UBC 2017 Stadium Neighborhood Tree Inventory Project

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SEEDS Sustainability Program

UBC sustainability

Presentation Content

1. Project introduction
2. Project procedures
3. Field results
4. Lidar accuracy analysis
5. Summary

Project Background

- **SEEDS, CCP, UBC Faculty of Forestry and IRSS**
- Campus wide inventory in **1998**
- **11,000 on-campus trees** were surveyed
- Need for creating an updated campus tree inventory as part of a larger **urban forest campus management plan**
- **2017 Stadium neighborhood tree inventory as pilot project**

SEEDS Sustainability Program

campus + community planning

forestry university of british columbia

Integrated Remote Sensing Studio

Why create an tree inventory?

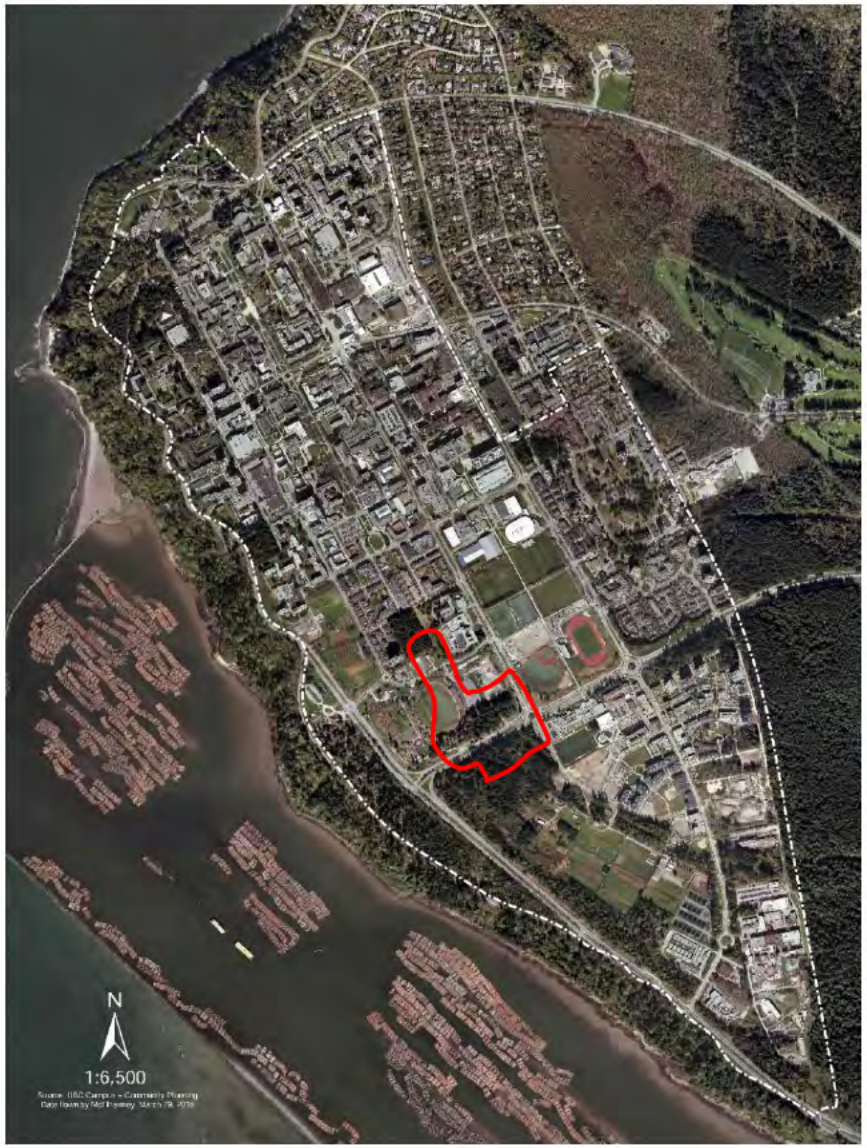
- A foundational part of effective urban forest management
- Assess ecosystem services including:
  - Carbon sequestration and storage
  - Pest and disease control
  - Wildlife management in urban environment
- Provide data for tree management
- Aid in future neighborhood planning

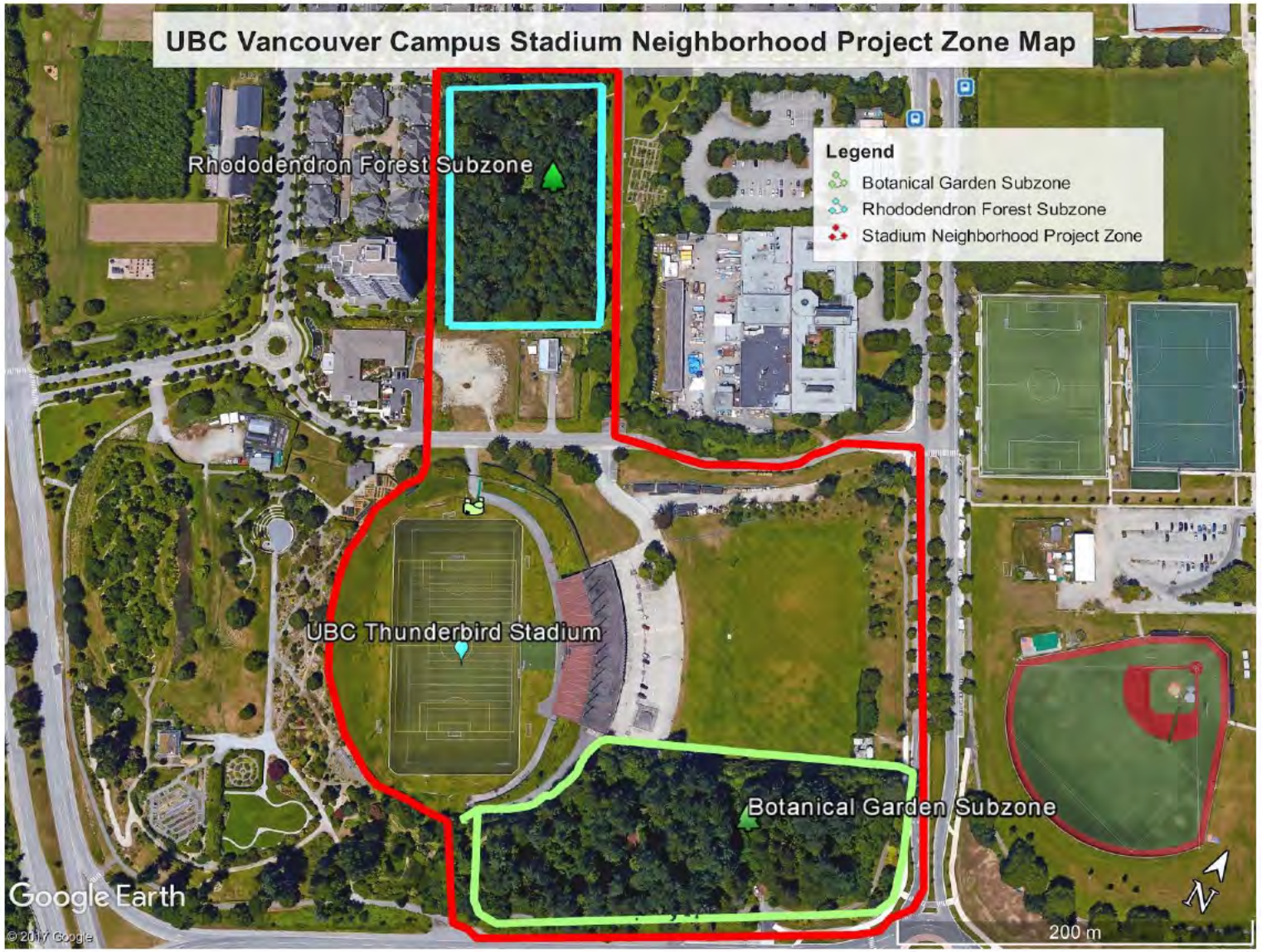
Stadium Neighborhood Tree Inventory Objectives

