LEAF REMOVAL PROGRAM:

MAPPING SEASONAL TREE LEAF DEBRIS ACCUMULATION SCENARIOS IN A CHANGING CLIMATE

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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 the City of Vancouver 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 Vancouver or the University of British Columbia.

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02

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03

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04

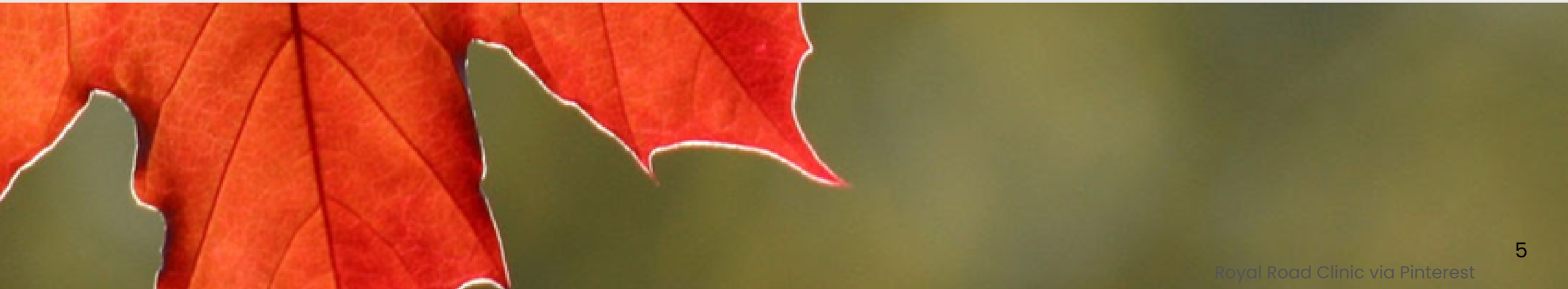
CONSIDERATIONS FOR THE FUTURE

GOALS OF THE PROJECT

Identify opportunities to **optimize Sanitation Operations** (**Leaf Cleaning Program**) based on tree ecological knowledge and climate change

Develop maps to inform crew allocation for leaf removal based on tree types and seasonality.

PROBLEM STATEMENT



Royal Road Clinic via Pinterest

IDENTIFIED OPERATIONAL CHALLENGES IN

LEAF REMOVAL SERVICE

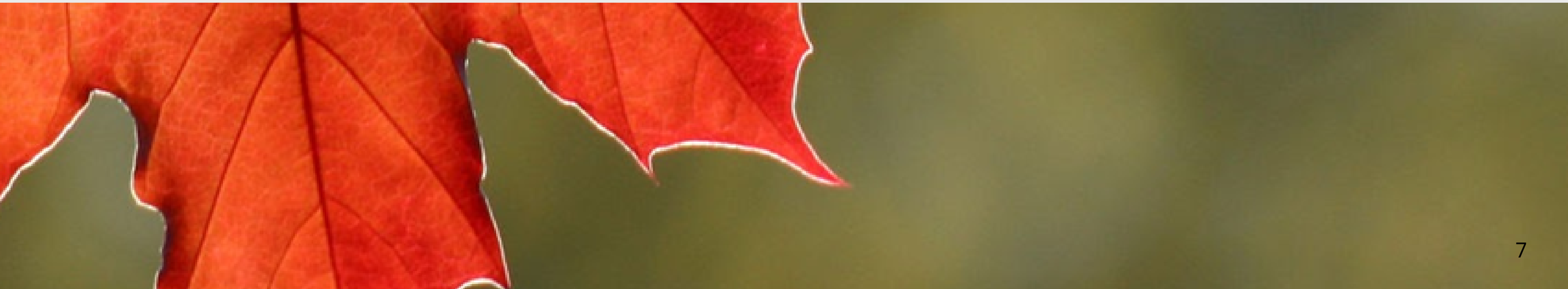
1. **Decoupling** between service schedule and leaf-fall patterns

2. Areas of **high volume accumulation** of leaf litter

3. **Unpredictability** for planning the following season

TREE ECOLOGY & CLIMATE CHANGE

Relevant for addressing operational challenges



WHAT NORMALLY MAKES LEAVES FALL DOWN ?

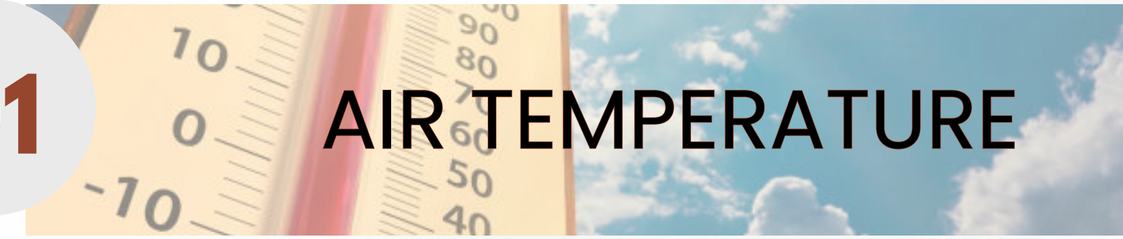
Trees in temperate regions have evolved over millions of years to adapt to low temperatures and short day light.

A group of trees called **deciduous**, drop their leaves in Autumn mainly to save nutrients and water.

Basically, it allows the tree to save energy and survive for the next growing season.

RESPONSE TO CONSTANT DECREASE IN

01



02

REVEALING

AUTUMN COLORS

As temperature and sunlight decrease, **chlorophyll** the green pigment that trees use to produce sugar, starts to break down

Starting to reveal to the human eye other pigments present in the leaves

When the process is completed, the cells that bound the leaf to the branch die off and the leaf will drop.

