URBAN GREENING EXPLORER

An Interactive Dashboard for Exploring Vancouver’s Public Trees

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# Introduction

## Background

Urban trees are critical green infrastructure. They clean the air, capture carbon, absorb rainwater, providing habitat, improving our health and well-being, protect the city from storms, extreme heat, and the impacts of climate change (City of Vancouver, 2025a). Vancouver maintains extensive open datasets on its public trees and neighbourhoods, yet this information is distributed across portals and is not packaged for interactive, neighborhood-level exploration by students, community groups, or planners. An interactive dashboard can address this gap by combining point-level exploration of individual trees with neighborhood summaries and density-based comparisons.

## Problem Statement

While the datasets exist, they are not designed for everyday exploration. For example, a resident may wish to know which trees are in their local area, what species are most common, or how their neighborhood compares to others in terms of greenery. Existing static reports do not support this kind of place-based inquiry. The proposed Urban Greening Explorer will respond to this need through three interactive views: a point map of trees (Explore Trees), neighborhood-level choropleths and rankings (Neighbourhood Overview), and a simple density-based lens (Green Comfort Zones) that highlights where greenery is most concentrated.

## Research Gap

Previous work on Vancouver’s canopy tends to present citywide summaries or high-level targets but rarely connects individual tree records to neighborhood polygons for analysis. There is also limited effort to present these insights in a public-friendly, interactive format. This project fills the gap by building a reproducible workflow that joins tree points to Local Areas, computes density and basic indicators, and visualizes them through choropleths, rankings, and quantile-based comfort zones. This approach is intentionally descriptive, offering transparency into current patterns without making prescriptive planting recommendations.

## Assumptions

This project assumes that only public trees are included in the dataset, since private trees are excluded from the City of Vancouver’s inventory. Records without valid geographic coordinates are assumed unusable and therefore excluded from analysis. It is also assumed that the Local Area Boundaries provided by the city are accurate representations of Vancouver’s neighborhoods and can be treated as consistent spatial units for comparison. Although the public tree dataset refreshes monthly, some attributes such as planting date or diameter may not reflect the most current field conditions. For the purposes of this research, the dataset is treated as sufficiently accurate and representative to support exploratory neighborhood-level analysis.

## Potential Benefits

The Urban Greening Explorer will make Vancouver’s open data more accessible and interpretable to a broad audience by transforming raw records into interactive maps and comparisons. For community members, it offers an intuitive way to explore their local trees and better understand patterns of greenery in their neighborhoods. For planners and students, it provides a reproducible workflow for spatial analysis that highlights disparities in tree density across the city. The inclusion of Green Comfort Zones encourages public discussion about environmental equity, livability, and resilience to urban heat. By framing the tool as exploratory and research-oriented, the project contributes to civic data literacy and fosters new opportunities for public engagement with environmental sustainability.

# Proposed Research Project

## Objectives

The overarching objective of this project is to create an interactive, research-oriented dashboard that allows the exploration of Vancouver’s public tree dataset in ways that are both scientifically meaningful and publicly accessible. The first objective is to develop an interactive map interface (Explore Trees) that enables users to view individual tree records, filter by attributes such as species, planting year, and average diameter, and understand micro-level patterns in the city’s tree distribution. The second objective is to conduct spatial joins between tree locations and Local Area boundaries in order to compute neighborhood-level indicators such as total trees, unique species and density (trees per km²). These will be presented through choropleth maps, rankings, and comparative tables to provide a meso-level lens on urban greening (Neighbourhood Overview). The third objective is to define and visualize Green Comfort Zones by identifying neighborhoods in the top quantile of tree density. This perspective offers a macro-level understanding of where greenery is most concentrated, providing insights into potential environmental and social benefits associated with higher tree density.