1. Create a **tree inventory** of Stadium Neighborhood

2. Develop **a protocol** for the creation of a tree inventory for the entire UBC Vancouver campus

Project Zone

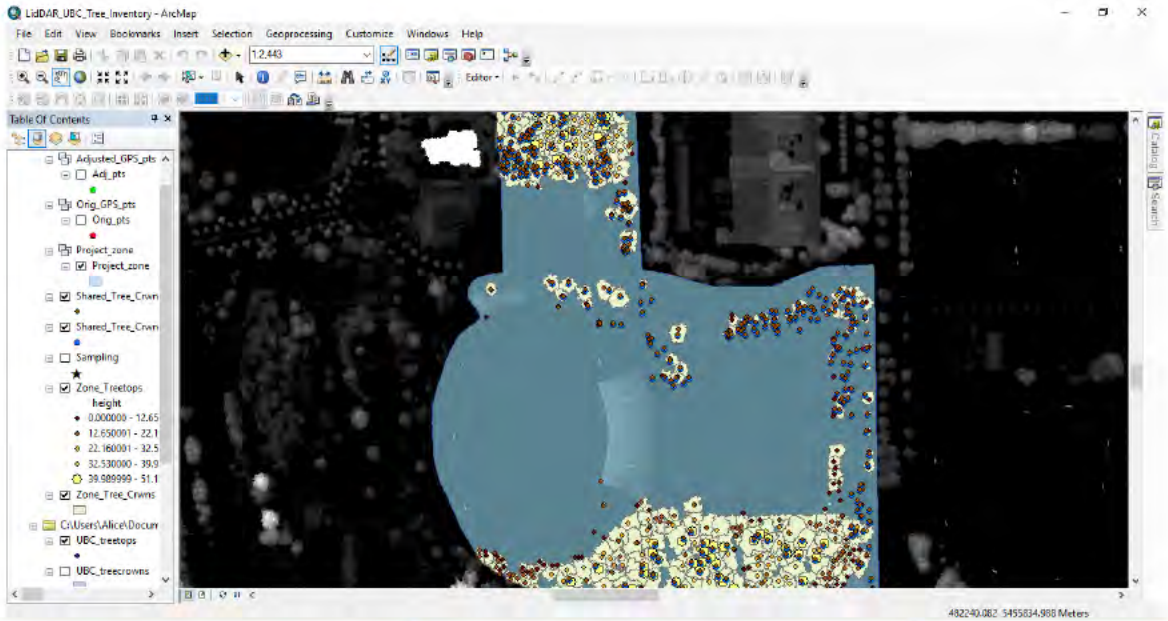


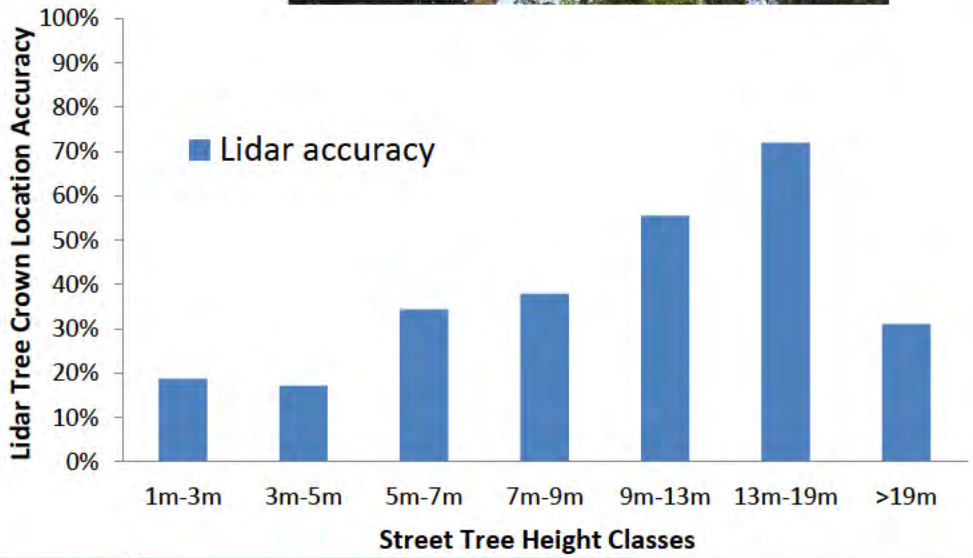


Procedures

Project Procedures

1. Collect field data
2. Analyze the lidar accuracy
3. Produce a handbook to guide future campus tree inventory



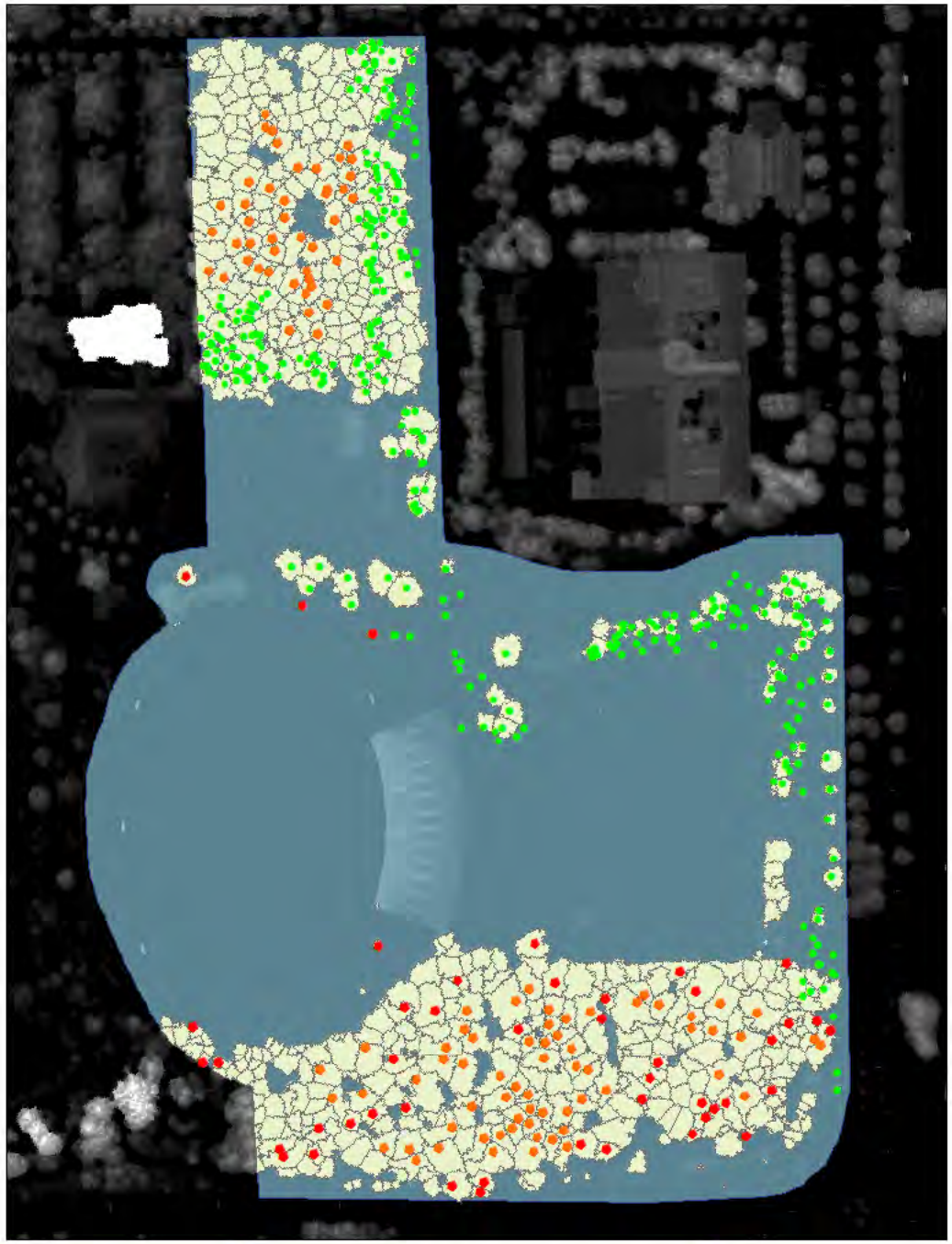


1. Field Data Collection

Conduct **census of all trees** on streets and in portion of Rhododendron Wood subzone

Measure **tall trees** as identified by lidar in the Rhododendron and Botanical Garden subzones

Conduct **stratified random sampling** at the Botanical Garden subzone



Field Data Attributes

- Species Identification
- Mortality Status
- Ground Cover
- Diameter at Breast Height (DBH)
- Height of Tree
- Crown Width
- Tree Health and Risk Assessment

Health and Risk Visual Assessment

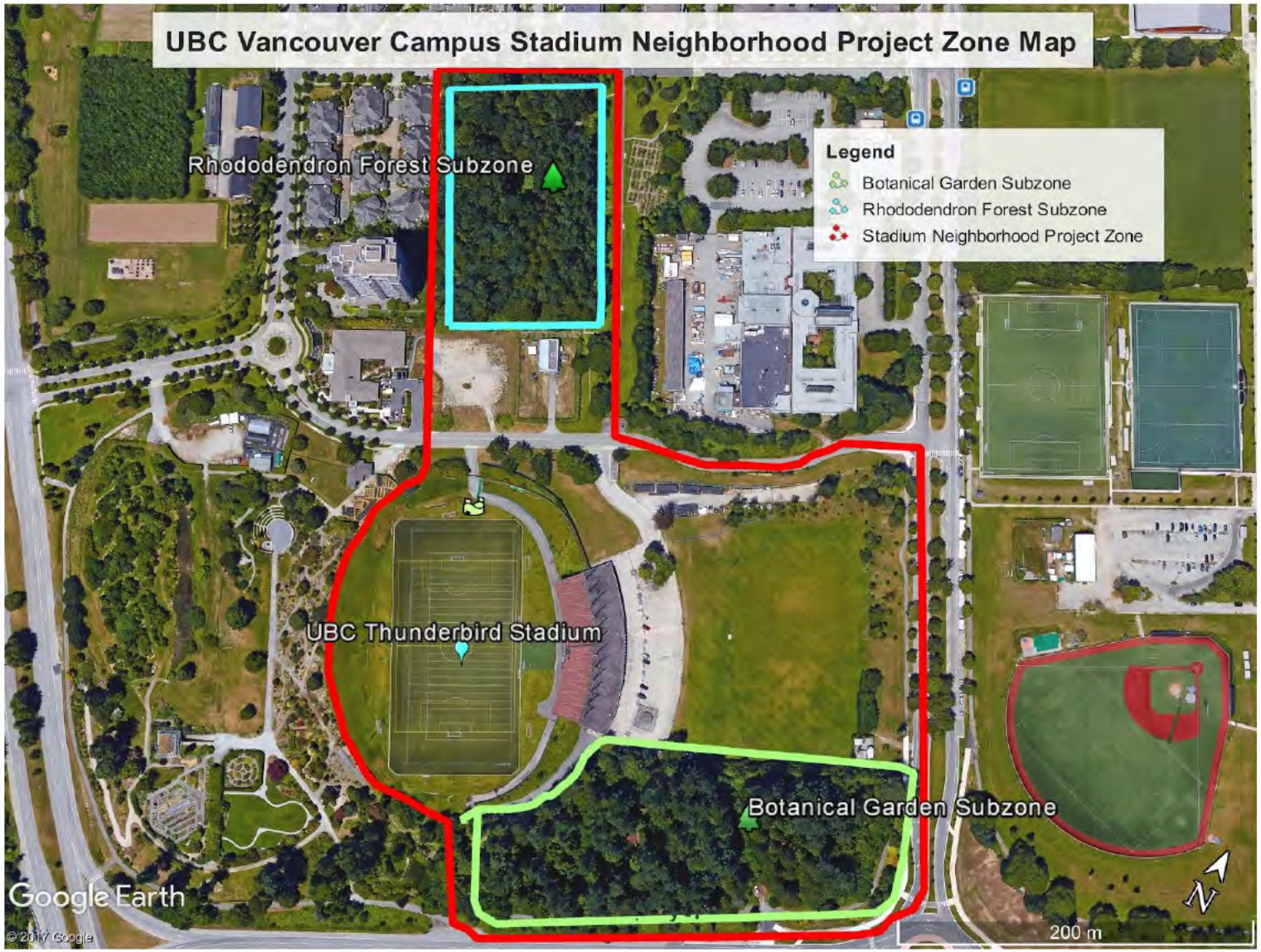
- Adapted from both the US Forest Service Urban Tree Risk Management and International Society of Arboriculture (ISA) Tree Health and Risk Assessment
- Two Steps to Visual Assessment:
  1. **Probability of Failure** - quantifies potential of failure
  2. **Probability of Target** - quantifies probability of harm to humans and structures