THE EXACT CONDITIONS REQUIRED

WILL VARY WITH THE SPECIES/TREE TYPE

CHESTNUT

MAPLES

OAKS

Less tolerant

COLD TOLERANCE

More tolerant

WHAT HAPPENS UNDER CLIMATE CHANGING CONDITIONS?

ADDING COMPLEXITY TO THE ALREADY COMPLEX PHENOMENON

TEMPERATURE

+DAY Temperatures =
+Evapotranspiration =
Earlier leaf-fall due to drought

+ NIGHT Temperatures =
+ Trapping of chlorophyll =
Delayed leaf-fall due to higher sugar production

PRECIPITATION & AIR HUMIDITY

-Precipitation =
+Water stress =
Earlier leaf-fall due to drought

+Precipitation =
+ Relative humidity=
Delayed leaf-fall due to lack of chemical signaling

SPRING-FALL RELATIONSHIP AND OTHER UNKOWNS

Earlier leaf unfolding=
earlier leaf fall and vice versa

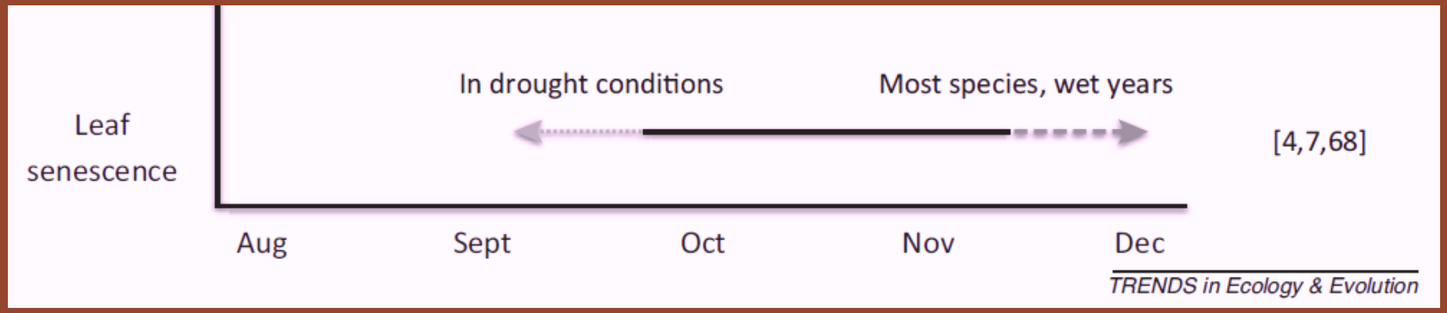
Increased CO2, nitrogen availability can delay leaf fall, intraspecific variability, etc.

THE SCIENTIFIC COMMUNITY IS TRYING TO UNDERSTAND THIS COMPLEXITY TO

FIND PATTERNS AMONG SPECIES

With increased temperatures and drier conditions, **SOME** species will drop their leaves earlier.

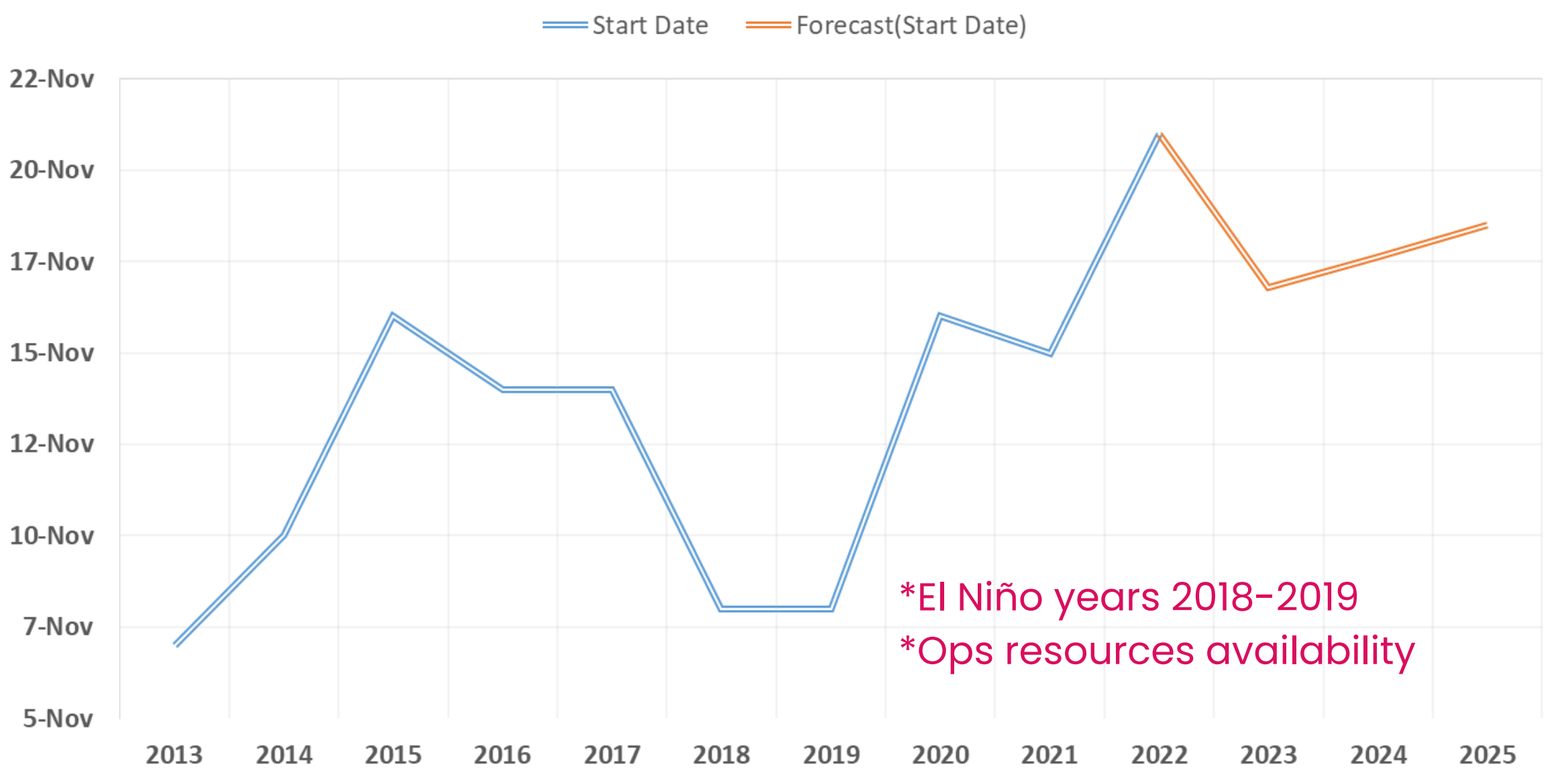
But with warm conditions and higher humidity, **MOST** species will delay the foliage dropping.



