Optimizing Ecosystem Services of Urban Forests for Climate Resilience

MScSM
Master of Science in Sustainability Management UofT

Valerie Lin
Supervisor: Tenley Conway
MScSM Class of 2024 | SSM1100

Background

'Urban forests' is often used as an all-encompassing term for urban vegetation, including individual trees or a collection of trees that exist in urban areas. The implementation of urban forests as a climate adaptation solution is commonly employed in North America. However, knowledge gaps exist in how urban forests might mitigate climate change impacts and the key tree traits to consider in urban forest management. This paper seeks to fill some of the knowledge gaps by exploring the interactions between urban forests, their vulnerabilities against climate change, and three urban sustainability issues: urban heat island effect, carbon sequestration, and stormwater management.

Research Question

What needs to be considered by the City of Toronto to ensure its urban forest provides the ecosystem services that can help mitigate and adapt to climate change?

Methodology

Literature Review

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) method was used to conduct a literature review. The PRISMA method consists of a multi-step checklist in which the parameters of the literature search are defined by a set criteria.

Literature Analysis

A synthesis matrix was utilized to organize and analyze differing perspectives across all selected literature. Some factors and metrics used were: tree species, age, and size, ecosystem service measured and magnitude, and study region.

Areas of Focus

Urban Heat Mitigation

- Increases in tree canopy cover is positively linked to reductions in surrounding air temperature
- Trees that are planted without in-between spaces can maximize canopy shading
- Pavement and infrastructure affect cooling capacities of urban forests

Stormwater Management

- Rough and rigid tree surfaces are better at intercepting precipitation
- Coniferous species are more effective at rainfall interception and run-off mitigation
- Dense tree canopies improve interception rates
- Rainfall intensity and duration is a significant indicator of interception rate

Carbon Sequestration

- Evergreen trees sequester carbon at a higher rate than deciduous trees
- Mature and larger trees have a higher carbon sequestration capacity
- Areas with minimal shading facilitate greater carbon sequestration
- Height, wood density, and leaf area are good proxies for sequestration rate

Climate Change Vulnerability

- Temperature is a greater indicator of vulnerability than species composition
- Hotter and drier climates are more vulnerable to climate change impacts
- Deciduous species may be more vulnerable to climate change in North America
- Non-native species may better adapt to changing climates than native species

City of Toronto

Aims to:

- Increase tree canopy coverage by 40% by 2050
- Increase native biodiversity
- Increase size diversity by planting mid-large sized trees
- Improve planting list to include climate-adaptive species
- Improve genetic diversity of native tree species

Key Considerations

- Tree species
- Tree size
- Tree surface texture
- Spatial configuration
- Deciduous vs. evergreen
- Canopy density
- Foliage attributes
- Soil respiration
- Root structure
- Seasonality

Almas, A. D., & Conway, T. M. (2016). The role of native species in urban forest planning and practice: A case study of Carolinian Canada. Urban Forestry & Urban Greening, 17, 54–62. https://doi.org/10.1016/J.UFUG.2016.01.015
Berland, A., Shiflett, S. A., Shuster, W. D., Garmestani, A. S., Goddard, H. C., Herrmann, D. L., & Hopton, M. E. (2017). The role of trees in urban stormwater management. Landscape and Urban Planning, 162, 167–177. https://doi.org/10.1016/J.LANDURBPLAN.2017.02.017
Esperon-Rodriguez, M., Tjoelker, M. G., Lenoir, J., Baumgartner, J. B., Beaumont, L. J., Nipperess, D. A., Power, S. A., Richard, B., Rymer, P. D., & Gallagher, R. v. (2022). Climate change increases global risk to urban forests. Nature Climate Change 2022 12:10, 12(10), 950–955. https://doi.org/10.1038/s41558-022-01465-8
Khan, T., & Conway, T. M. (2020). Vulnerability of Common Urban Forest Species to Projected Climate Change and Practitioners Perceptions and Responses. Environmental Management, 65(4), 534–547. https://doi.org/10.1007/s00267-020-01270-z
Konijnendijk, C. C., Ricard, R. M., Kenney, A., & Randrup, T. B. (2006). Defining urban forestry – A comparative perspective of North America and Europe. Urban Forestry & Urban Greening, 4(3–4), 93–103. https://doi.org/10.1016/J.UFUG.2005.11.003
Howe, D. A., Hathaway, J. M., Ellis, K. N., & Mason, L. R. (2017). Spatial and temporal variability of air temperature across urban neighborhoods with varying amounts of tree canopy. Urban Forestry & Urban Greening, 27, 109–116. https://doi.org/10.1016/J.UFUG.2017.07.001
Pasher, J., McGovern, M., Khoury, M., & Duffe, J. (2014). Assessing carbon storage and sequestration by Canada's urban forests using high resolution earth observation data. Urban Forestry and Urban Greening, 13(3), 484–494. https://doi.org/10.1016/j.ufug.2014.05.001
Ren, Z., He, X., Pu, R., & Zheng, H. (2018). The impact of urban forest structure and its spatial location on urban cool island intensity. Urban Ecosystems, 21(5), 863–874. https://doi.org/10.1007/S11252-018-0776-4/FIGURES/4
Selbig, W. R., Loheide, S. P., Shuster, W., Scharenbroch, B. C., Coville, R. C., Kruegler, J., Avery, W., Haefner, R., & Nowak, D. (2022). Quantifying the stormwater runoff volume reduction benefits of urban street tree canopy. Science of The Total Environment, 806, 151296. https://doi.org/10.1016/J.SCITOTENV.2021.151296
Sustaining and Expanding the Urban Forest: Toronto's Strategic Forest Management Plan. (2013).
Wang, Y., & Akbari, H. (2016). The effects of street tree planting on Urban Heat Island mitigation in Montreal. Sustainable Cities and Society, 27, 122–128. https://doi.org/10.1016/J.SCS.2016.04.013