Probability of Failure Rating	
1	**Decay <25%,** minor architectural problem
2	**Decay 25-40%,** single crack, minor root damage
3	**Decay 25-40%**, multiple cracks, moderate root damage
4	**Decay 25-40%**, dead wood, large cracks
5	**Decay >40%,** dead wood, severe damage

Probability of Target Rating	
1	**Occasional Use;** i.e. forest, quiet path
2	**Moderate Use**; i.e. quiet park, street trees
3	**Heavy Use;** i.e. school playground, popular park

Field Results

Project Zone



Background of Rhododendron Wood

History

- 4.5 hectare closed-canopy forest
- Named after old rhododendron plantings
- Flowers died in the early 1980's
  - Large conifers continued to grow, closing canopy
  - Irrigation system fell into disrepair

Impatiens parviflora

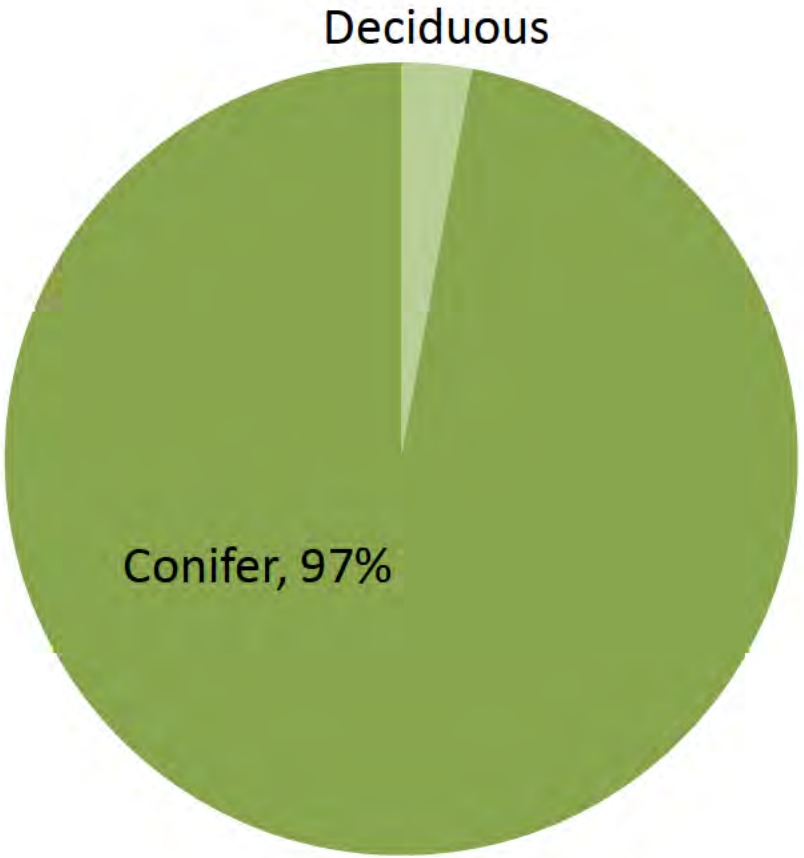
Future

- Susceptible to abiotic/biotic disturbances
- Presence of invasive species: *Impatiens parviflora* (small balsam or touch me not), *Rubus armeniacus* (Himalayan blackberry), and *Hedera helix* (English ivy)