Gallinat et al. 2015

OBSERVED TREND IN VANCOUVER

ACCORDING TO HISTORICAL START DATES OF LEAF COLLECTION



Year	Start Date
2013	7-Nov
2014	10-Nov
2015	16-Nov
2016	14-Nov
2017	14-Nov
2018	8-Nov
2019	8-Nov
2020	16-Nov
2021	15-Nov
2022	21-Nov
2023	?

WORLD METEOROLOGICAL ORGANIZATION

2023: EL NIÑO YEAR

- *El Niño* is a weather cyclic event causing drier summers in the Pacific Northwest due to warming sea surface anomalies
- *La Niña* is the cooling phase of the weather oscillation, brings heavier rains, cooler temperatures in fall and winter

SO HOW CAN WE TACKLE THE COMPLEXITY FOR OPTIMIZING THE LEAF PROGRAM??

THE BRIGHT SIDE

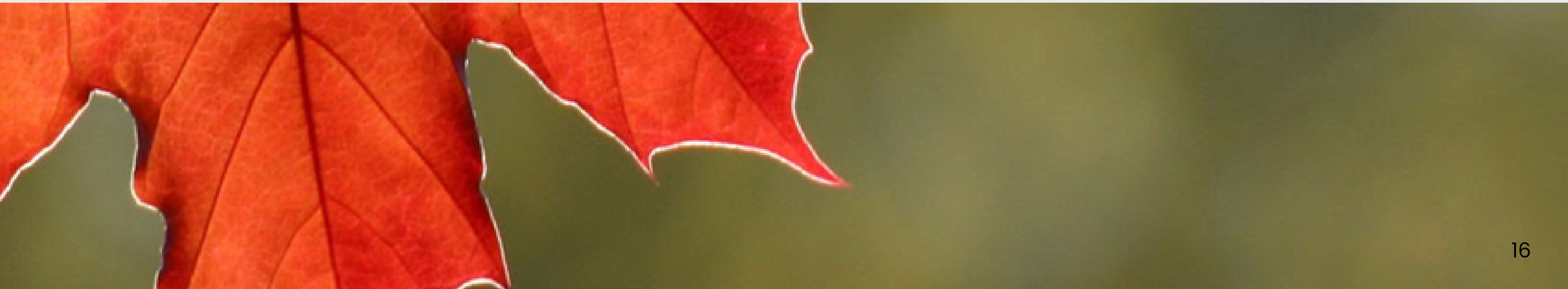
Regardless of the starting time of leaf-drop, which will **likely continue to be delayed...**

...each species will show a consistent response in leaf fall-timing

Therefore, we can draft a **leaf-drop sequence scheme per tree type**

ANALYTICS & OUTCOMES

Strenghts and limitations



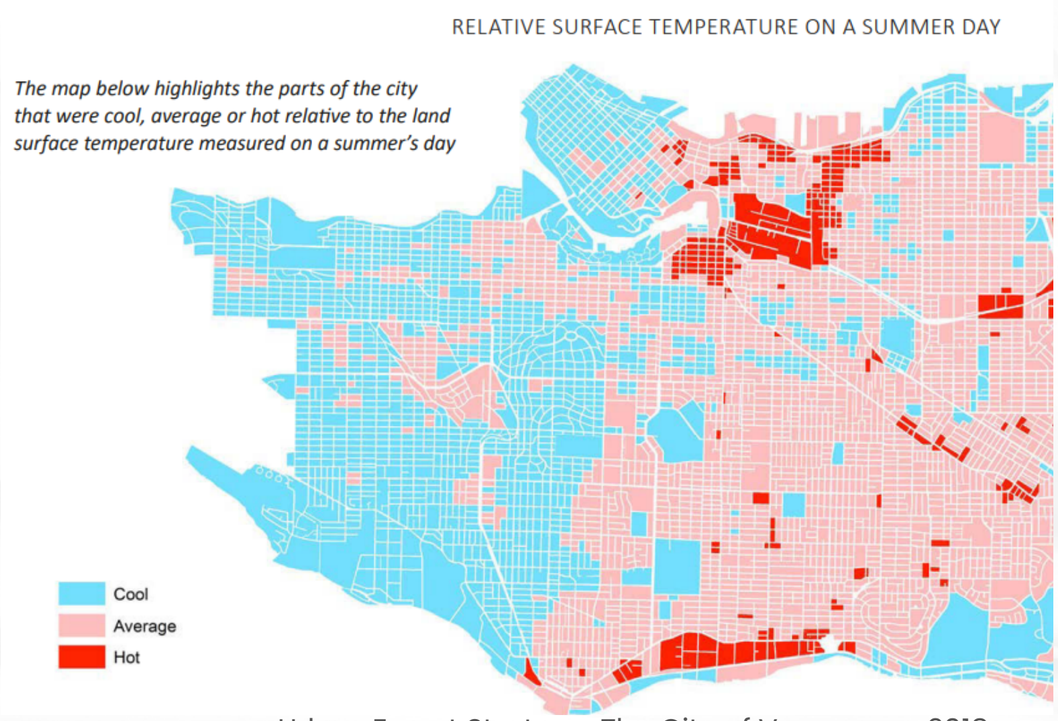
WHAT THE STUDY COVERS

STRENGHTS

- The more common and more abundant trees in Vancouver, which cover approx. 60% of the canopy coverage. Data from Urban Forestry Inventory & spatial database.

