



Vancouver
Green
Bus
Atlas

Agatha Czekajlo

My name is **Agatha Czekajlo** and I am currently an MSc student in the Integrated Remote Sensing Studio under Dr. Nicholas Coops' supervision (Forest Resources Management Department, Faculty of Forestry, UBC). My project involves the characterization of peri-urban land use of select major Canadian cities over the past three decades, from 1984 to 2016. To do this I use freely-available Landsat satellite imagery in combination with other geospatial datasets and socio-economic census data. I am focusing part of my efforts in the application of these methods to distinguish urban green spaces and summarize their change spatially (within and between cities), as well as temporally over the 33-year time series. My work heavily relies on the use of GIS for spatial analysis and visualization.

My academic involvement with urban studies has exposed me to many urban related **social** and **environmental** issues. The City of Vancouver has set a goal to reduce its greenhouse gas emissions by 80% below 2007 levels by the year 2050¹. That is a reduction of 224,400 tons of CO₂ emissions (tCO₂e). By 2017 the City of Vancouver has been emitting 2,610,000 tCO₂e, still a long way off from the goal of emitting at most only 561,000 tCO₂e by 2050. One way the City of Vancouver has proposed to reach this emissions goal is to encourage the use of greener transportation options, including public transit, making them the majority (over 50%) of trips taken.

*... a bus ride with **more visible greenness** will generate a **more pleasant riding experience** and encourages greater riderships ...*

*... existing literature has largely focused on objectively measuring transit **accessibility** rather than the **experience** ...*

Although increased transit use is a key component of achieving emission reduction and enabling sustainable urban development, this is typically not a preferred option by commuters. Existing literature has largely focused on objectively measuring transit accessibility but only a handful investigate the overall riding experience of transit users. In Vancouver, commuters can often spend several hours using transit daily. From my own experience, I regularly commute ~3 hours a day from New Westminster to UBC. Improving that experience is crucial to encourage greater transit use in Vancouver and aid in reaching emission targets.

Urban green spaces, which are spaces in urban areas that include some vegetation, such as parks, urban forests, wetlands, and street verges², positively impact our wellbeing. They have the potential to provide essential ecosystem services to our concrete-ridden environment, such as regulating temperature, and reducing air pollution^{3,4}. Urban green spaces are related to have positive impacts on individual wellbeing by improving our mental health^{5,6}, as well as providing areas for recreation, increasing aesthetic and economic values⁷.

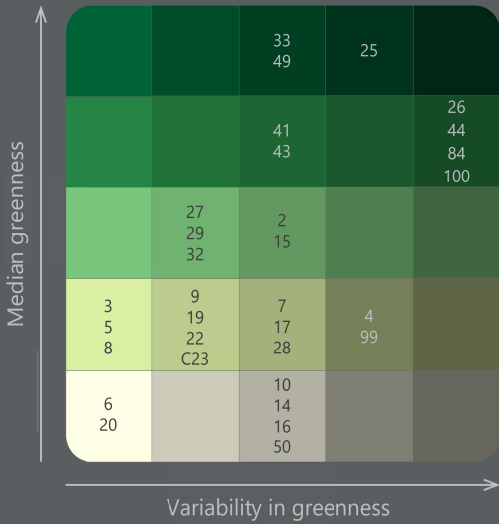
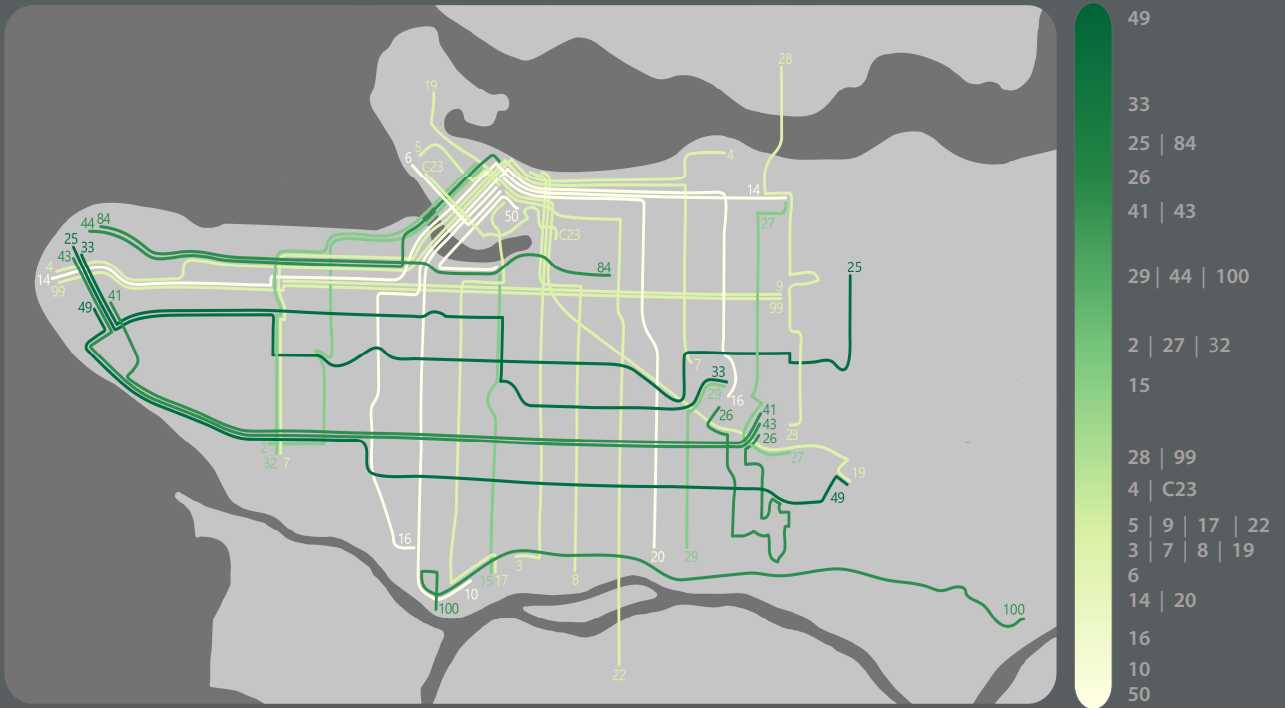
... **Google street view images** offer a more *relatable* measure of *street level greenness* ...