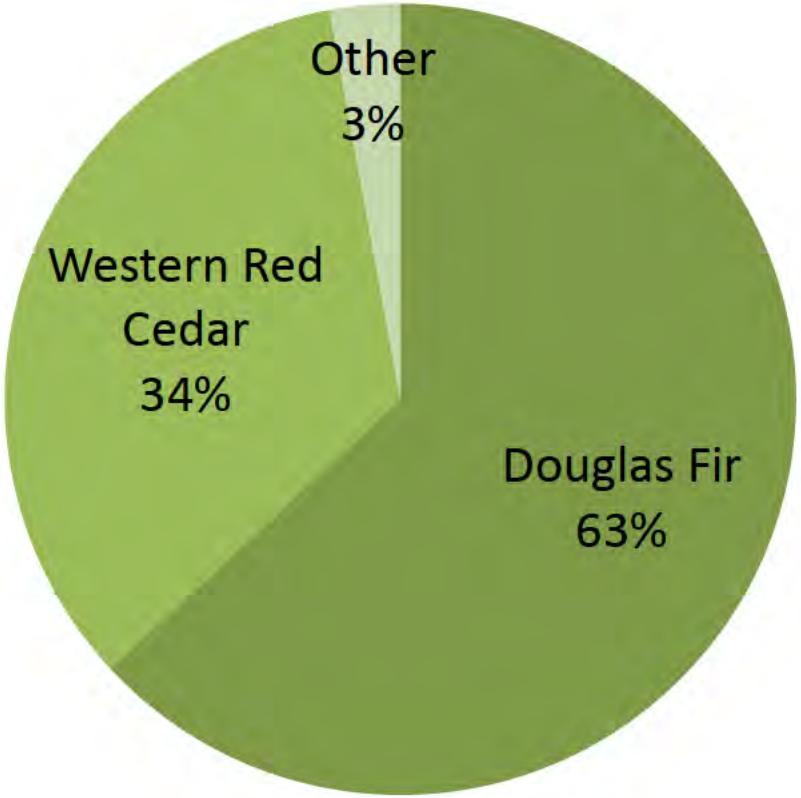
Subzone 1: Rhododendron Forest

Field Data Analysis: Rhododendron Subzone

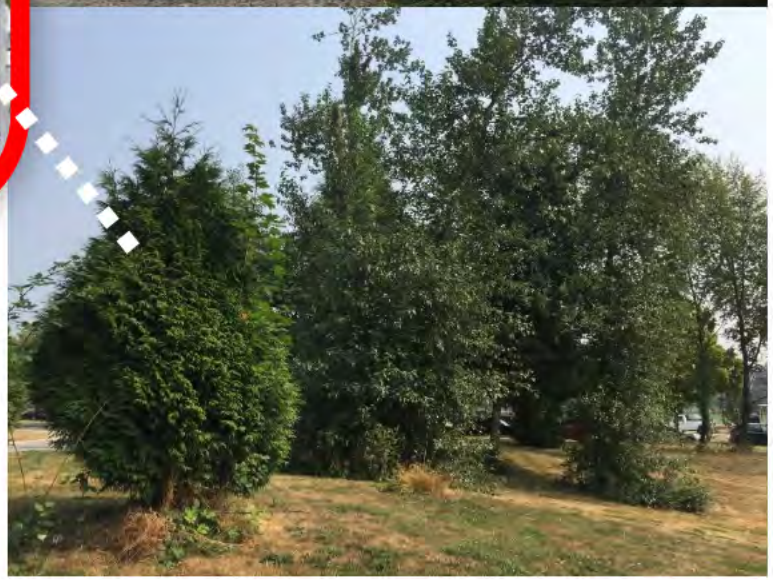
Deciduous vs Conifer



Species Distribution

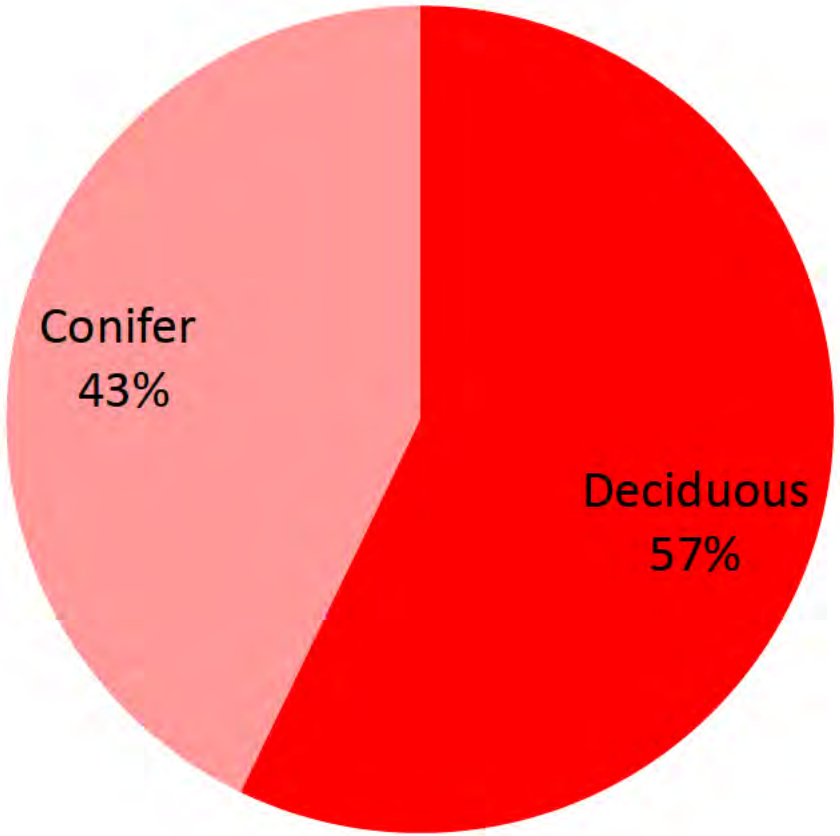


Subzone 2: Street Trees

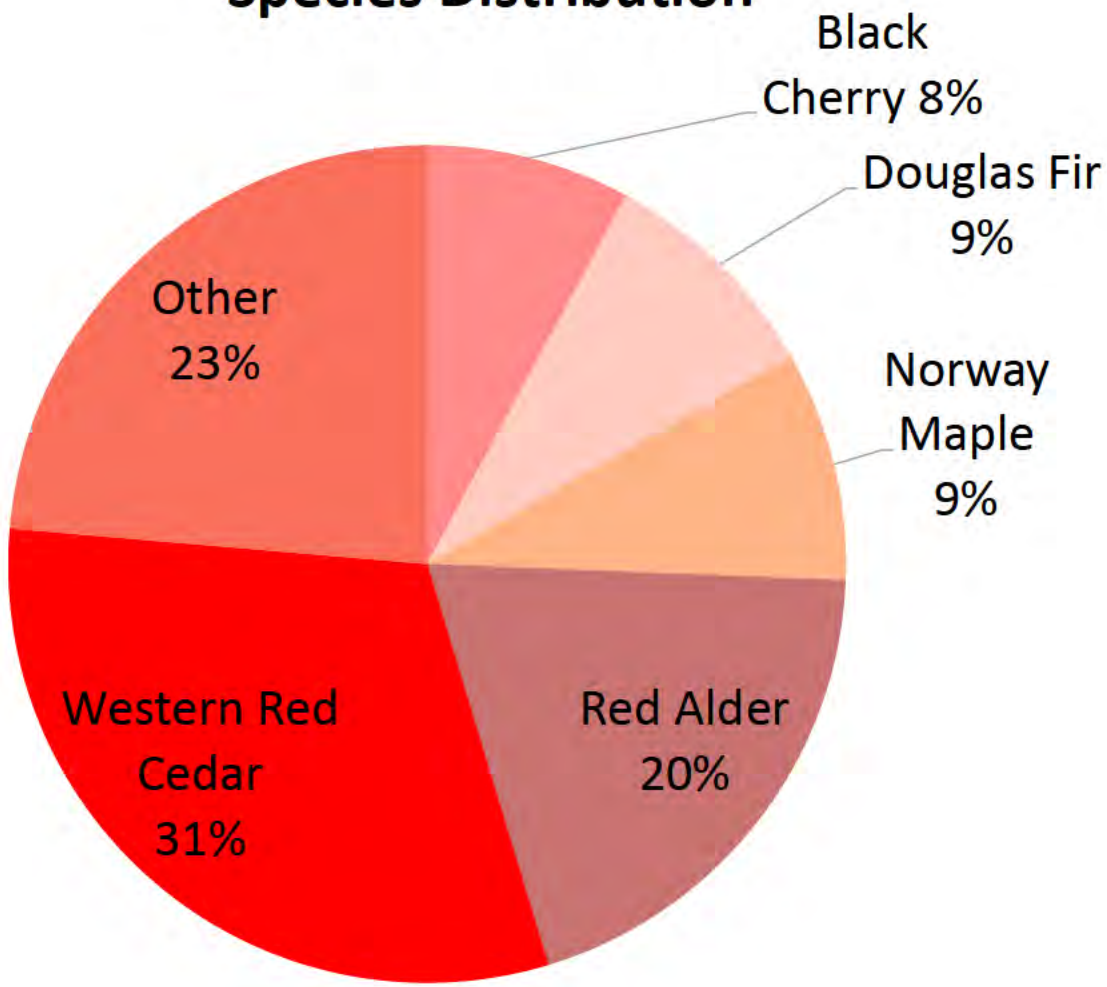


Field Data Analysis: Street Tree Subzone

Deciduous vs Conifer



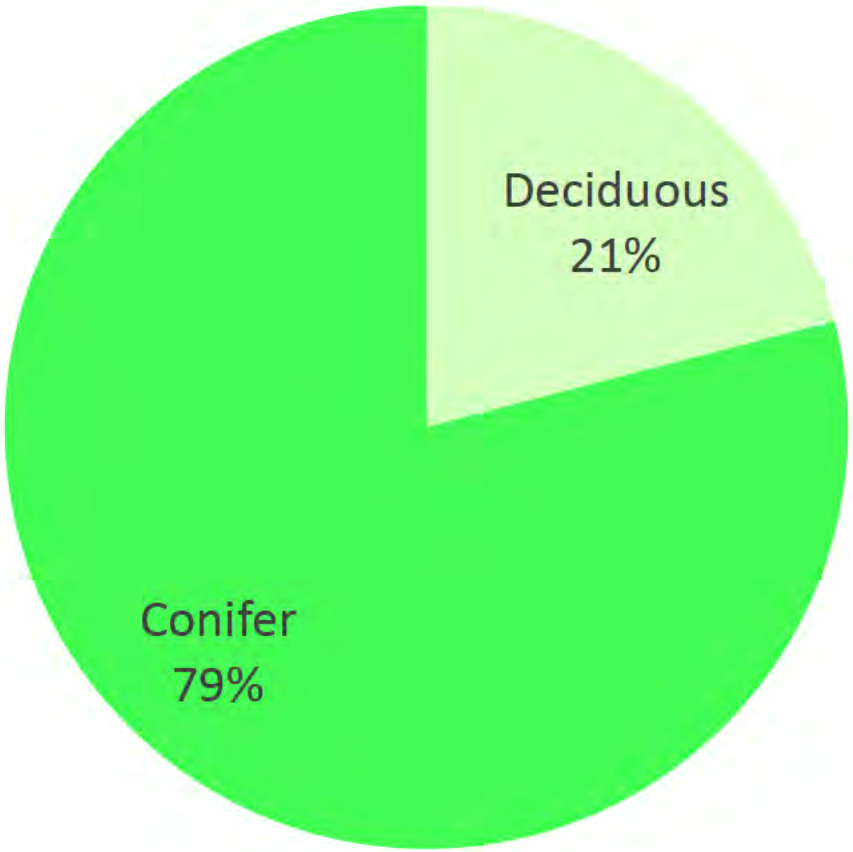
Species Distribution



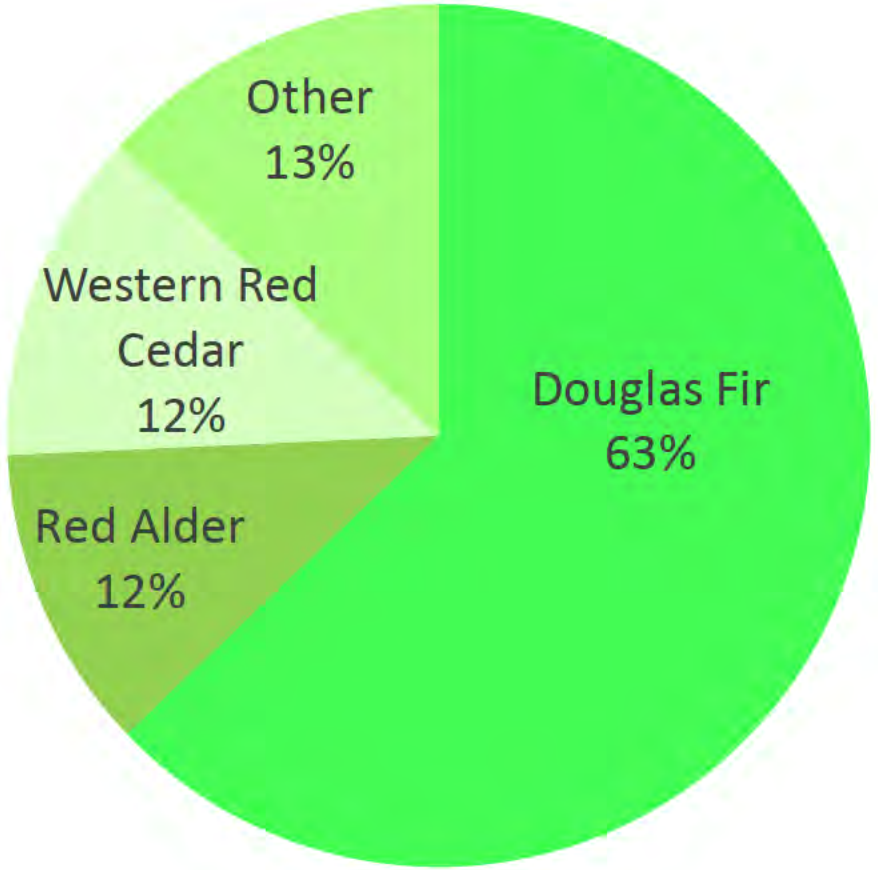
Subzone 3: Botanical Gardens

Field Data Analysis: Botanical Garden Subzone

Deciduous vs Conifer

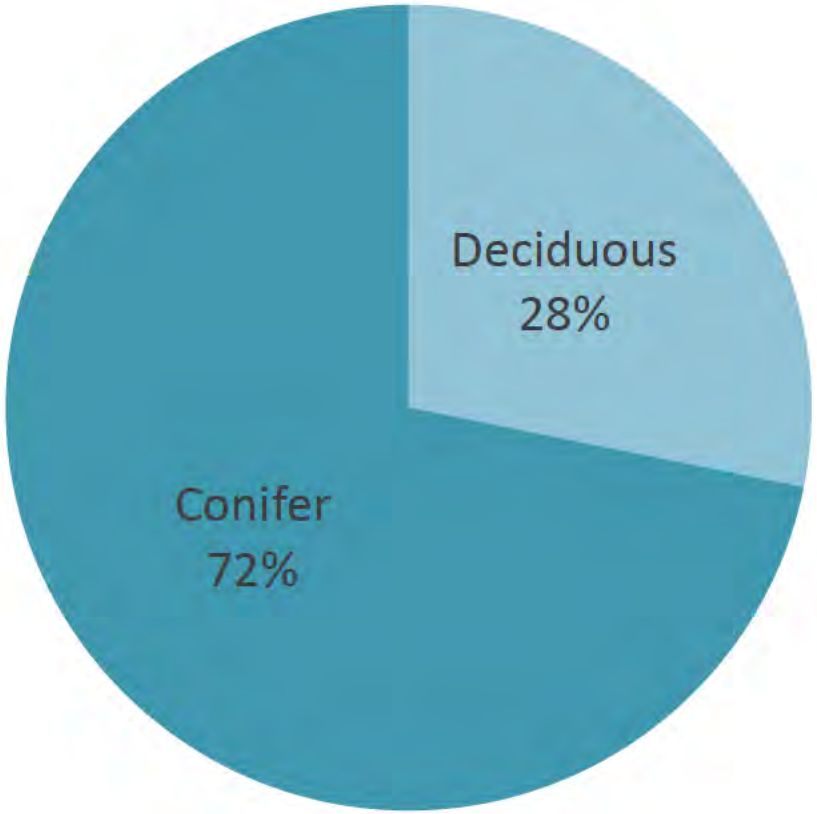


Species Distribution

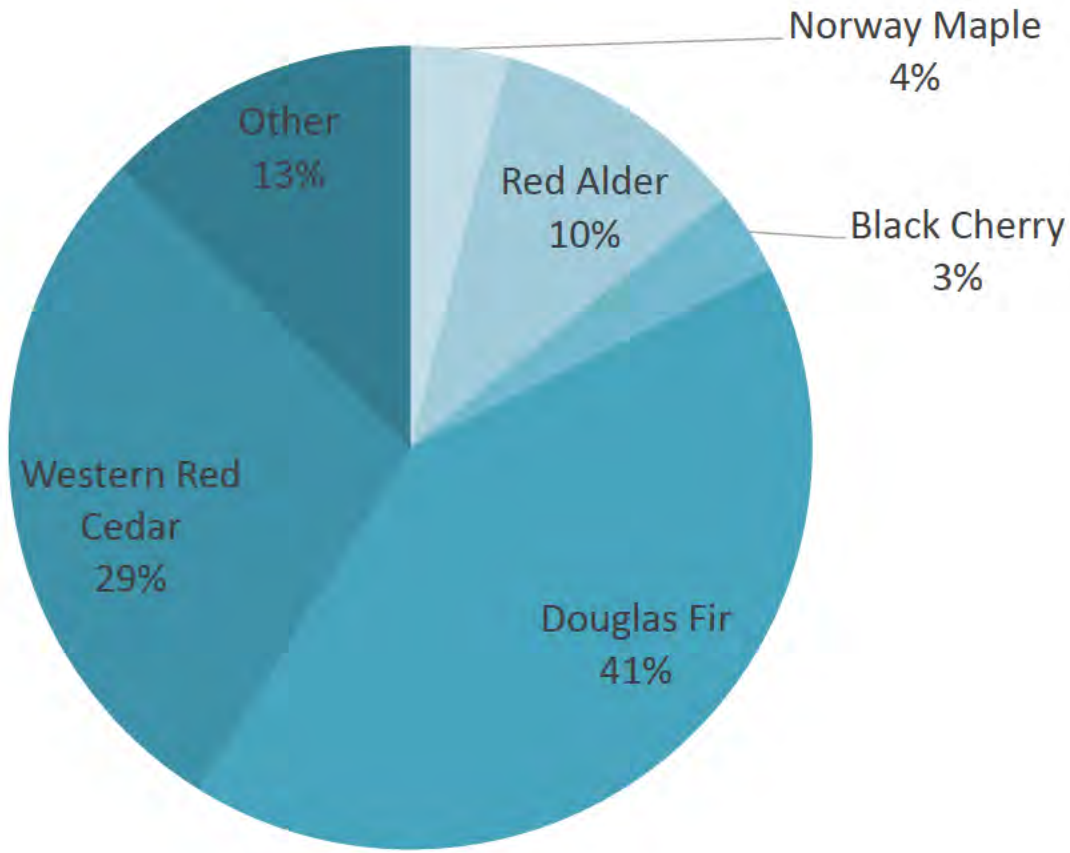


Field Data Summary: Project Zone

Deciduous vs Conifer



Species Distribution



Unique Trees

Fagus sylvatica 'Asplenifolia'