## Methodology and Justification

The app follows a clear spatial data analysis process. First, the tree dataset is read in a way that correctly identifies location information, even if it is stored under different column names. Second, neighborhood boundaries are loaded from a digital map file and converted into a standard format so they can be displayed and measured accurately. Third, each tree is matched to the neighborhood it falls within. Fourth, neighborhood-level statistics are calculated, including the total number of trees, the number of different species (by scientific name), the average trunk diameter, and the earliest and most recent planting years. Finally, tree density is calculated as:

**trees per km² = tree count ÷ neighbourhood area (km²).**

This is a standard, interpretable metric in urban forestry and spatial planning for comparing green presence across bounded areas.

The “Green Comfort Zones” concept is intentionally simple and descriptive: neighborhoods at or above the 80th percentile of tree density are highlighted as relatively greener places under current conditions. The approach is grounded in common cartographic and exploratory data analysis practice using quantiles to make density differences legible without asserting health causality or recommending interventions. This design is justified by Vancouver’s Urban Forest Strategy emphasis on public understanding of tree benefits (City of Vancouver, 2025a), and established GIS practice for neighborhood comparisons using polygon areas, spatial joins, and choropleth visualization (Longley et al., 2015).

## Data Sources

This project uses local files only which are:

1. Public Trees (CSV)
2. Local Area Boundaries (GeoJSON)

both from the City of Vancouver Open Data Portal (City of Vancouver, 2025b; 2025c). No external APIs are used while all computations occur on the workstation, improving reproducibility and avoiding rate limits or schema drift.

## Data Analytics

The data processing begins by ensuring that only tree records with valid geographic coordinates are included, since some records in the City of Vancouver’s inventory may be incomplete. Each tree is then assigned to a Local Area Boundary, which allows the data to be aggregated and compared across neighborhoods. To ensure that density calculations are accurate, neighborhood areas are measured using a consistent projection that converts boundaries into square kilometers. From this foundation, summary tables are generated that show the total number of trees, the diversity of species, the average diameter, and the range of planting years for each area. These processed results provide the basis for the dashboard’s maps, rankings, and comfort zone visualizations.

## Indicators and “Green Comfort Zones”

Neighborhood indicators in this project include total trees, unique species, average diameter (inches), and planting year range. Tree density, defined as trees per square kilometer, is the central metric for comparing greenery across neighborhoods in a standardized way. Building on this, the app computes “Green Comfort Zones,” which highlight neighborhoods at or above the 80th percentile of tree density. While this measure does not directly capture oxygen levels or air quality, these zones can be understood as areas with relatively higher concentrations of trees that are likely to provide more shade, localized cooling, and stormwater absorption. They also serve as an intuitive way for residents to recognize greener spaces that may contribute to community well-being, aesthetic value, and resilience against urban heat.

From a research perspective, the comfort zones provide a transparent, reproducible lens for interpreting current patterns of tree distribution. They reveal disparities across neighborhoods, making it easier to reflect on questions of environmental equity without engaging in prescriptive planning or recommending specific planting actions. This framing encourages discussion about the role of greenery in urban environments while remaining exploratory and data-driven.

## Technology Stack

The application is written in Python using Streamlit for the user interface, Pandas/NumPy for tabular operations, GeoPandas/Shapely for spatial processing, pyproj for projections, Folium (with streamlit-folium) for interactive maps, and Altair for charts. This stack was chosen to maximize productivity for a single developer while producing publication-quality, browser-based outputs that are easy to reproduce and share.

## Expected Results

The project will deliver a functioning Explore Trees dashboard with three tabs. The Interactive Tree Map tab will render point markers with tooltips for species, planting date, and diameter and allow filtering by local area, species, common name, planting year, and minimum diameter. The Neighbourhood Overview tab will present a density choropleth and a sortable ranking table of local areas by trees per km² (with totals and unique species). The Green Comfort Zones tab will highlight neighborhoods in the top density quantile and list them in a table, alongside a shaded map. Beyond the software deliverable, the project contributes a reproducible workflow for transforming open civic data into interpretable neighborhood comparisons, advancing applied research on urban sustainability and public data use. The tool not only demonstrates applied spatial analysis but also contributes to broader discussions on how open data can be transformed into accessible, research-grade insights for the public.

