Tree inventory of UBC Farm to accelerate agroforestry research

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1. Background

Juxtaposed with the agricultural production systems at the UBC Farm is a large area of second growth forest. This remnant forest, the largest contiguous forested area of campus, is an important biodiversity reservoir on-campus as it is home to a wide range flora and fauna. But we don't have any detailed information of the forest structure, species composition, or function yet. This is important to know as the forest can be a vital resource on campus for research and learning. This project aimed to fill this gap by conducting a comprehensive inventory to form a necessary baseline for future research, learning and monitoring.

2. Objective

The objective was to undertake a 100% inventory of all trees >10cm diameter at breast height (DBH), identify and record them in an UBC campus-wide database format.

3. Methods

We measured each tree that was more than 10 cm diameter at breast height (DBH) at 1.37 m above the ground within the 11.58 ha plot within the farm forest (Fig. 1). We only recorded dead trees that were standing and excluded all fallen dead trees during the inventory. For each tree, we recorded different tree attributes following the UBC campus wide tree inventory to maintain consistency across campus (see details in Table 1).

We used a dbh tape to measure the dbh and a clinometer and a laser rangefinder to measure tree height. Rest of the measurements such as crown width, percentage canopy missing and crown light exposure were based on visual estimation. Each tree was also permanently tagged using aluminum tree tags.

Figure 1. A map showing the surveyed forest area (11.58 ha) on the UBC Farm (within the red line)

Variables	Definition (unit)
Tree ID	Tree species
Tag ID	Unique tag number given to each tree
Status	Tree is alive or dead
Land use	Agriculture (A) (category assigned for i-TRee Eco)
HDbh (m)	Height at which dbh measurement was taken if not measured at 1.37 m
Dbh (cm)	Diameter at breast height
Tree height (m)	Height from the ground to the top of the tree (alive or dead)
Crown width (m)	Width of the tree crown measured at two opposite angles
Percentage canopy missing (%)	Percentage of the crown volume that is not occupied by branches and leaves
Crown light exposure	Number of sides of the tree's crown receiving light from above or the side (max. 5). Top of the tree is counted as one side. Four other sides are assessed by dividing the crown vertically into four quadrants around the stem

Table 1. Details of the variables measured for every tree during the inventory

4. Results

4.1 Species richness and diversity:

The project commenced in July 2020 and finished off in June 2021. We recorded a total of 4913 individuals consisting of 21 species (Table 2).

Species Code	Scientific Name	Common Name
THU PLI	*Thuja plicata*	Western Red Cedar
PSE MEN	*Pseudotsuga menziesii*	Douglas Fir
TSU HET	*Tsuga heterophylla*	Western Hemlock
ABI GRA	*Abies grandis*	Grand Fir
CUP NOO	*Cupressus nootkatensis*	Yellow Cedar
ACE MAC	*Acer macrophyllum*	Bigleaf Maple
ALN RUB	*Alnus rubra*	Red Alder
POP TRI	*Populus trichocarpa*	Black Cottonwood
BET PAP	*Betula papyrifera*	Paper Birch
RHA PUR	*Rhamnus purshiana*	Cascara
PRU EMA	*Prunus emarginata*	Bitter Cherry
SOR AUC	*Sorbus aucuparia*	Mountain Ash
ABI PRO	*Abies procera*	Noble Fir
COR FLO	*Cornus florida*	Florida Dogwood
ILE AQU	*Ilex aquifolium*	English Holly
CRA MON	*Crataegus monogyna*	Hawthorn
MAL FUS	*Malus fusca*	Pacific Crab Apple
PIC SIT	*Picea sitchensis*	Sitka Spruce
SAL SCO	*Salix scouleriana*	Scouler's Willow
ALN GLU	*Alnus glutinosa*	Black Alder

Table 2. Tree species recorded within the farm forest during the inventory

The top five most dominant species were Western red cedar (49.5% of total trees), Bigleaf maple (14.1%), Douglas fir (10.9%), Red alder (10.1%), and Western hemlock (07.1%) (Fig. 2). This was in contrast to the patterns in tree diversity at UBC campus that was mostly dominated by Maple trees (> 20%) followed by Western Red Cedar (11%) and Pine trees (7%)[1].