Cut-Leaf European Beech

Styrax japonicus
Japanese Snowbell

Acer ginnala
Amur Maple

Cornus florida
Flowering Dogwood

Field Data Summary

Table 1. Tree physical characteristics in each subzones.

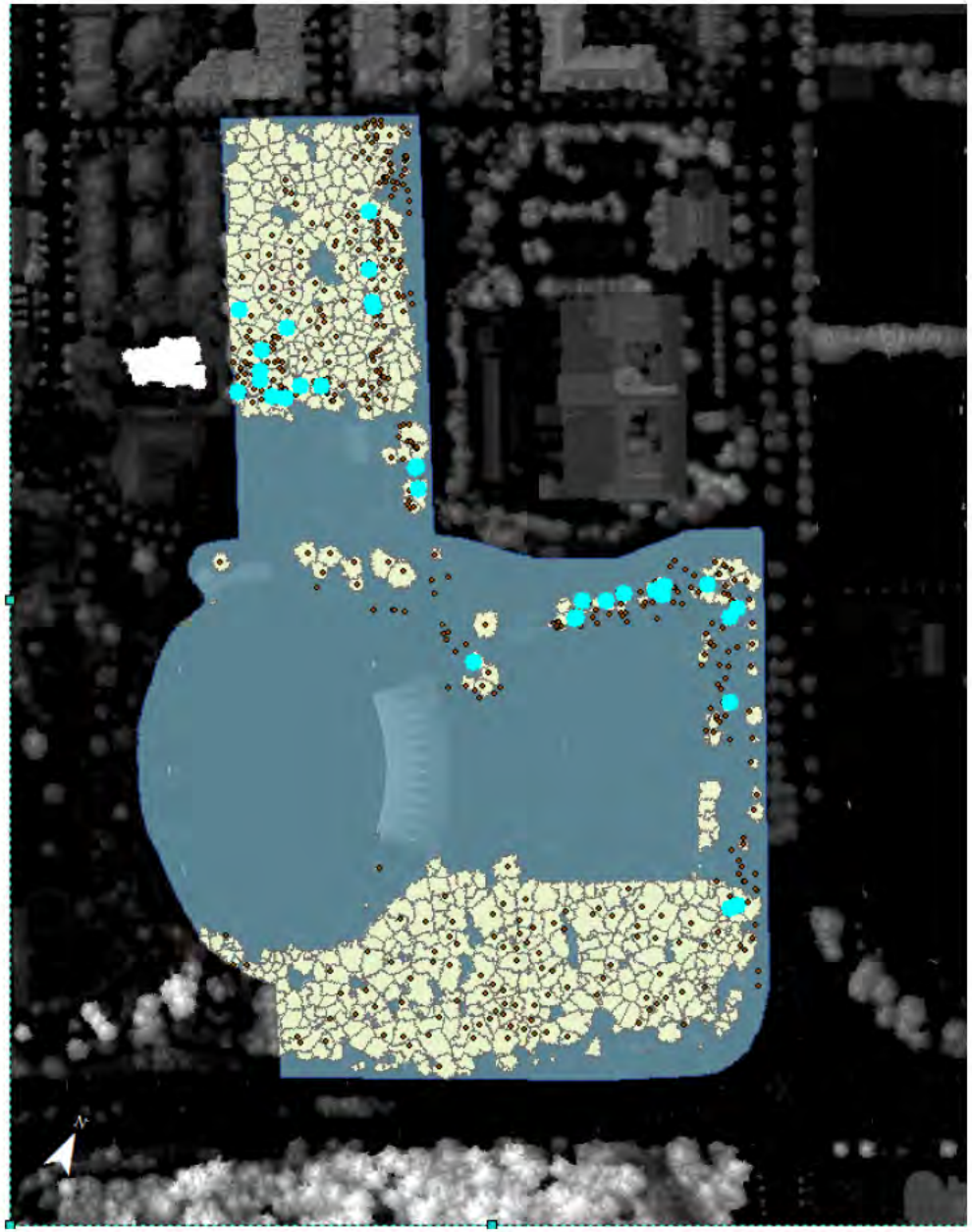
	Rhododendron Subzone	Botanical Garden Subzone	Street Trees
Average DBH (mm)	457.11	**752.58**	208.64
Average Height (m)	NA*	NA*	10.11
Average Crown Width (m)	6.54	**8.71**	6.63
Average Point of Failure	1.7	1.3	**1.8**
Average Point of Target	1.0	**1.8**	1.2

Note: *Tree heights in Rhododendron and Botanical Garden subzones were not measured.

Trees with High Point of Failure

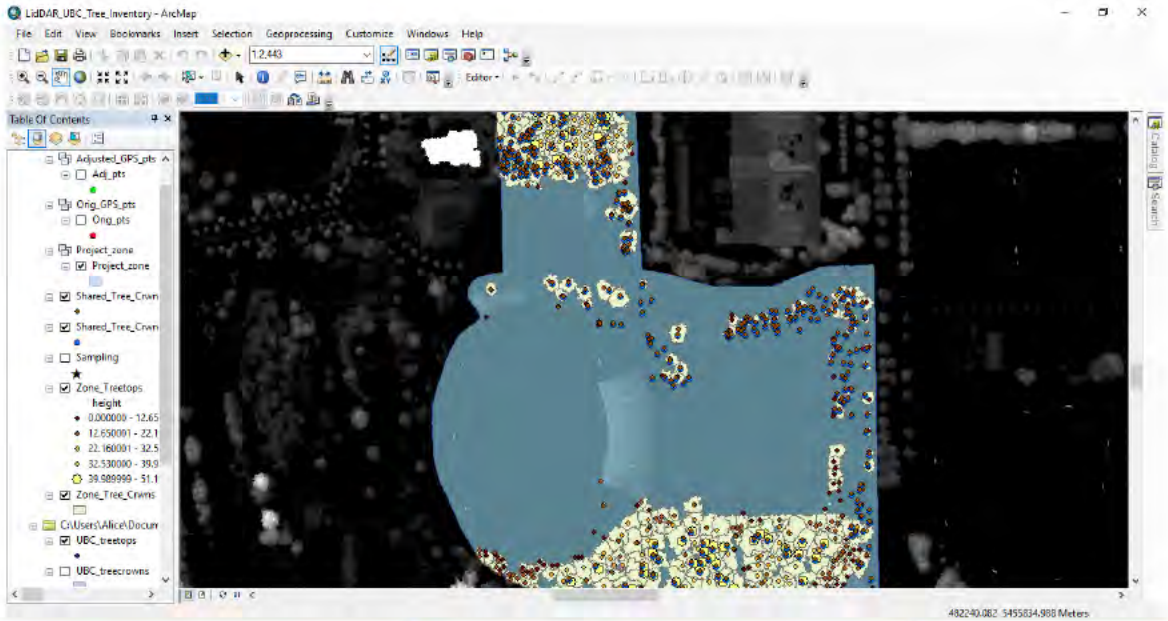
- 33 trees total
- Majority in Rhododendron Wood subzone and street trees
- Most frequent species:
  - 13 Douglas-fir
  - 8 Western red cedar
  - 6 Black cherry