- Mature trees and old trees only, with a dense canopy that contributes significantly to leaf debris, identifying hotspot areas of high volume of leaves

- The sequence of leaf-fall among species, providing a classification according to their timing.



Urban Forest Strategy, The City of Vancouver, 2018

WHAT COULD BE INCLUDED NEXT

LIMITATIONS

- Variations within city microclimates
- Variations due to irrigation, soil conditions or tree halth conditions
- Analysis of the exact start date of the leaf-fall season, considering climate conditions and weather events such as El Nino and La Nina.

MOST COMMON AND MORE ABUNDANT TREES

Maple Trees

25%

Two dominant species:

Norway Maple
Bowhall Red Maple

Cherry Trees

20%

Two dominant species:

Kanzan Cherry
Pissard Plum

Ash Trees

5%

No dominant species (10)

Oak Trees

5%

No dominant species (18)

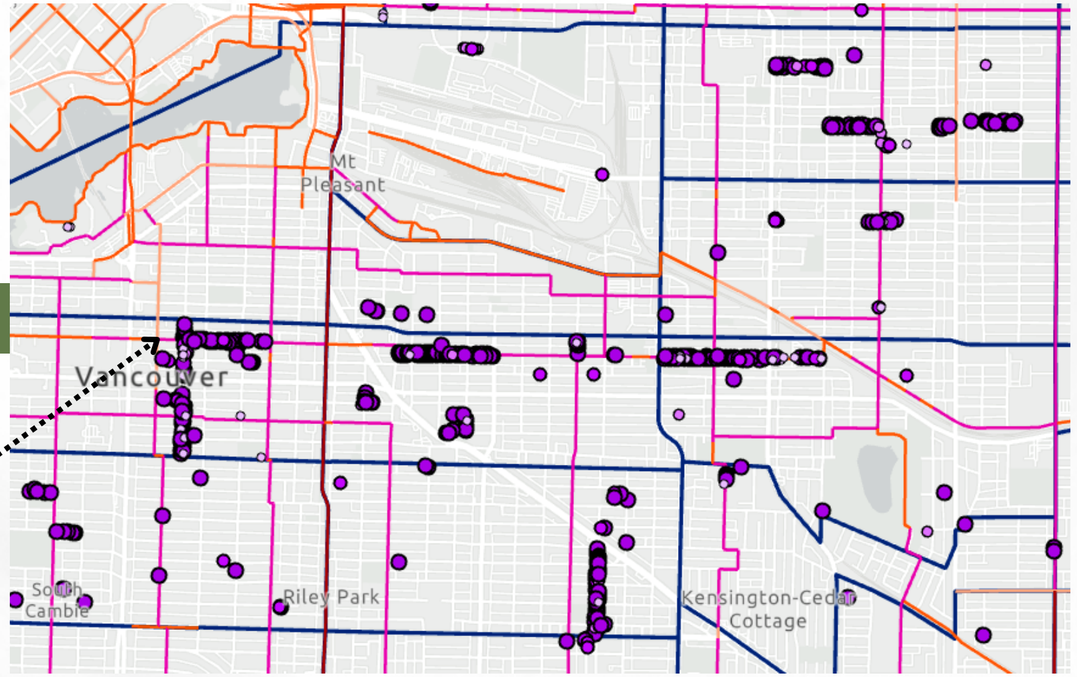
OTHER INCLUDED SPECIES

Horsechestnut

1.7%

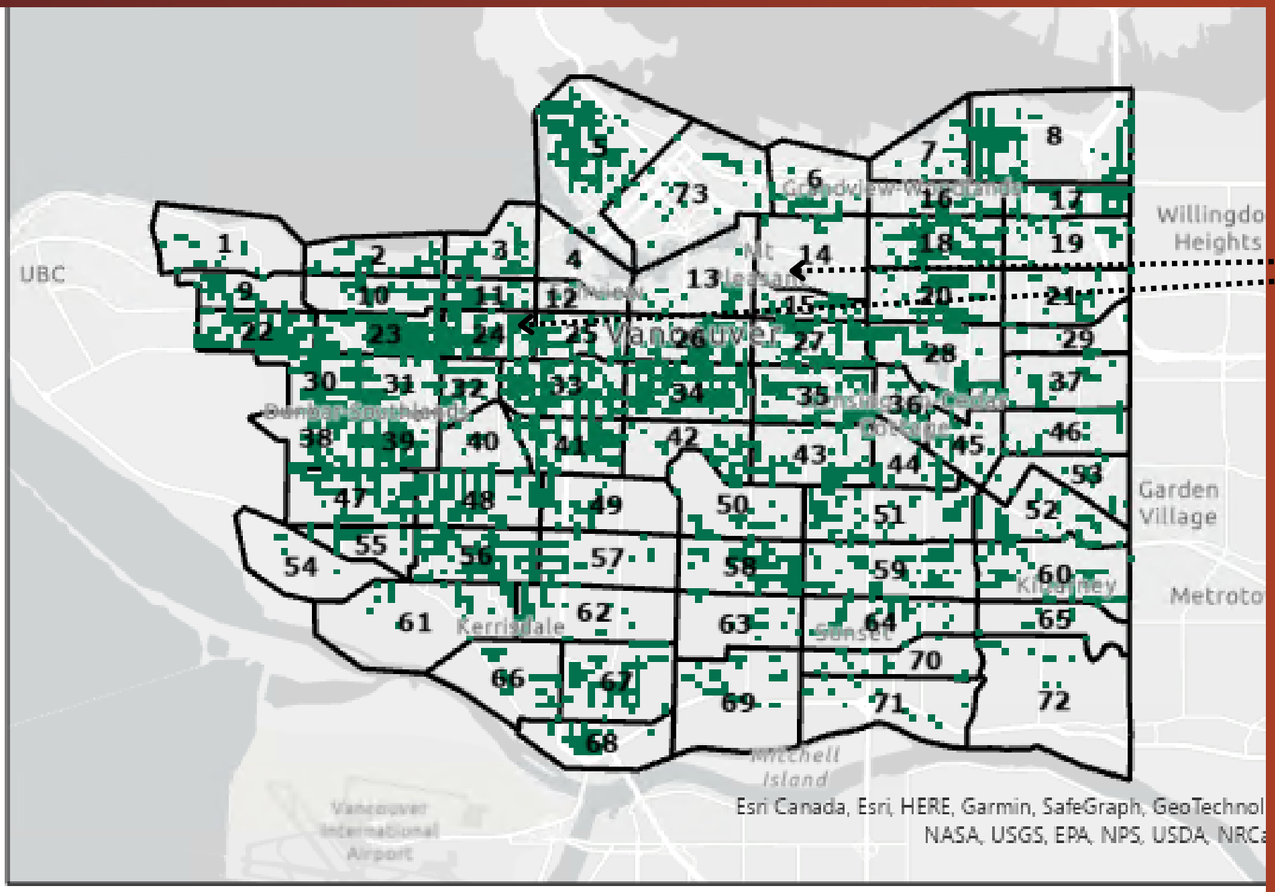
Due to records of safety concerns associated with its debris on bikeways

i.e. E 10th Avenue



IDENTIFICATION OF AREAS OF HIGH VOLUME ACCUMULATION

BY ESTIMATING CANOPY DENSITY



- Considerable differences in the expected leaf volume across service zones.

- Denser service zones will likely take more time to complete.

zones 22, 23 & 24 = high volume
zones 4, 13, 14 = low volume

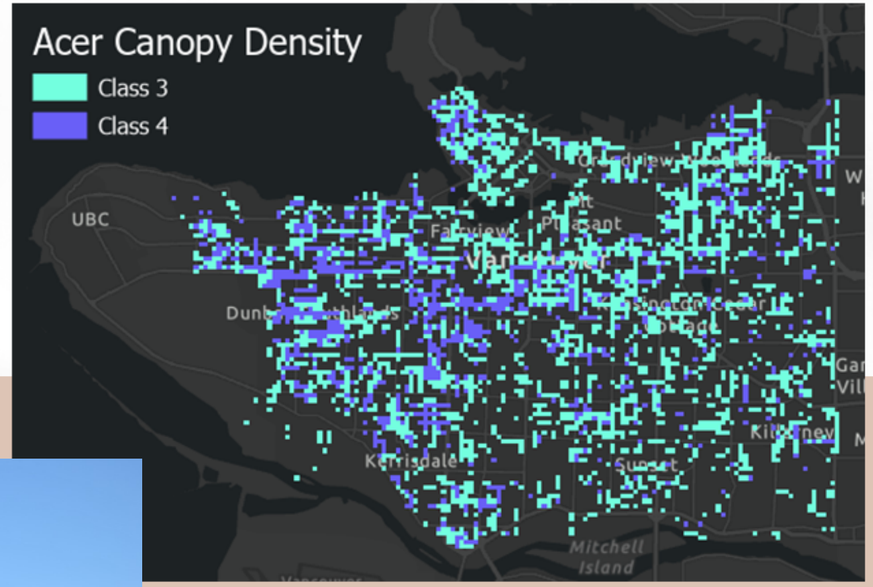
How does this map contrasts your experiences in the field?

Trees' canopy continues to develop over the years.
With the classification of young, mature and old trees it is possible to project hotspot areas in the future.

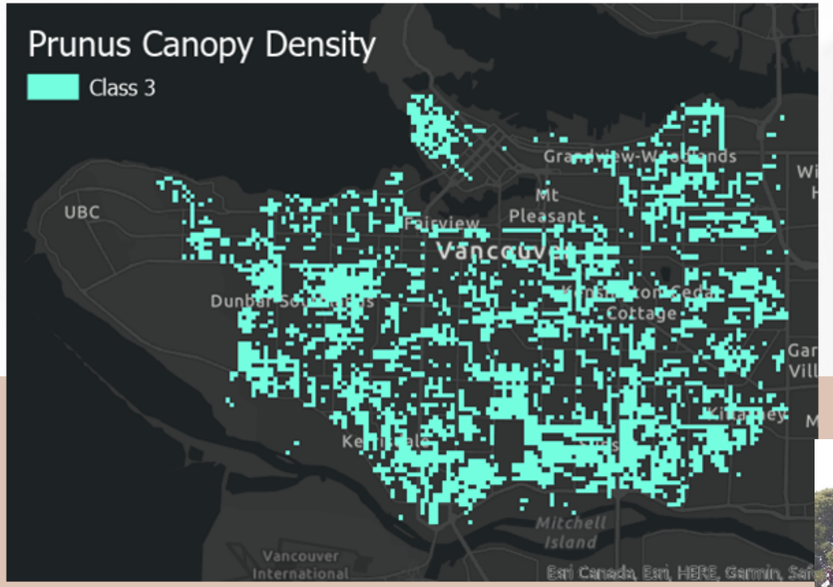
i.e. In 5 years, trees that were not considered here would need to be factored.