# Project Planning and Timeline

The timeline for this project is structured across distinct phases, beginning with the proposal drafting and revision, and progressing through data wrangling, exploratory analysis, dashboard development, and final reporting. Table 1 summarizes these phases, their timing, milestones, and expected deliverables.

**Table 1. Summary of Project Phases, Milestones, and Deliverables**

|  |  |  |  |
| --- | --- | --- | --- |
| **Phase** | **Dates** | **Milestones** | **Deliverables** |
| Proposal Phase (Initial) | Sept 6 – Sept 17, 2025 | Brainstorm project ideas, explore and review datasets, drafted proposal according to the requirements and submitted. | Initial version of proposal submitted. |
| Proposal Revision | Sept 20 – Sept 27, 2025 | Incorporated professor’s feedback and removed bullet points, improved citations, removed “Tree Planning,” expanded “Explore Trees.” | Final revised proposal submitted. |
| Data Wrangling & Spatial Join | Sept 28 – Oct 2, 2025 | Robust CSV parsing, polygon normalization, projections, spatial join. | Cleaned tree & boundary datasets. |
| Exploratory Analysis & Visualizations | Oct 3 – Oct 10, 2025 | Species counts, planting years, initial charts, sanity checks. | Summary visualizations. |
| Dashboard Explore Trees Tab | Oct 11 – Oct 19, 2025 | Point map and filters/tooltips, stats panels, distributions, sampling logic. | Prototype Explore tab. |
| Midterm Report & Demo | Oct 20 – Oct 25, 2025 | Submit midterm report, present Explore Trees tab with preliminary neighbourhood table, record a midterm video demo showcasing the implementation so far. | Midterm report, demo, and midterm video submission |
| Neighbourhood Choropleth & Ranks | Oct 26 – Nov 5, 2025 | Area-based density, choropleth, sortable ranking table. | Draft Neighbourhood Overview tab. |
| Green Comfort Zones | Nov 6 – Nov 12, 2025 | Implement ≥80th percentile threshold, shaded map, supporting list/table. | Comfort Zones tab. |
| Testing & Usability | Nov 13 – Nov 20, 2025 | Debug, UI polish, performance, legends/accessibility, reproducibility check. | Refined dashboard. |
| Result Synthesis | Nov 21 – Nov 28, 2025 | Summarize insights and limitations, draft findings narrative. | Draft findings & rankings. |
| Final Report Writing | Nov 29 – Dec 7, 2025 | Methods, results, discussion, screenshots, and reproducibility notes. | Completed final report. |
| Defense Preparation | Dec 8 – Dec 15, 2025 | Slides, final app polish, rehearsal of live demo narrative. | Final defense presentation and working app. |

**Figure 1. Gantt Chart**

**A graph with green squares

AI-generated content may be incorrect.**

# Implemented Feature 1 – Explore Trees Dashboard

## Introduction

The first implemented feature, *Explore Trees*, represents a major milestone in transitioning from backend data wrangling to an interactive, map-based dashboard. This feature aligns with the first major objective of the proposal, which is to visualize Vancouver’s public tree data interactively at both point and neighbourhood levels. The overall direction remained consistent with the proposal. However, several refinements were made during implementation. There was no significant change of direction, as all planned components, including the map, filters, and statistics were delivered successfully. Only valid tree records containing latitude and longitude were plotted, as incomplete coordinates could not be reliably mapped. Before development, several mapping libraries such as Folium, Pydeck, and Kepler.gl were compared. Folium was selected for its simplicity, Streamlit integration, and ability to render GeoJSON overlays efficiently. The original midterm milestone was met on time, with additional improvements such as tooltip formatting and performance optimization integrated slightly ahead of schedule.