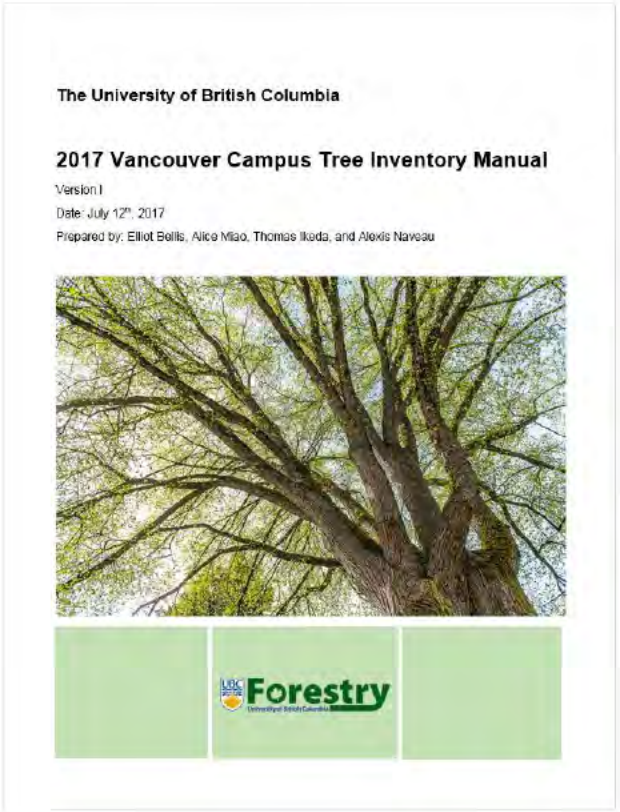
= Tree with point of failure scoring a 4 or 5

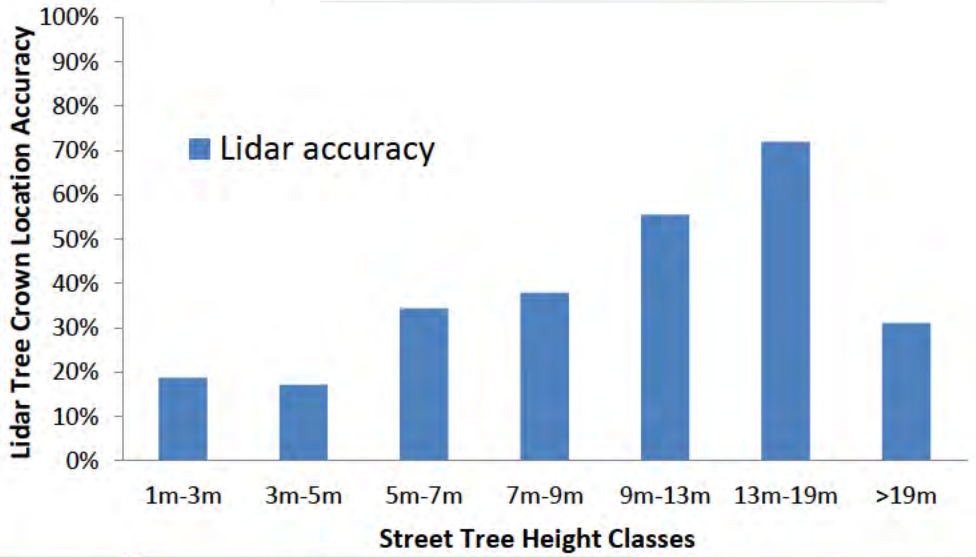


Project Procedures

1. Collect field data
2. Analyze the lidar accuracy
3. Produce working procedure manual to guide future campus tree inventory





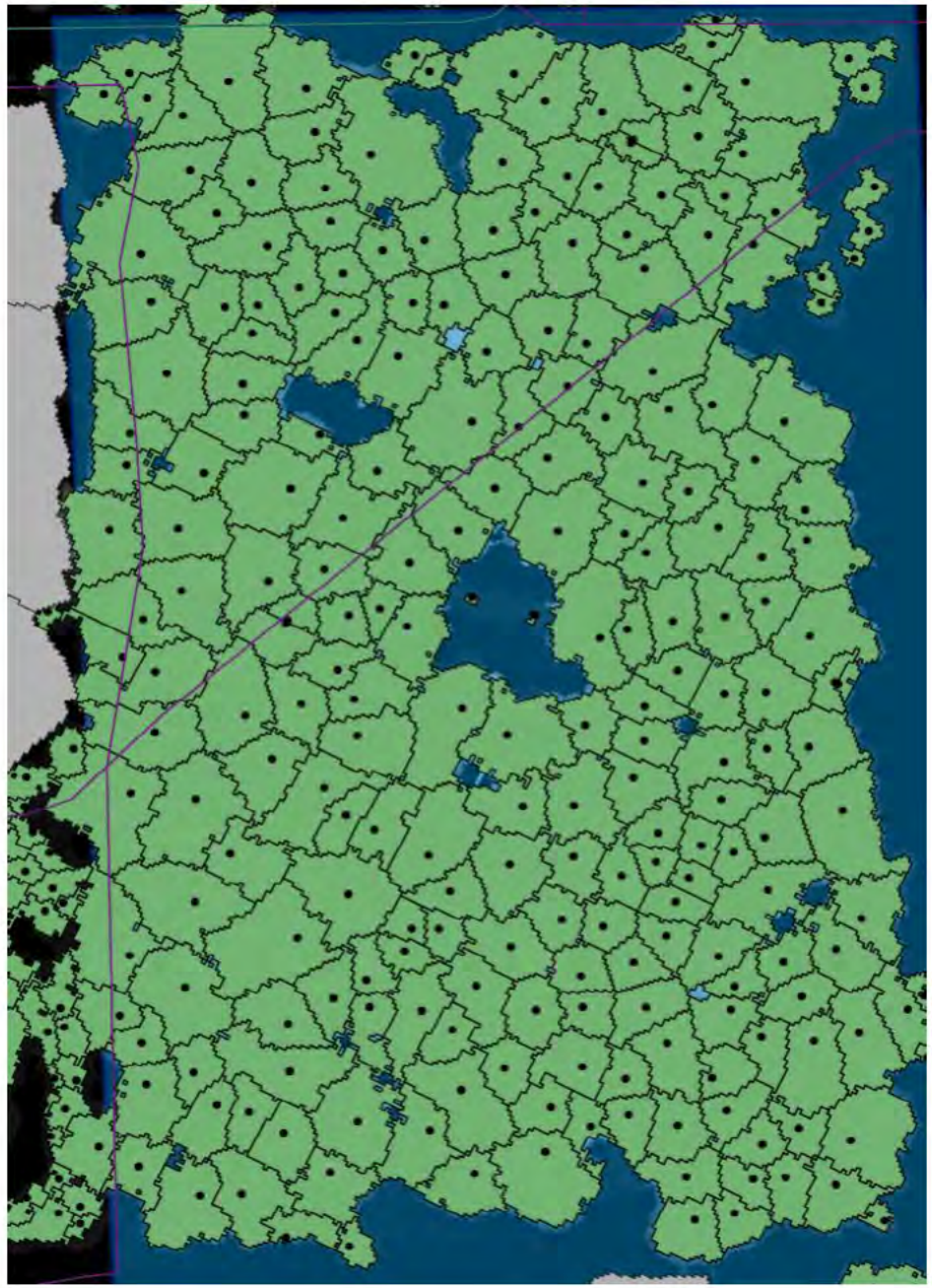


2. Lidar Accuracy Analysis

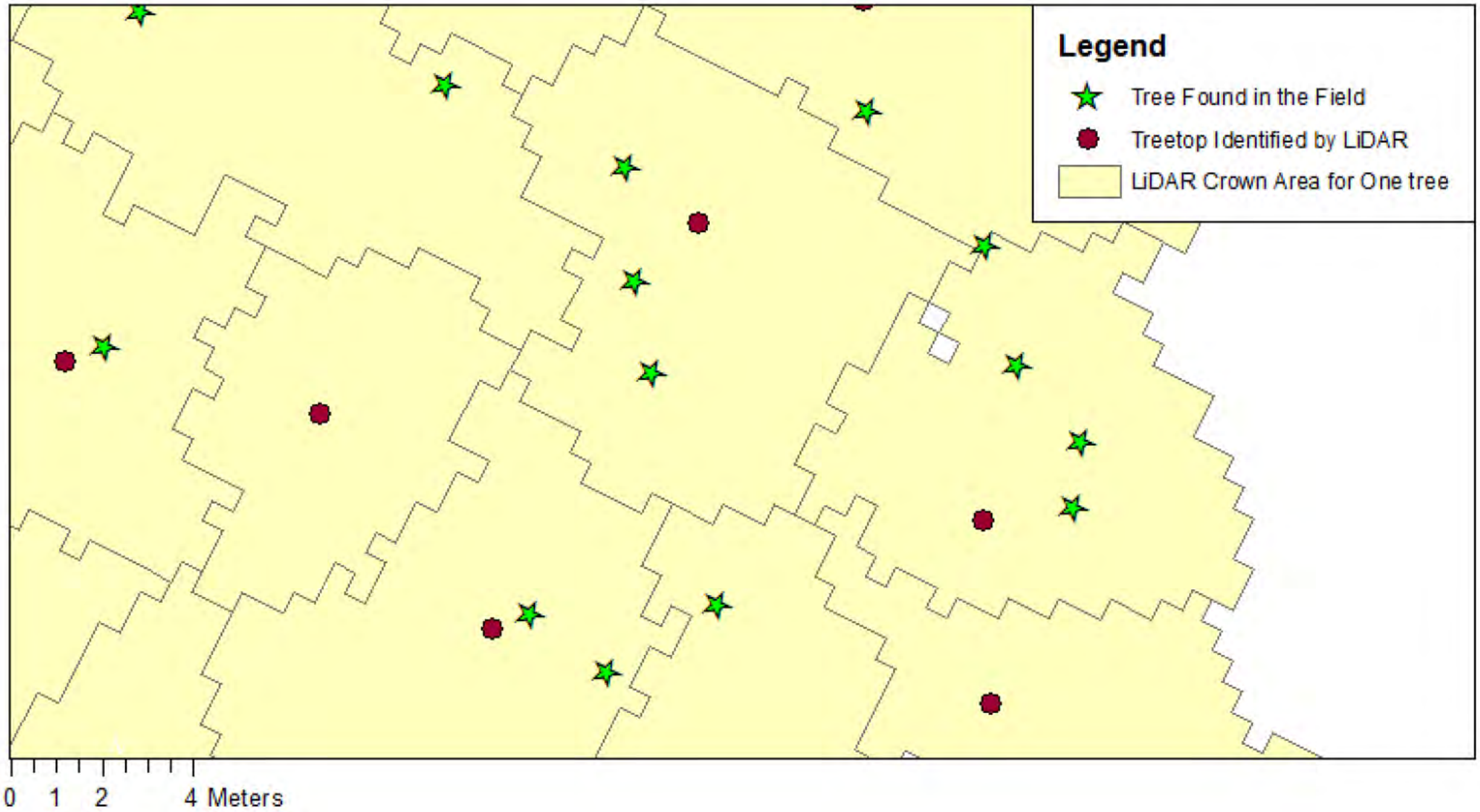
- Urban forest inventory faces **unique challenges**
- **Light Detection and Ranging** (lidar)
- Lidar extracts tree attributes **automatically**
- Time and economically **efficient**
- However, **requires ground-truthing survey** to assess lidar measurement accuracy and to train algorithms