IDENTIFICATION OF AREAS OF HIGH VOLUME ACCUMULATION
BY ESTIMATING CANOPY DENSITY PER TREE TYPE

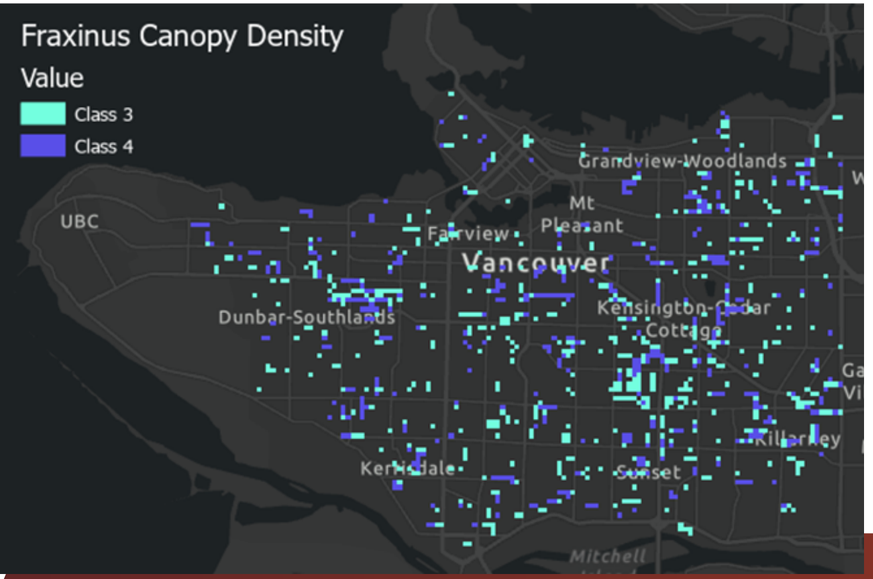
Maple Trees



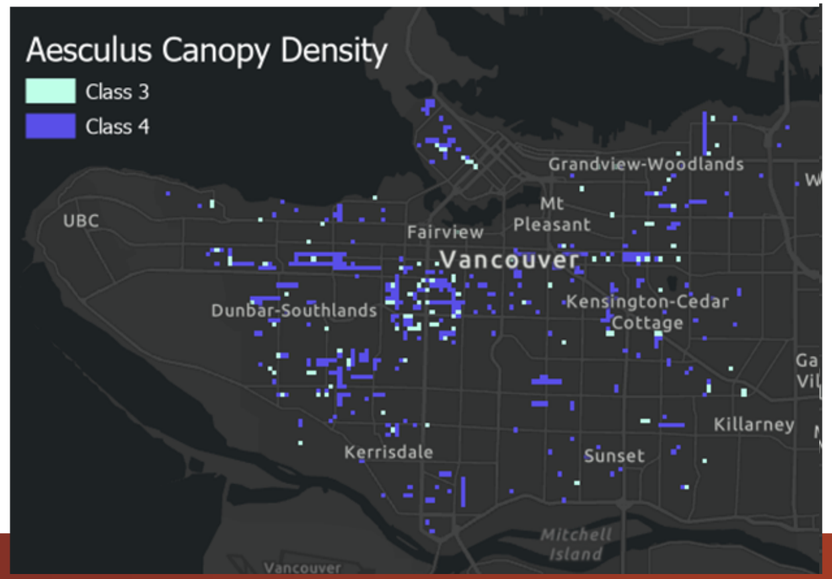
Cherry Trees



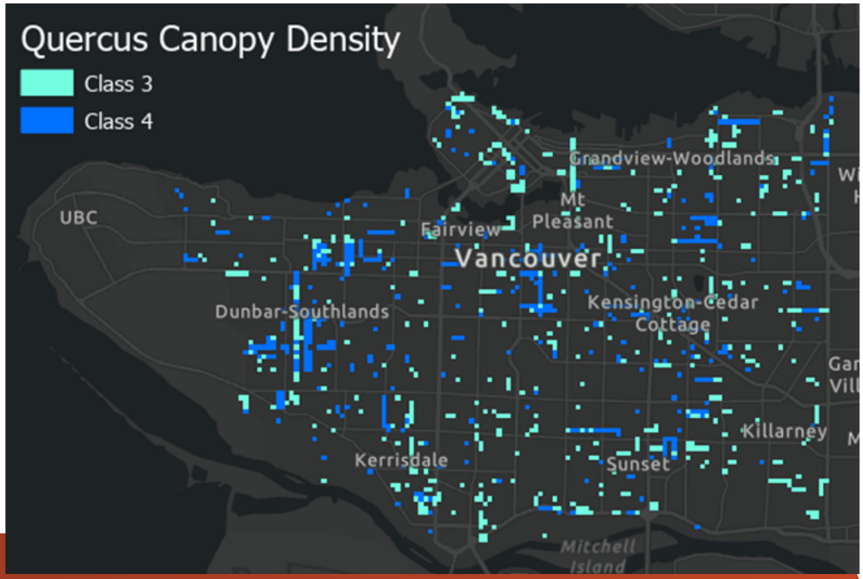
Ash Trees



Chestnut



Oaks



CLASSIFYING THE LEAF-DROP TIMING

CALENDAR OF LEAF-FALL BY TREE TYPE

- Can inform where to service first, suitable areas for pre-sweeping & areas that will present litter later in the year