## Details of Implemented Feature

The *Explore Trees* tab provides an interactive Folium map embedded within a Streamlit web application. It integrates two datasets, *Public Trees (CSV)* and *Local Area Boundaries (GeoJSON)*, both obtained from the City of Vancouver Open Data Portal. A Folium map was initialized, centered on Vancouver, and styled using the CartoDB Positron base layer for visual clarity. Neighbourhood boundaries were overlaid using Local Area polygons, and when a user selects a neighbourhood via the sidebar, its outline is highlighted in green for emphasis. Each tree record is represented as a circular marker of uniform size, and to maintain responsiveness for large datasets, a sampling mechanism limits the display to 6,000 points at a time.

Each marker contains an interactive tooltip showing the tree’s common name, scientific name, planting year, trunk diameter (in inches), and neighbourhood. This design allows users to obtain detailed information without leaving the map interface. A layer control widget enables toggling between neighbourhood boundaries and point layers. The map dynamically adjusts zoom and centering based on the filtered dataset, while caching (@st.cache\_data) ensures smooth interaction and rapid data reloading. This implementation successfully transformed static CSV and GeoJSON data into an exploratory spatial visualization that users can navigate intuitively.

A map of a forest

AI-generated content may be incorrect.

*(Figure 1: Explore Trees Map View with Local Area Overlay)*

A map of a city

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*(Figure 2: Example Tooltip Displaying Tree Attributes)*

# Implemented Feature 2 – Sidebar Filters, Key Stats, and Distributions

## Introduction

The second implemented feature focuses on the data exploration interface, combining filters, summary statistics, and visual analytics into an integrated workflow. This part of the dashboard translates the processed tree data into meaningful insights through a responsive and intuitive layout. It allows users to explore Vancouver’s tree data from multiple perspectives, such as species, location, planting year, and size, all in real time. The direction of development remained consistent with the original plan, though greater attention was given to layout clarity and user experience after early testing. The overall goal of this component is to make civic data interpretation straightforward and engaging for both public and academic audiences.

## Details of Implemented Feature

The sidebar enables users to dynamically filter and refine the dataset, instantly updating the map and visual outputs. It provides dropdown selectors for Local Area, species (Latin), and common name, as well as sliders for minimum planting year and minimum diameter. These controls make it possible to focus on specific subsets of data, such as large trees planted after a certain year or species that dominate certain neighbourhoods.

Below the map, a *Key Statistics* panel summarizes essential information based on the active filters, including the number of trees displayed, unique species count, average diameter, and range of planting years. This section updates instantly as filters change, providing a clear snapshot of the dataset in context.

Two exploratory visualizations, built with Altair, complement these statistics. The first is a bar chart showing the top 15 most common tree species, and the second is a histogram illustrating the distribution of planting years. Together, these charts reveal species dominance and planting trends across decades. The interface is organized using Streamlit’s column layout, ensuring a balanced structure where the map, metrics, and charts flow naturally on the page. All captions, labels, and tooltips were revised for consistency and clarity. Performance testing confirmed that responsiveness remained smooth even with multiple filters applied simultaneously.

A screenshot of a phone

AI-generated content may be incorrect.

*(Figure 3: Sidebar Filter Options)*

*A graph of growth and growth

AI-generated content may be incorrect.*

*(Figure 4: Key Stats Panel and Charts Displaying Top Species and Planting Years)*

# Implemented Feature 3 – Neighbourhood Overview Tab

## Introduction

The third implemented feature introduces the *Neighbourhood Overview* tab, which provides a high-level summary of tree distribution and diversity across Vancouver’s neighbourhoods. This directly supports the project’s second objective, to compute and present greening indicators such as total trees, unique species, average diameter, planting-year range, and density (trees per square kilometre) for each Local Area. The feature’s development followed the proposal plan with minimal deviation, though additional emphasis was placed on improving readability. A sortable, scrollable data table was implemented instead of a choropleth map at this stage, prioritizing clarity and reproducibility. The choropleth visualization remains planned for the next development phase.