A map that shows which Vancouver bus routes provide the most green space exposure is an innovative indicator to the overall ridership experience of public transit. Based on previous literature, my assumption is that a bus ride that includes more visible greenness will generate a more pleasant riding experience, and thus encourage greater ridership of that route. Contrastingly, routes that lack green spaces should be prioritized by The City of Vancouver. However, traditional geospatial measures of green spaces from aerial photography or satellites that use a bird's-eye view do not directly correlate to what transit users can actually see during their rides. **Google street view images** offer a more relatable measure of street-level greenness as their imagery are taken at the height of a regular-sized car.

My **Green Bus Atlas** shows which Vancouver bus routes provide the greenest experience. Green for the context of this project refers to the amount of trees and other vegetation that are visible in the space. To do this, I have downloaded Translink's (Vancouver's Transit company) bus route data⁸ and selected the regularly-scheduled bus routes that have the majority of their route within the City of Vancouver. Additionally, I acquired street-level tree fraction data, which was extracted from 2018 Google Street View images, from Middel et al. (2019) at the Canadian Urban Environmental Health Research Consortium (CANUE)⁹.

How I did it.

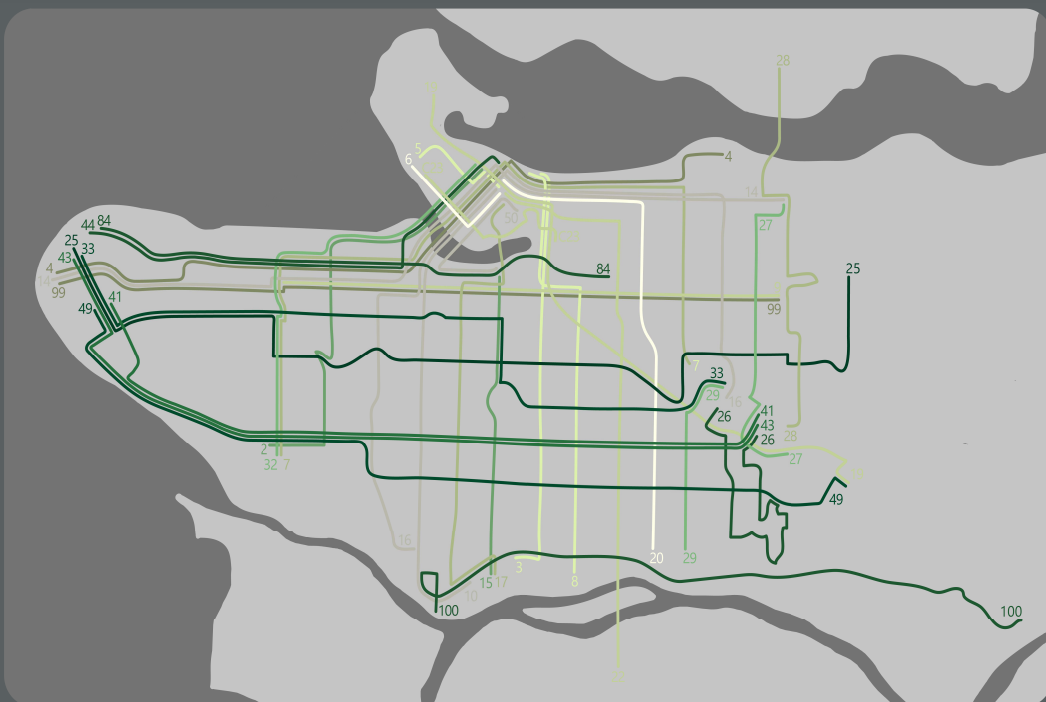
To create these maps, I used ***Spatial Join*** on the tree fraction point data with the 32 selected Vancouver bus routes, and matched within a radial distance of 25 m to allow for spatial inconsistencies between the two datasets. I used the ***Generate Points Along Line*** function to create points along each bus route at 12.5 m intervals, in order for these points to correspond with at least 2 observations of tree fraction data (which occurred mostly 9 – 11 m apart). Next, I executed the ***Split Line at Point*** function on each of the bus routes using the points I generated in the previous step to separate each bus route into up to 500 m segments. Using the ***Spatial Join*** function twice, with the ***Field Map of Join Features*** option set to median the first time and standard deviation of tree fraction for the second, I calculated the median and standard deviation of tree fractions for each 500 m bus route segment. Additionally, I calculated the median and standard deviation of the tree fraction for each entire bus route. I normalized the median tree fractions using the ***Field Calculator*** in order to make comparisons between and within bus routes. Next, I categorized