Understanding the carbon sequestration value of the City of Victoria's urban forest

EXECUTIVE SUMMARY

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Disclaimer

This report was produced as part of the UBC Sustainability Scholars Program, a partnership between the University of British Columbia and various local governments and organizations in support of providing graduate students with opportunities to do applied research on projects that advance sustainability across the region.

This project was conducted under the mentorship of City of Victoria staff. The opinions and recommendations in this report and any errors are those of the author and do not necessarily reflect the views of the City of Victoria or the University of British Columbia.

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Introduction

City of Victoria's existing urban forest data and the quantification of the amount of carbon that is sequestered by trees in the city and the knowledge of resilience benefits (such as avoided stormwater runoff, shading and cooling benefits, pollution absorption, aesthetic etc.) can give the city a more fulsome picture of its greenhouse gas inventory and a deeper understanding of the value of the urban forest. Insight into the additional ecosystem services and benefits trees provide would directly aid the city in future management of the urban forest and climate adaptation measures. Nature based solutions (NBS) are a way used by the Government of Canada towards achieving a net-zero greenhouse gas emissions by 2050 since NBS can contribute toward removing 1/3rd of the atmospheric carbon dioxide (Griscom et al., 2017). Urban Forests are one such nature-based solutions. Trees reduce runoff via various process such as: transpiration, interception, soil erosion reduction, and by increasing soil absorption. However, these depend on the tree species, tree canopy cover and leaf area density[1]. They also absorb and provide a remedy to trace amounts of toxic chemicals like metals, fuels, and solvents (United States Environmental Protection Agency, 2013). Urban forests also help in reducing flooding and improve a city's water quality (The Mersey Forest, 2014).

Objectives

To access the benefits of urban forest in carbon sequestration and resilience benefits the project had three objectives:

1. Estimate the carbon storage in urban forests using iTree Eco and break the analysis down into information that can further drive City policies. e.g., carbon sequestration by species and, such as neighborhood, to support community level carbon sequestration tracking, trends, and potential target setting.
2. Use i-Tree Eco and Hydro, to review additional urban forest ecosystem services to assess the resiliency benefits such as and stormwater attenuation by catchment/watershed.
3. Undertake a feasibility assessment to establish if existing private urban forest data is sufficient to estimate carbon sequestration values. If feasible, develop and apply a methodology to estimate the carbon sequestration value of trees in the City of Victoria on private lands at the neighborhood and catchment/watershed level.

[1] https://treecanada.ca/resources/canadian-urban-forest-compendium/17-stormwater-management-and-urban-forests/. Accessed on June 02, 2022

Research Approach

Objective 1

Tree species data were taken from Tree Keeper data about the City's urban forest on public land and analyzed for carbons storage and sequestration using iTree Eco. Carbon contents were further broken down according to age class, species, and community areas. iTree Eco is a model that uses tree measurements and local hourly air pollution and meteorological data to estimate ecosystem services and structural characteristics of the urban forest. It is developed by USDA Forest Service[2].

Objective 2

iTree Hydro was further explored considering that it provides comprehensive processing of hydrologic effects than iTree Eco. It simulates the effects of changes in urban tree cover and impervious surfaces on the hydrological cycle, including streamflow and water quality, for watershed and non-watershed areas. It is a vegetation-specific urban hydrology model, developed to model urban vegetation effects so natural resource managers and urban planners can quantify the impacts of changes in tree and impervious cover on local hydrology to aid in management and planning decisions. It models the hydrological cycle and estimates runoff volume using elevation (Digital elevation model or Topography maps), land cover, weather, and hydrological parameters. Feasibility study of iTree Hydro was carried out for the storm water attenuation for catchment areas of Victoria. Digital Elevation Model were prepared for catchment areas. There were barriers to certain hydrological parameters such as annual average flow of catchment area, soil type, wetting front suction, effective porosity, surface hydraulic conductivity, max depth of water in the upper soil zone, initial soil saturation, land base proportions. So iTree Eco was used for stormwater runoff estimation.

Objective 3

Lidar data was used for the feasibility assessment. The steps taken were: 1) Lidar derived digital models: Digital Elevation Model (DEM) and Digital surface model (DSM), 2) Canopy height models (CHM), 3) Locating treetops using LiDAR: Minimum height 'hmin' technique was applied using the 'find_trees' function in lidR (R package).

[2] https://www.itreetools.org/. Accessed online on April 11, 2022

Summary

The total carbon stocks in the urban trees of public areas in the City of Victoria is 24,237 tonnes sequestered at the average rate of 240 tonnes per year. Species such as Gary oak (*Quercus garryana*), Cherry plum (*Prunus cerasifera*), Elm (*Ulmus carpinifolia*), Big maple leaf (*Acer macrophyllum*), Horsechestnut (*Aesculus hippocastanum*), Douglas fir (*Pseudotsuga menziesii*) *etc.* stored more carbon stocks and covered higher canopy cover than other species.

Avoided runoff and pollution removals were estimated based on local weather from the designated weather station for stormwater basins. The estimated avoided runoff and pollution removal by urban trees aligned with the tree cover area which signifies that, the more the area of catchment is covered by trees the better the avoided runoff and pollution removals. Trees and forests reduce stormwater runoff by capturing and storing rainfall in the canopy and releasing water into the atmosphere through evapotranspiration which regulates water cycle.

The study also recognized the benefits of parkland trees vs boulevard trees in avoiding the runoff. The parkland trees avoided more storm water runoff. Parklands have more vegetated areas which allows the runoff to slowly absorb into the ground while the boulevards have pavements and allows more water to run to longer drain leading to the gutters, inlets and pipes that make up the storm drainage system and finally flow to streams and rivers. Vegetative surfaces and trees help improve stream quality and watershed health primarily by decreasing the amount of stormwater runoff and pollutants that reaches water systems.

Recommendations

1. Along with carbon benefits urban trees have a lots of other resilience benefits so before substituting the matured trees, managing them well is crucially important. Although the carbon absorption is slow in matured forest, tree canopy cover is larger, and this greatly helps in stormwater management. So, a careful and detailed planning to replace the matured tree is crucial.
2. Increase of green structures such as: rain gardens, permeable pavements, rainwater harvesting systems *etc.* need to be increased in the parking lots, boulevards to increase the absorption of stormwater. Increasing green structure might provide an opportunity to replace matured trees because green structures could offset the benefits of the canopy cover at least for a short run-in stormwater management until a newly planted tree grows a great canopy.

3. Areas like downtown have a smaller number of trees so I recommend increasing new planting sites. This can add to the beauty of the city as well provide multiple benefits.
4. iTree Hydro is a sophisticated model for stormwater attenuation. So, I highly recommend the hydrological parameters' barriers listed in this study be overcome.
5. Along with the public areas the carbon stocks and sequestration of private forests are equally important. Lidar data seems to be useful, so I highly recommend the completion of Lidar data feasibility study and applying it for the private urban forests.

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