The Shannon Wiener diversity index was 1.59. This value typically ranges from 1.5 to 3.5[2,3]. Therefore, this suggests that UBC farm forest has a relatively low species richness and uneven community (Fig. 2).
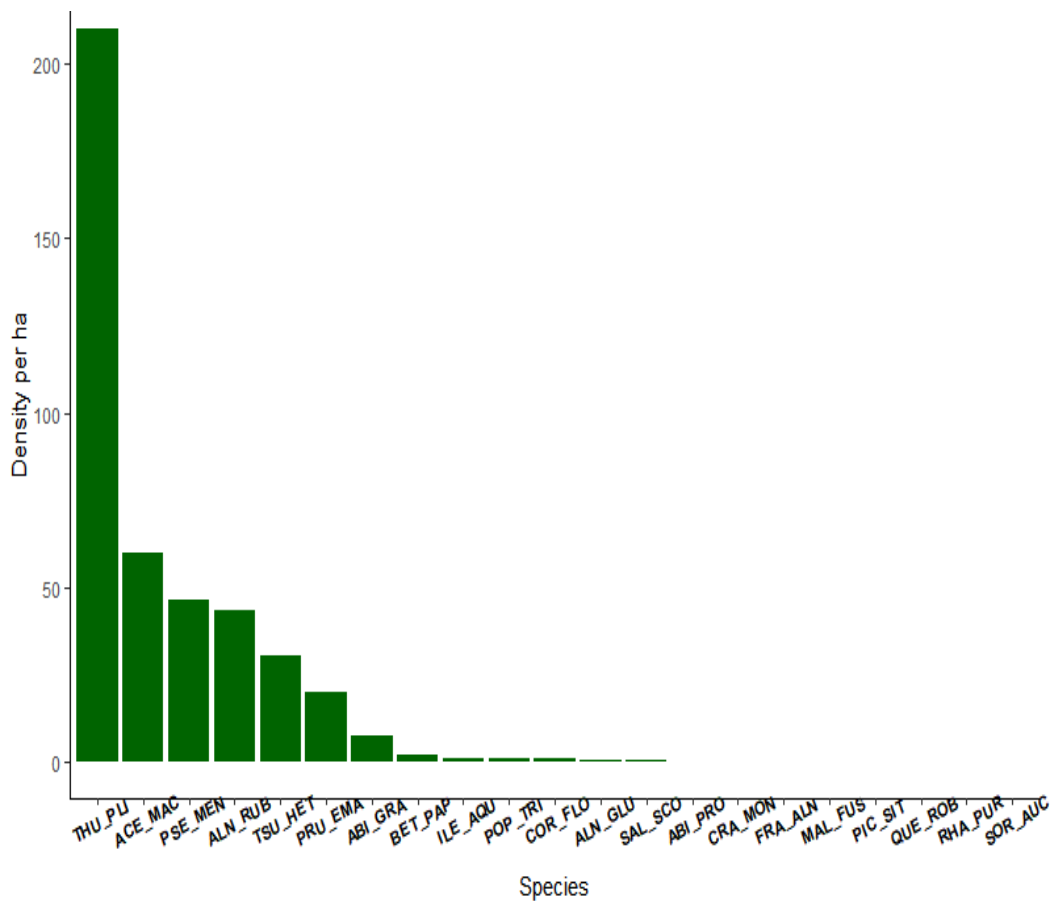
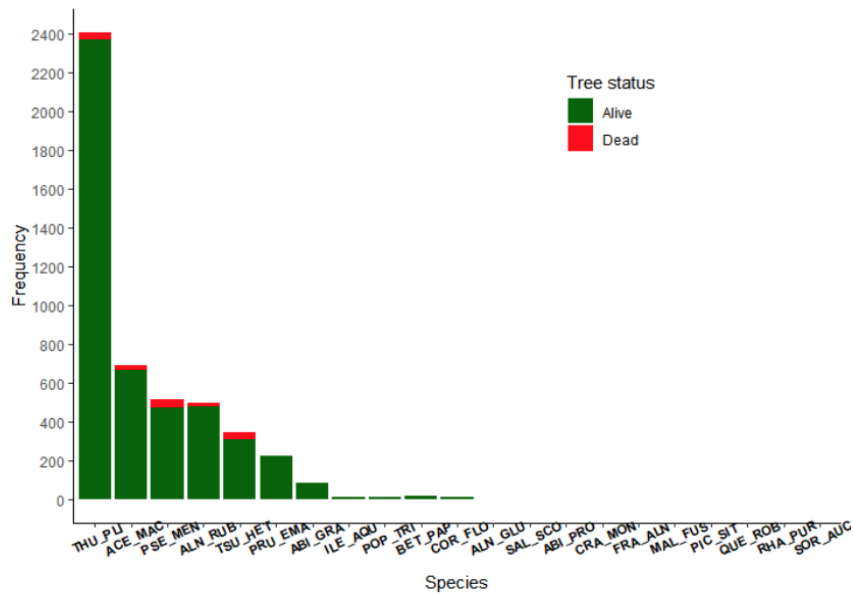*Figure 2. Species density per ha in the farm forest*

Figure 3. Proportion of dead and alive trees across species in the farm forest

There was also a small proportion of dead trees in each species (Fig. 3).