the normalized median tree fractions, as well as the normalized standard deviations of tree fractions, into 5 intervals for all routes. The 25 combinations of normalized median tree fraction intervals and normalized standard deviation of tree fraction intervals were summarized into a 5 x 5 green score matrix. After exporting the bus route maps from ArcGIS, I used Adobe Illustrator for aesthetic enhancement.



Of the **32 bus routes** analyzed, the majority fall towards the low end of the greenness (i.e. median tree fraction) spectrum. Since buses tend to take major roads for their routes, this is not surprising. However, the **top 5** greenest bus routes in the City of Vancouver are:

- #49** (Metrotown - Dunbar - UBC)
- #33** (29th Avenue Station - UBC)
- #25** (Brentwood Station - UBC)
- #84** (VCC-Clark Station - UBC)
- #26** (Joyce Station - 29th Avenue Station)

The first four of these routes pass through Pacific Spirit Park, a large densely-forested park, along the way to UBC. When the variability of greenness (i.e. standard deviation of tree fractions) is also considered, it becomes clear which green routes use busier and more developed roads. The **#49** and **#33** use lower density roads and show less variability in greenness. Contrastingly, the **#84** and **#44**, which similarly travel in the East-West direction but on busier roads closer to downtown, show higher greenness variability.



49

The #49 (Metrotown - Dunbar - UBC) is the **greenest** Vancouver bus route. It passes by two large parks: Pacific Spirit Park on the UBC Endowment Lands and Central Park on the Vancouver-Burnaby city edge. Additionally, the #49 passes through lush neighborhoods, such as Dunbar-Southlands.



99

The #99 B-Line (Commercial-Broadway - UBC) is the **busiest** route in Greater Vancouver, enabling ~17 million annual boardings over the past 5 years¹⁰. However, the amount of visible green spaces along this route is quite average, putting it in only **15th** place. Pacific Spirit Park on the UBC Endowment Lands is also along this route, and contributes the the most greenness. Other green parts are along East Broadway between Granville St. and Cambie St., as well as along East Broadway between Nanaimo St. and Rupert St.



10

The #10 (Downtown - Granville - Marpole) is one of Vancouver's **least green** bus routes. Although it passes through the tree-rich neighborhood of Shaughnessy, a lot of the route also runs through densely developed areas like Downtown, South Granville, and Kerrisdale-Oakridge. A surprising patch of matured street trees and a small park green-up the southern portion of the #10 route around the cross-section of West 57th Avenue.