Locating Lidar Trees

- Avenza Maps ™ used to match lidar tree to field tree
- GPS signal **weak** in forested areas due to:
  - Phone accuracy
  - Tree canopy cover
- GPS signal **strong** in street tree areas due to:
  - Absence of dense tree canopy cover
- Multi-stemmed trees presented problems
- Placed pin on map when tree was measured
- Marked each tree's pin with Avenza ID #



Lidar Tree Location Accuracy Assessment



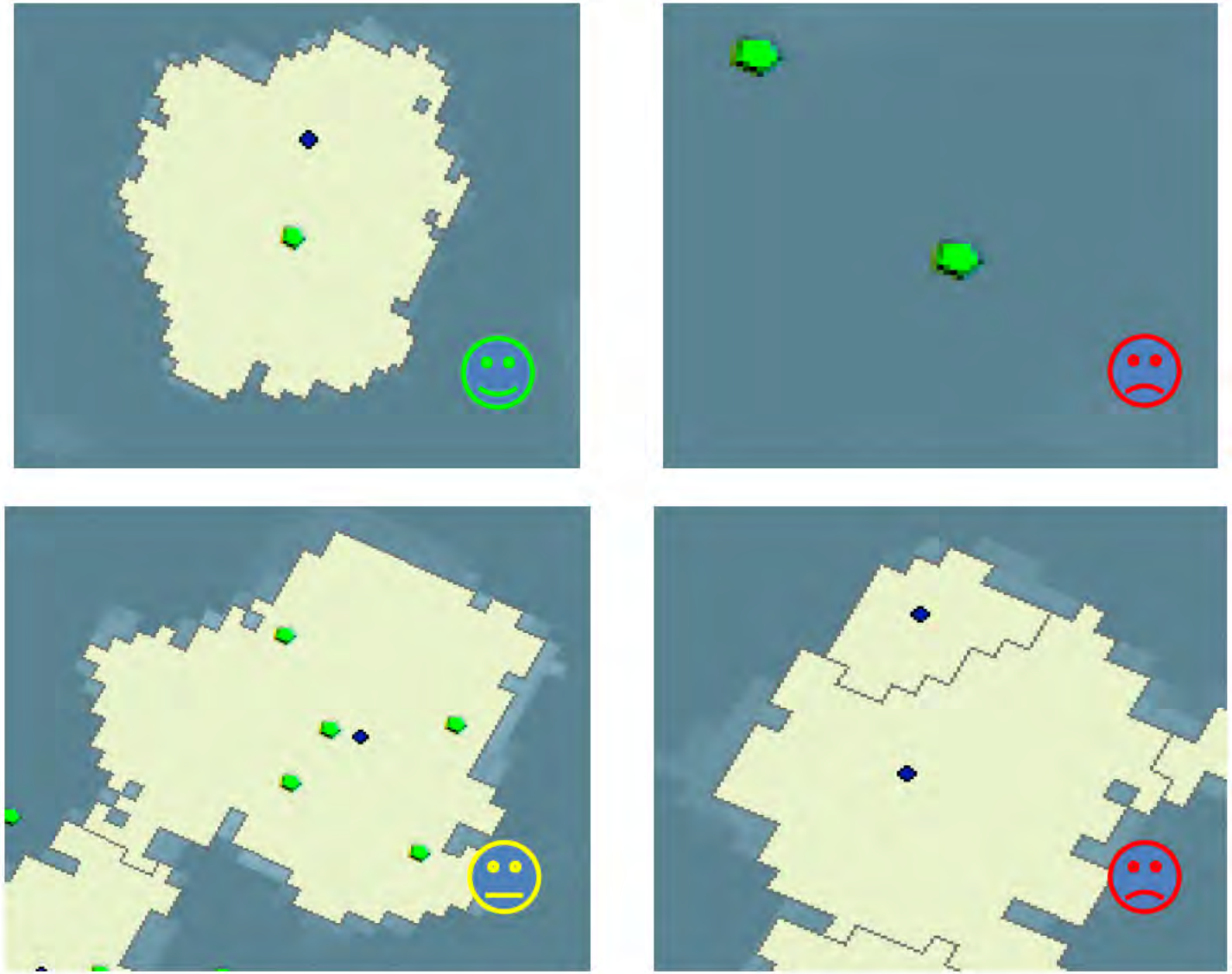
Lidar Tree Location Accuracy Assessment

- Different algorithms are available for processing lidar data
- Lidar data accuracy varies
- Requires high lidar accuracy for urban tree inventory
- Accurate tree?

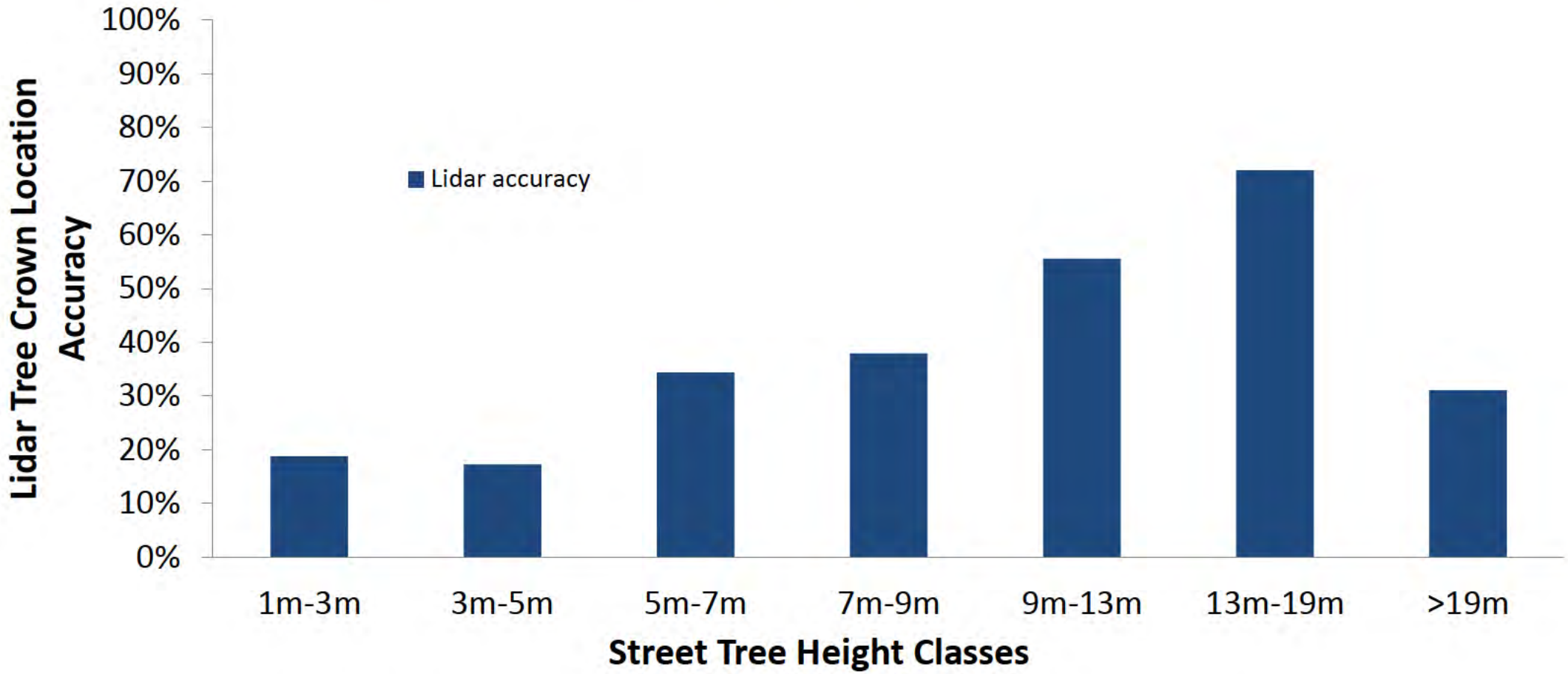
Lidar Tree Location Accuracy Assessment

What is an accurate tree?

- GPS point for tree measured in-field
- Treetop identified by lidar
- Tree crown delineated by lidar
- Project zone



Lidar Tree Location Accuracy Assessment



- Average lidar tree crown location accuracy for **street trees** is **38%**

Lidar Tree Location Accuracy Assessment

Avenza ID	ID detected	Cluster index
178	0	1
179	1	1
180	0	0
181	1	0
182	0	1

Trees in Forested Subzones

182 measured trees total in the subzone

74 accurate trees

Lidar Accuracy : 41%

Note : Tree heights were not measured in forested area due to construction barriers.