4.2. Tree dbh:

The tree dbh ranged from 5 to 146.5 cm with an average of 34.8 cm. This was relatively lower than UBC Botanical Garden that had an average dbh of 75.3 cm[1]. On average, Douglas fir trees were the largest in size followed by Bigleaf maple, Western hemlock, Western red cedar, and Red alder respectively (Fig. 4).
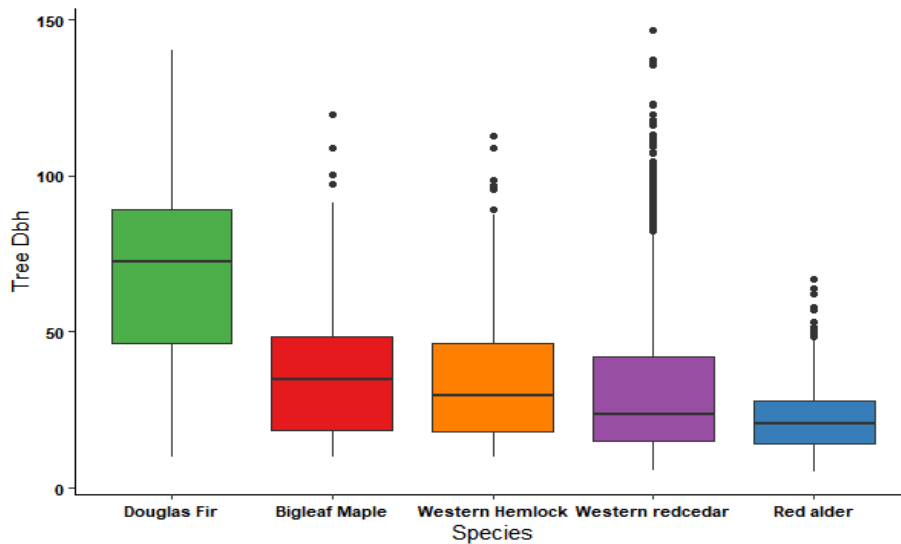

Figure 4. Boxplots showing Dbh ranges for the five most common species in the UBC farm forest

We also assessed the dbh class distribution for the five most dominant species. Red alder, Western red cedar, Bigleaf maple, and Western hemlock were dominated by trees in the smaller size classes and the proportion of trees in each dbh class decreased as the tree dbh increased (Fig. 5). However, the Douglas fir population had relatively fewer small or big trees and was mostly dominated by trees with medium dbh classes.
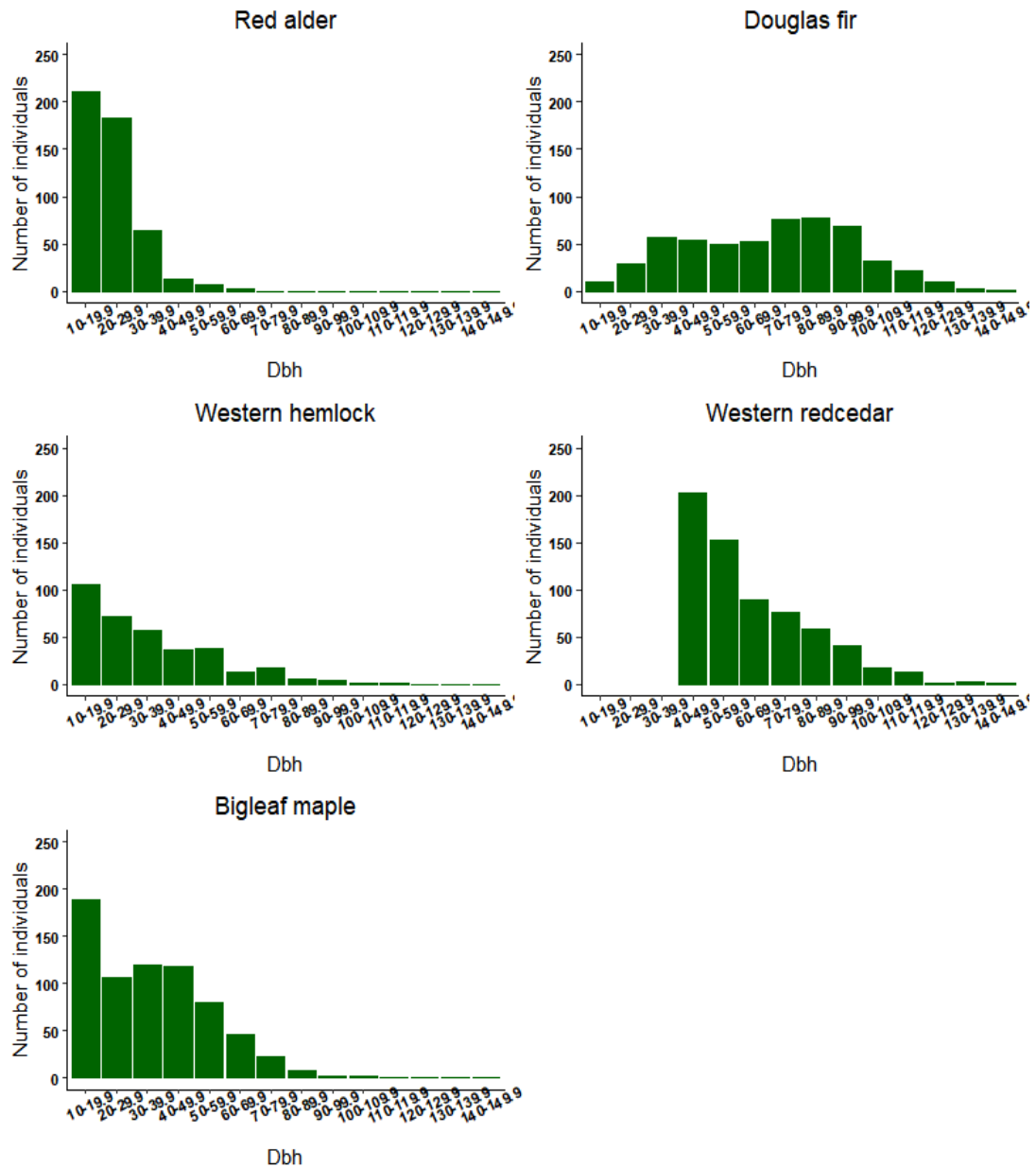