	Symbology
Early shedding	1,2,3, represent volume
Mid shedding	1,2,3, represent volume
Late shedding	1,2,3, represent volume
Fall equinox: 9/22/23	◑
Winter solstice: 12/21/23	◐

Classification by

Early, Mid, Late Season leaf-drop timing based on peaks

Tree type	Timing classification
Ash Trees	EARLY
Chestnut	EARLY
Norway Maple	MID
Bowhall Red Maple	MID
Pissard Plum	MID
Kanzan Cherry	LATE
Oaks	LATE

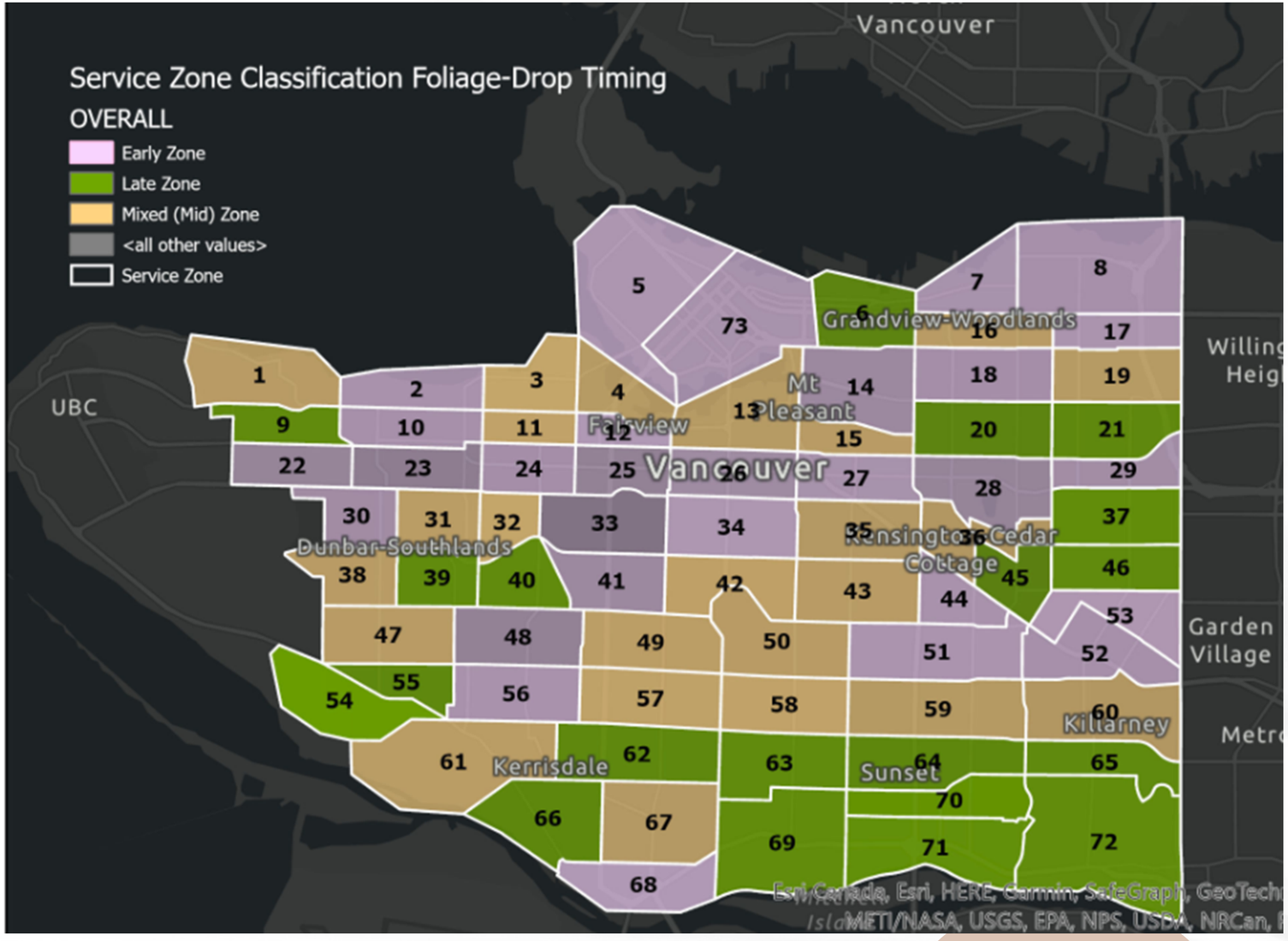
UBC Sustainability Scholar Project -Summer 2023

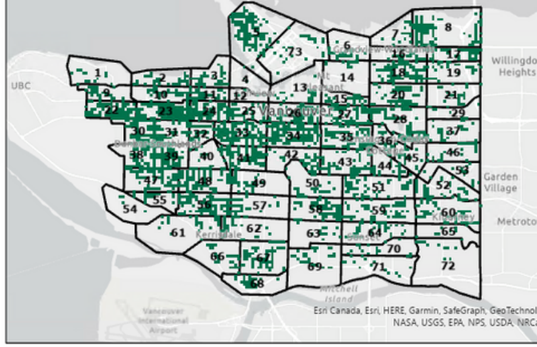
Author: Paulina Vazquez-Quintana

Leaf Abscission Phenology Calendar for the Most Abundant Deciduous Tree Species and Genus in the City of Vancouver