## Details of Implemented Feature

The neighbourhood-level metrics were generated through grouped aggregations of the tree dataset. The program aggregates records by Local Area and merges them with corresponding neighbourhood areas calculated in square kilometres. For each neighbourhood, the table presents the total number of trees, number of unique species, average trunk diameter, earliest and most recent planting years, and the computed density of trees per square kilometre.

The *Neighbourhood Overview* tab displays these indicators using Streamlit’s st.dataframe() component, offering sorting and scrolling functionality. This approach enables users to compare metrics across neighbourhoods directly, identify patterns of tree distribution, and recognize areas of higher or lower greening density. The table is dynamically generated using the same cleaned dataset employed in the *Explore Trees* tab, ensuring full consistency and preventing redundant computations.

This feature bridges the gap between individual-level data and citywide analysis, laying the groundwork for upcoming modules such as *Green Comfort Zones*, which will classify neighbourhoods by tree density percentile.

A screenshot of a computer

AI-generated content may be incorrect.

*(Figure 5: Neighbourhood Overview Tab Showing Summary Table of Tree Metrics by Local Area)*

# Lessons Learned and Future Work

Developing the *Urban Greening Explorer* has been an intensive learning experience that bridged several concepts from my coursework in data analytics, web development, and software engineering. Through this project, I learned to combine multiple data-processing libraries such as Pandas, GeoPandas, and Shapely to handle real-world geospatial datasets efficiently. Understanding coordinate systems, projections, and spatial joins helped me realize the practical complexity of working with location-based data. In addition, implementing the Streamlit dashboard allowed me to connect data science logic with front-end interactivity, reinforcing lessons from previous courses in user experience and software design.

Another key takeaway was the importance of performance optimization. When rendering thousands of data points on a Folium map, I learned that naive implementations could easily overload the browser. Introducing sampling, caching, and clean map layer management were crucial steps to ensure a smooth user experience. I also realized the significance of user-centered design, not just focusing on functionality but ensuring that the interface communicates information clearly and intuitively.

Looking ahead, the next phase of the project will expand the *Neighbourhood Overview* into a fully visualized choropleth map, displaying tree density and related metrics geographically. Another planned feature is the *Green Comfort Zones* module, which will highlight the top 20% of neighbourhoods by tree density. Beyond these features, I plan to integrate an AI-generated insight module within the *Green Comfort Zones* tab. After computing neighbourhood density metrics, the system will call a lightweight API to generate an automated summary describing the environmental characteristics of each area. For example, the AI could summarize which neighbourhoods show the highest diversity of species or the oldest average trees, and explain how greener areas may contribute to urban resilience. This enhancement will make the dashboard more interactive and narrative-driven, allowing users to gain not only visual but also textual interpretations of their data. It aligns with current trends in data storytelling and generative AI, transforming the project into an intelligent analytical tool rather than a static visualization.

This project has strengthened my technical foundation for a future career in data-driven environmental analytics, where programming, visualization, and sustainability intersect. The lessons learned in managing spatial data, optimizing performance, and designing intuitive interfaces will continue to guide my professional growth in the intersection of AI and urban data science.

# Concluding Remarks

The *Urban Greening Explorer* demonstrates how open civic data can be transformed into accessible, interactive insights that support environmental understanding and community engagement. By connecting individual tree records with neighbourhood-level indicators, the project offers both micro- and macro-level perspectives on Vancouver’s green infrastructure. The dashboard now allows users to explore species diversity, planting trends, and local tree density, bringing transparency to a dataset that was previously difficult for the public to interpret.

This midterm milestone represents a solid technical and conceptual foundation for the remainder of the project. The upcoming work will focus on extending visual layers, refining interactivity, and improving the interpretability of results through advanced mapping and statistical summaries. I would like to acknowledge Douglas College, my instructor Dr. Bambang A. B. Sarif, and my peers for their continuous feedback and support throughout the development process. Their guidance has helped shape this project into a meaningful contribution that blends environmental data science with public engagement.