Figure 5. Size class distributions for the five most common species at the UBC farm forest

These patterns suggest that Red alder, Western red cedar, Bigleaf maple, and Western hemlock are regenerating and relatively young population whereas Douglas fir population is maturing[3]. This is important as it can have important implications for the growth, survival and the structural composition of the forest in the face of climate change.

4.3. Tree height

The tree height ranged from 1.6 m to 60 m with an average of 23.5 m. On average, Douglas fir trees were the tallest followed by Bigleaf maple, Western hemlock, Red alder, and Western red cedar respectively (Fig. 6). This is comparable to the height range found in Main Mall, UBC (6.8 m-37.6 m, Main Mall Tree inventory)[1].
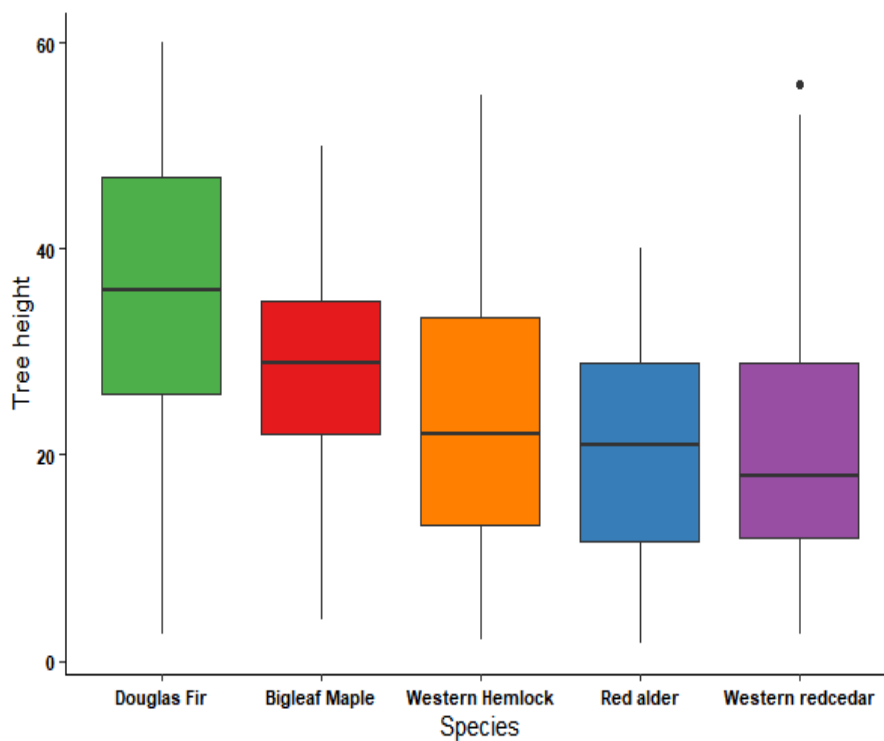

