETE	3/21					3/28					4/4					4/11					4/18					4/25					5/2				
		M	T	W	R	F	M	T	W	R	F	M	T	W	R	F	M	T	W	R	F	M	T	W	R	F	M	T	W	R	F	M	T	W	R	F
Development Tasks	% complete	DR III																																		
Data Upload	100%																																			
Only allow LAS, and LAZ	100%																																			
Data Cleaning and Denoising	100%																																			
Chunk data with C++ for cleaning	100%																																			
Use LidR classify_noise to clean data	100%																																			
Point Classification	100%																																			
classify_ground() from LidR	100%																																			
Individual Tree Segmentation	100%																																			
Use RANSAC for tree boles(1.37m)	100%																																			
Error reporting	100%																																			
Derived Data Products	100%																																			
Diameter	100%																																			
Center Point	100%																																			
Data Summaries/Visualization	100%																																			
Tabular Summaries	100%																																			
2D/3D	100%																																			
Refinement and bug testing	90%																																			

UNIT TESTING PLAN

6 modules



FILE UPLOADING

- 1) .las or.laz file types
- 2) Total size of file doesn't exceed 10GB

DATA CLEANING

- 1) File cleaned
- 2) User receives message pop up

DATA PLOTTING

- 1) Ground classified
- 2) Height normalized
- 3) Noise classified
- 4) Points filtered
- 5) Point cloud plotted

DRAW SLICE OF TREE

- 1) Plot of slice will be created when button is pressed

CIRCLE SHAPE FITTING

- 1) CSV file gets returned correctly with best overall count and circle fit(x,y,r)

DATA SUMMARY TABLE

- 1) Info about individual trees can be displayed in a 2D table

Usability Testing Plan

- Observe end users from Forestry department with the user interface
 - Group 1 - First impressions of app
 - Group 2 - Improved first impressions of app
- Users fill out a questionnaire at end of testing session
 - Rate their experience on a scale of 1 to 10
 - Open-ended questions about each task i.e. what they liked/disliked, what they would like changed, etc.



LumberHack Usability Test Questionnaire

In this section, we will ask users about their experience on each task with the team's user interface.

1. Overall look of the application:

- a. Please rate on a scale of 1 to 10 how well you like the design of the application.
- b. What would you change about the design?

2. Launch the application:

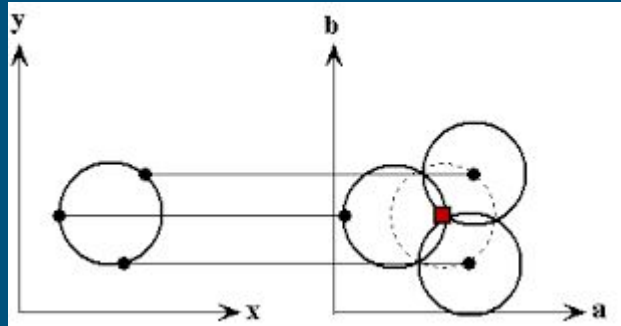
- a. Please rate your experience on a scale of 1 to 10 when launching the application.
- b. What would you change?

3. Load a lidar file:

- a. Please rate your experience on a scale of 1 to 10 when loading a lidar file.
- b. What would you change?

Future Work

- Visualization of the point clouds at the two points in time
- Vignettes explain the functionality of the package and the Shiny app
- Package uploaded and passing all CRAN checks so it can be an official “CRAN” package



Conclusion

Our project aims to:

- Streamline data collection
- Enable non-technical ecologists an easy way to extract information
- Provide ecologists with more time to evaluate and plan forest treatment

Based on successful development of this prototype, our client is very excited about our fully developed Shiny app for forestry researchers and ecosystem health.