		Month 2023/2024	September					October				November					December				
		Week starting Monday	8/28	9/4	9/11	9/18	9/25	10/2	10/9	10/16	10/23	10/30	11/6	11/13	11/20	11/27	12/4	12/11	12/18	12/25
		Mean weekly temperature (°C) 2022/2023	19.28	16.24	16.44	14.50	15.54	14.77	12.68	11.66	9.44	6.97	2.96	2.91	6.06	0.31	2.21	2.79	-5.07	6.79
		Mean weekly rainfall (mm) 2022/2023	0.00	0.70	0.27	0.00	0.03	0.00	0.00	0.23	8.61	11.80	2.19	0.00	4.19	0.17	3.06	0.40	5.07	12.33
		Speed of Max Gust (km/h) 2022/2023	39	67	37	39	32		63	47	55	94	62	31	53	70	54	35	35	54
Tree Genus or Speci	Common nan	No. individua				◑														◐
Prunus serrulata	Kanzan Cherry	13,053										1	2	3	3	2	1			
Acer platanoides	Norway Maple	12,230							1	2	3	3	2	1						
Acer spp.	Maple	12,060		1	1	2	2	3	3	2	1									
Prunus cerasifera	Plum Cherry	11,381									1	2	3	3	2	1				
Acer rubrum	Red Maple	8,932					1	1	2	3	3	2	1							
Fraxinus	Ash	7,538			1	2	3	3	2	1										
Tilia	Linden	6,622					1	2	3	3	2	1								
Carpinus betulus	European Hornbeam	5,406							1	2	3	2	1							
Fagus sylvatica	European Beech	5,249											1	2	3	3	1			
Prunus spp.	Cherry Trees	4,950						1	1	1	2	2	1							
Acer freemani	Freeman maple	4,306								1	2	3	3	2	2	1	1			
Crataegus	Hawthorn	3,852										1	2	3	3	2	1			
Quercus spp.	Oak	3,345										1	1	2	3	2	1			
Ulmus	Elm	2,982					1	2	3	3	2	2	1							
Magnolia kobus	Magnolia	2,737				1	2	3	2	1										
Aesculus	Chestnut	2,560			1	2	3	3	2	1										
Parrotia	Persian Ironwood	2,483										1	2	3	1					
Quercus palustris	Pin oak	2,013												1	2	2	1			
Platanus acerifolia X	London Plane Tree	1,828					1	2	3	2	1									
Sorbus	Mountan Ash	1,652		1	1	2	2	1							1	2	2	1	1	
Quercus rubra	Red Oak	1,437						1	2	3	1	1								
Betula pendula	European White Birch	1,220			1	1	2	2	1											
Liquidambar styraciflua northern cultivar	Sweetgum	1,139								1	2	3	1	1						
Liriodendron	Tuliptree	972										1	2	3	3	2	1			
Liquidambar styraciflua southern cultivar	Sweetgum	477												1	2	3	1			
Catalpa bignonioides	Comon Catalpa	372				1	2	3	3	2	1									

ZONE CLASSIFICATION BY PREDOMINANCE OF LEAF-FALL TIMING TREE TYPES



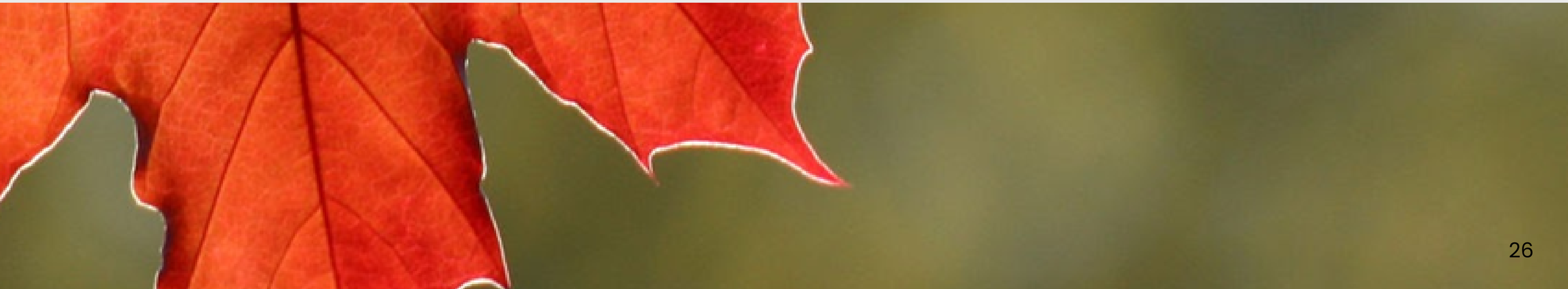


>40% of Early species = Early
Even percentages = Mixed (Mid)
>40% of Late species = Late

By considering the expected leaf-volume accumulation and timing, a new schedule for crew deployment could be designed.

How does this zoning proposal compares to your observations of the past few years?

FUTURE CONSIDERATIONS



MORE AND

MORE LEAVES COMING

The City of Vancouver is one of the greenest cities worldwide with **23% of canopy cover.** In 2020, the Board of Parks & Recreation announced the goal of increasing it to **30% by 2050**

- 96% of street trees are deciduous.

With more canopy cover, and an extended growing season, larger leaf productivity is to be expected.
i.e. Between 2010-2017: 16,116 new trees were planted in streets

Priority neighborhoods: those with less canopy coverage, such as Downtown Eastside and Marpole

From the Operations perspective, this could justify an increase in needs for technical and financial resources for execution in the coming years

The City of Vancouver,
Urban Forest Strategy 2018

CONNECTING TWO
SILOED SECTORS

Currently there are no guidelines in the **Urban Forestry Strategy** that include the autumn leaf-fall timings into the urban forest planning.

The recommendation of including seasonality of leaf-fall has been made to Urban Forestry Department.

Currently increasing tree diversity is the main guideline, it could be done by grouping zones with diverse trees but with similar functional patterns.

Identified areas susceptible to flooding could be a starting point for integrating it to the urban forest design

The City of Vancouver, 2022

Friend of Trees, 2012

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THANK YOU