# Appendix

The appendix provides supporting materials that help readers understand the *Urban Greening Explorer* project more thoroughly. It includes installation instructions, a user guide, dataset and software details, and a brief code explanation to ensure reproducibility.

## Appendix A: Installation Guide

To run the *Urban Greening Explorer*, the following steps should be followed:

**Prerequisites**

Make sure Python3 is installed on the system.

**Clone the app**

git clone https://github.com/emergingTechExplorer/F2025\_4495\_071\_LDi299

cd F2025\_4495\_071\_LDi299/Implementation

**Create a Python virtual environment**

python3 -m venv env

source env/bin/activate

**Install necessary packages**

pip install -r requirements.txt

**Run the app**

streamlit run app.py

The application will open automatically in your default browser at <http://localhost:8501>

## Appendix B: User Guide

The *Urban Greening Explorer* is a Streamlit-based web application designed for interactive exploration of Vancouver’s public tree dataset.

### Main Features

1. Explore Trees Tab:
   1. Displays a Folium map with tree markers and neighbourhood boundaries. Users can filter trees by neighbourhood, species, common name, planting year, and minimum diameter.
2. Neighbourhood Overview Tab:
   1. Shows a sortable summary table with aggregated greening indicators such as tree count, unique species, average diameter, planting year range, and trees per square kilometre.

### How to Use

1. Launch the app and navigate between the two available tabs.
2. Use sidebar filters to refine the dataset in the *Explore Trees* tab.
3. Hover over points on the map to view details in tooltips.
4. Switch to the *Neighbourhood Overview* tab to view area-level summaries.
5. The *Key Stats* panel and visual charts update dynamically based on the filters applied.

## Appendix C: Dataset and API Used

This project uses open data provided by the City of Vancouver Open Data Portal. All data is downloaded and processed locally to ensure reproducibility and offline access. No external APIs are used.

### Datasets

1. Public Trees (CSV)
   * Source: [City of Vancouver – Public Trees](https://opendata.vancouver.ca/explore/dataset/public-trees)
2. Local Area Boundaries (GeoJSON)
   * Source: [City of Vancouver – Local Area Boundary](https://opendata.vancouver.ca/explore/dataset/local-area-boundary)

## Appendix D: Software and Architecture

### Software Stack

1. **Programming Language:** Python
2. **Web Framework:** Streamlit
3. **Mapping Library:** Folium with Streamlit-Folium integration
4. **Data Processing:** Pandas, GeoPandas, NumPy
5. **Visualization:** Altair
6. **Version Control:** Git and GitHub

### System Architecture Overview

The application follows a simple client–server architecture. The Streamlit runtime handles both the backend data processing (spatial joins, aggregations, and caching) and the frontend user interface (maps, charts, and filters). All computation is performed locally, ensuring that data privacy and reproducibility are maintained.

## Appendix E: Code Explanation

The project’s main codebase resides in app.py. Key functions include:

1. **load\_trees()**
   1. Reads and cleans the Public Trees dataset, ensuring valid latitude and longitude coordinates and standardizing column names.
2. **load\_local\_areas()**
   1. Loads Local Area polygons from GeoJSON using GeoPandas, performs CRS projection to UTM for area computation, and returns a standardized GeoDataFrame.
3. **Spatial Join Logic**
   1. Combines tree points with their respective Local Area polygons to enable neighbourhood-level summaries. Tree density (trees/km²) is computed using area-based normalization.
4. **Map and Chart Rendering**
   1. Uses Folium for map visualization (with CartoDB Positron tiles) and Altair for bar and histogram charts.
   2. Caching (@st.cache\_data) ensures smooth updates when filters change.
5. **Explore Trees and Neighbourhood Overview Tabs**
   1. Implements the interactive interface, sidebar filters, dynamic statistics panel, and neighbourhood metrics table.

Each function is modular and well-commented to enhance readability and maintainability, ensuring future extensions such as *Green Comfort Zones* can be added seamlessly.

## References

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