- Average lidar tree crown location accuracy for **trees in forested subzones** is **41%**

Project Procedures

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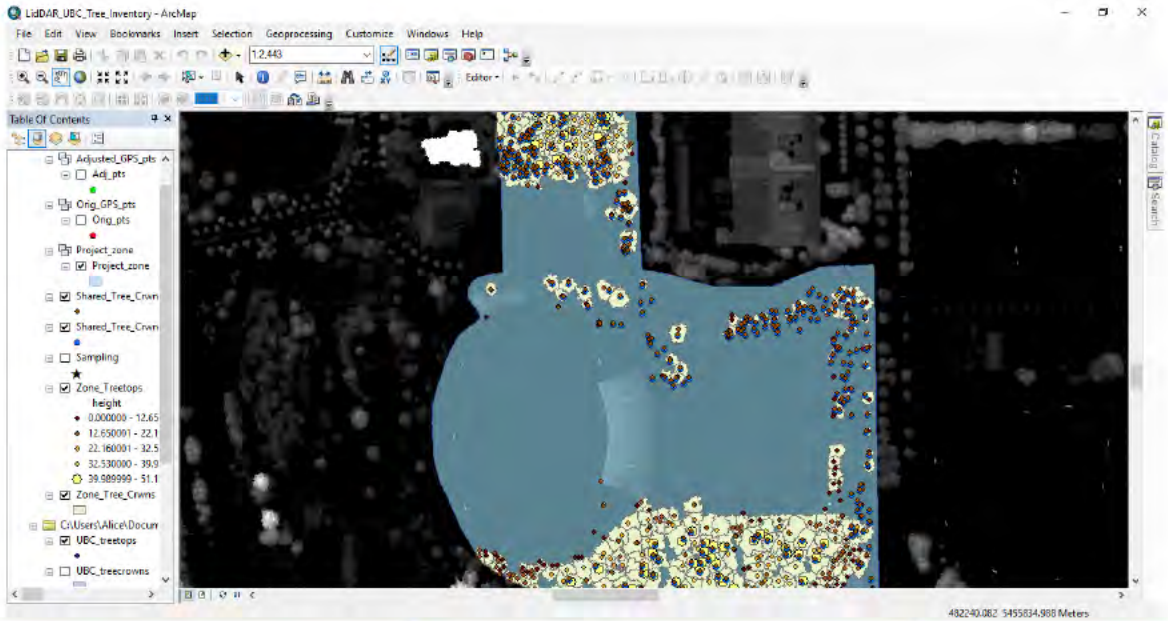
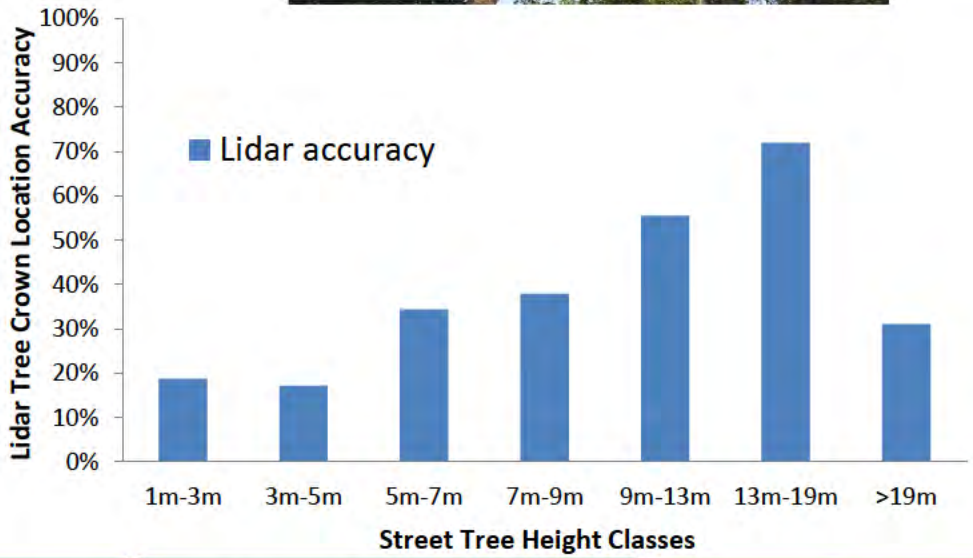
2. Analyze the lidar accuracy
3. Produce a handbook to guide future campus tree inventory





Summary

Summary

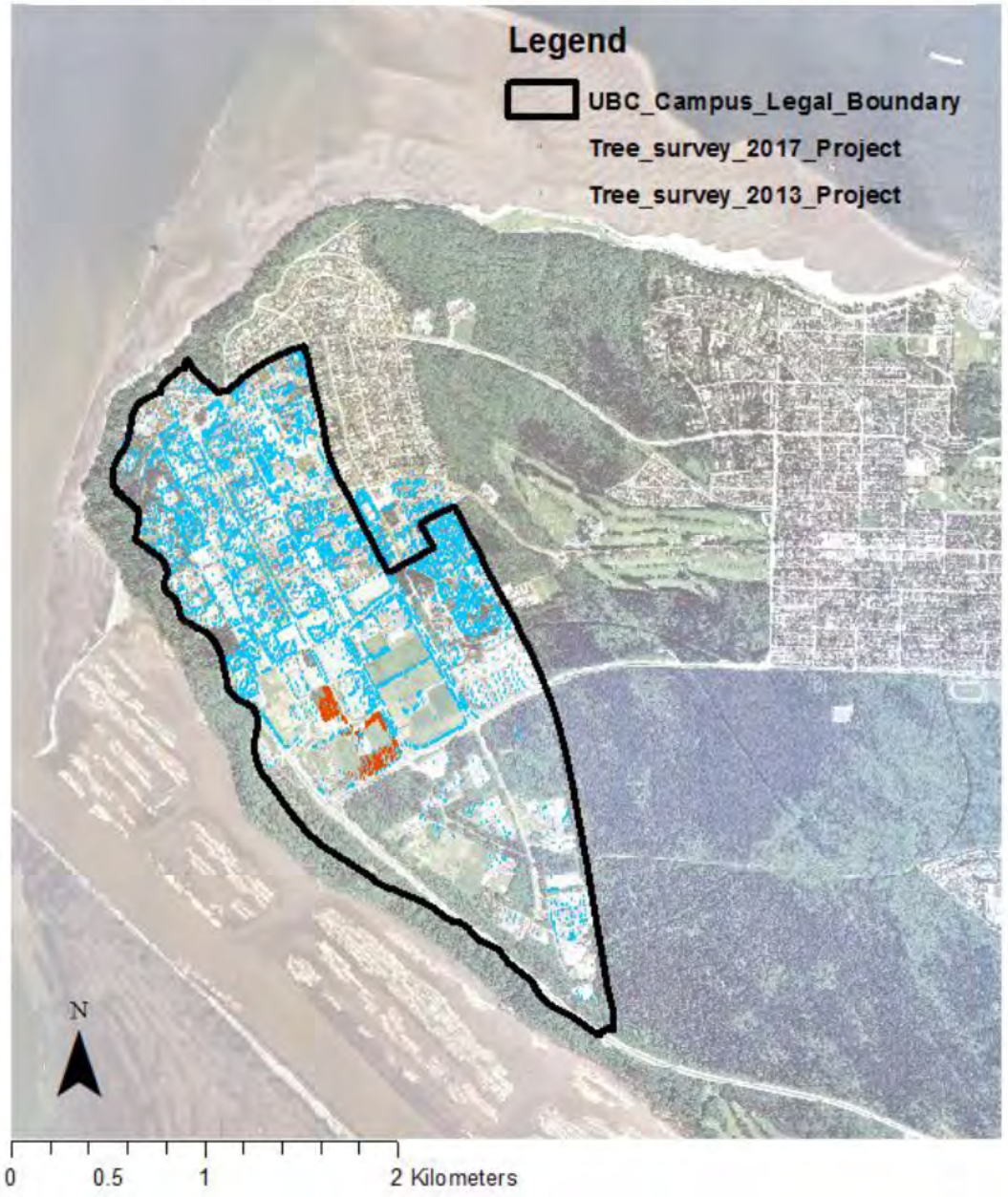
- The project was conducted during the **summer of 2017**
- **GIS data files** combined with 2010 tree inventory data
- **Lidar accuracy is low** but **can be improved** by using different algorithms
- Campus Tree Inventory **Handbook will be ready in late September**

Total Campus Canopy Cover Results

Total Canopy Cover	Area of University Endowment Land	Campus Canopy Cover Percentage
1,079,515.86 m^2	4,022,447.54 m^2	26.84%

UBC Vancouver Campus Canopy Distribution

UBC Vancouver Campus Tree Inventory Scope



Limitations and Improvements

Limitations

- Time restriction
- Access to equipment
- No rectified orthographic photos

Improvements

- Use of rectified orthographic photos alongside the lidar data
- Lidar algorithms can be adjusted to accommodate forest composition
- Increase frequency and seasons lidar is collected

Future Tree Inventory Protocol

Create a **future tree inventory protocol** for UBC Vancouver campus

1. Improve accuracy of lidar algorithms
2. Create a model to estimate DBH of the campus trees from lidar data
3. Obtain new rectified orthographic photo/lidar data annually
4. Conduct field work as needed
5. Regularly update tree inventory


Thank You!

1. Tree Census using Photos and LiDAR Data

Create a tree census including:

1. GPS locations of each tree (X,Y)
2. Crown Size
3. Height
4. Deciduous or conifer (or species group) from photos

2. Ground Survey

Allow samples via stratification:

1. Sort tree census from step 1 based on small, medium, large by crown size class, height class and species group.
2. Determine the number of trees to be sampled based on time limits.
3. Divide the number of sample trees by the total combinations of all strata.
4. Randomly select trees from each stratum.
5. Find the exact tree on site based on GPS locations from the census data.
6. Record species and DBH, as well as assess health condition.

Note: Stratification can be more in detail depending on species groups (down to genus).

3. DBH Model

DBH in relation to 100 % of LiDAR hits by species/species group using MINITAB.

Add estimated DBH to the census.

Note: Other models can also be built. For instance, DBH model in relation to LiDAR hits and crown size.

4. Updates

1. Every 2/5/10 yrs, we obtain new photo/LiDAR data.
2. Compare with previous year's census with new tree census.
3. May require limited field work when spot unusual data. For instance, a tree height change from 30m to 10m. This means the tree can be dead/has a broken top/is replayed by a new tree.
4. Update the tree census.
5. Import data into the model to estimate DBH in census.
6. Big updates when there is new planting of trees/cut downs on campus. Require citizen science or a UBC employee who will be assigned for this particular task.

Note: This inventory data will allow us to further calculate tree volume, campus carbon storage status, above/under-ground biomass which, in turn, will help to assess campus carbon balance.