Figure 6. Boxplots showing tree height ranges for the five most common species in the UBC farm forest

4.4. Relationship between tree dbh and height

We examined the relationship between tree dbh and height for the five most common species (Fig 7). For Douglas fir and Western red cedar, tree height increased with higher dbh before stabilizing towards the highest dbh points. For the rest of the three species, tree height decreased after reaching a peak dbh.
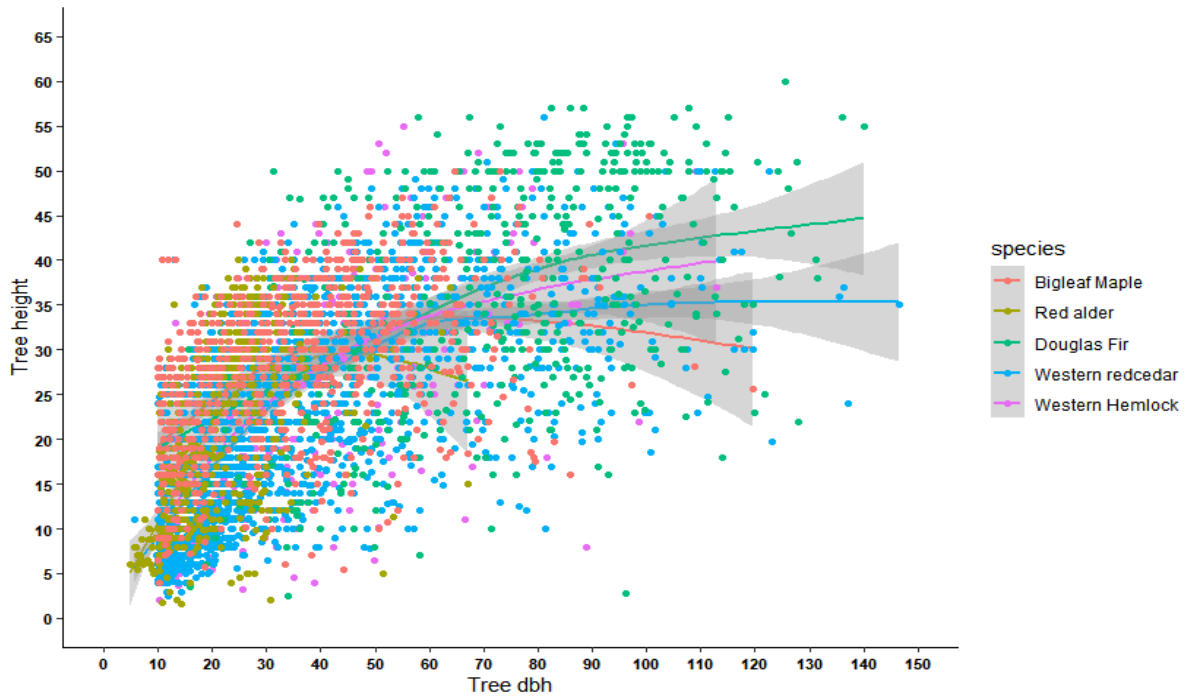
Figure 7. Plot showing the relationship between tree dbh and height for the five most common species at the UBC farm forest. Each point represents an individual tree with different colours showing the five different species.

5. Implications

This study provides an important baseline for future research on urban forestry, ecosystem services, biodiversity, climate change, potential sustainable timber production, and agroforestry. Long term periodic monitoring of the forest will help to gain a better understanding of the forest structure, growth and survival. This can also be used for carbon storage and ecosystem services assessment. Therefore, this inventory data can be an essential tool for the future sustainable management of the remaining forest on the UBC Farm. We hope this will also contribute towards a greater integration of forestry and agriculture at the UBC farm.

6. Literature cited

[1] UBC Vancouver Campus in a changing climate: Urban Forest Edition- a compilation of student research; Jan 2021

[2] Introduction, Simpson's Index and Shannon-Weiner Index. (2021, May 1). Retrieved July 2, 2021, from https://stats.libretexts.org/@go/page/2932

[3] Morgenroth, J., Nowak, D. J., & Koeser, A. K. (2020). DBH distributions in America's urban forests—an overview of structural diversity. Forests, 11(2), 135.