LAWN SHARE

IDENTIFYING POTENTIAL FOR LAND DIVERSIFICATION THROUGH THE TRANSFORMATION OF LAWNS

APRIL 2024

DAVID SUZUKI FOUNDATION
One nature.

Nouveaux Voisins

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DAVID SUZUKI FOUNDATION

Founded in 1990, the David Suzuki Foundation is a national, bilingual non-profit organization headquartered in Vancouver, with offices in Toronto and Montreal. The Foundation's mission is to protect the environment and our quality of life, now and in the future. Its work on resolving the climate crisis and massive decline in species focuses on three essential fields: climate solutions, thriving nature and sustainable communities. Through science, education, policy analysis of public interest and grassroots engagement, as well as partnerships with businesses, governments and civil society actors, the Foundation is working to define and implement solutions that allow us to live in harmony with nature. The David Suzuki Foundation counts on over 300,000 supporters across Canada, of which approximately 100,000 are in Quebec.

NOUVEAUX VOISINS

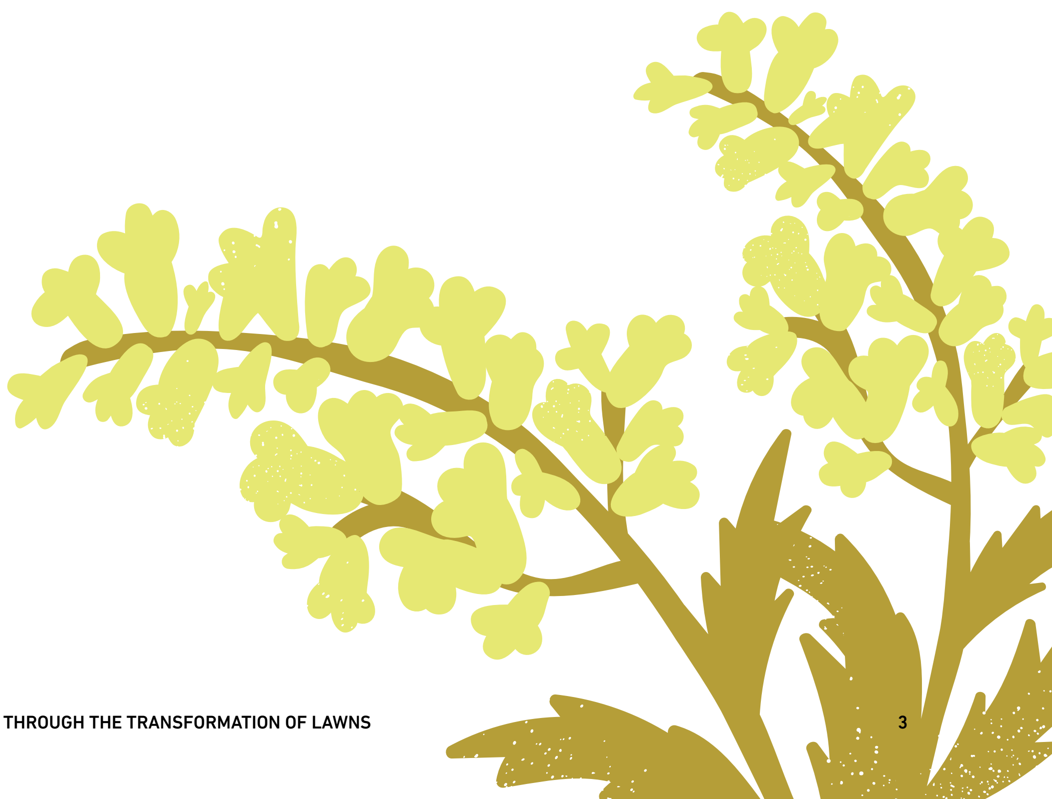
Nouveaux Voisins is a non-profit organization that works to regenerate the relationship between humans and all living beings, by developing communities' and individuals' resources to welcome and protect the biodiversity found in their environments. Among other methods, the organization fulfills its mission by designing and creating landscaping projects inspired by local ecologies. It also strives to mobilize knowledge by democratizing new approaches, helping to provide others with the interest and resources needed to take action for biodiversity. In so doing, Nouveaux Voisins actively contributes to efforts related to the ecological transition.

DARK MATTER LABS

Dark Matter Labs is an international non-profit organization that designs and builds new virtual infrastructure to support the social economy. It is constantly seeking to explore the ways in which communities, governance and the legal system are inter-related in order to imagine new alternatives.

For more information on the partners behind this work, visit:

- davidsuzuki.org
- nouveauxvoisins.org
- darkmatterlabs.org



PREFACE

During the winter of 2022, the David Suzuki Fondation, Dark Matter Labs and Nouveaux Voisins officialised their partnership in order to develop a grassroots educational and mobilization campaign to question the role of turfgrass lawns in our yards and neighbourhoods, and propose solutions to invite nature back into these spaces, one lawn at a time.

This process culminated in the April 2024 launch of the official LawnShare campaign and its French-language counterpart, *Partage ta pelouse*. These campaigns, led by the David Suzuki Foundation and its partners, are part of a Canada-wide effort to reimagine traditional lawns as healthy habitats for bees, butterflies and the rest of the nation's flora and fauna. Turfgrass lawns are one of the most noticeable landscapes in Canadian cities and municipalities. While they do play an important role in outdoor recreation, this traditional ornamental infrastructure can consume a staggering volume of resources, while only serving as a simplified ecosystem. As such, the LawnShare campaign seeks to raise awareness among households, organizations, businesses and municipalities in order to then support those who want to change how they care for their lawns or want to share them with nature by creating new habitats. Participants will receive simple lawncare tips to reduce their impact on the water, air and soil, as well as advice on how to transform these spaces to create habitats that are better suited to native flora and fauna. This report presents the mapping technique that was developed to help identify lawns in Canadian municipalities that were targeted by this campaign.

> For more information on the ***LawnShare*** campaign, visit:
> davidsuzuki.org/take-action/act-locally/lawnshare/

Photo : Nouveaux Voisins

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LIST OF ABBREVIATIONS

(Terms in italics are in French)

CARB	California Air Resources Board
CHM	Canopy Height Model
cm	Centimetre
CMM	*Communauté métropolitaine de Montréal* [Montreal Metropolitan Community]
CNRTL	*Centre National de Ressources Textuelles et Lexicales* [National Text and Lexical Resource Centre]
CSRS	Canadian Spatial Reference System
DTM	Digital Terrain Model
GCP	Ground Control Points
GHG	Greenhouse gas
GIS	Geographic information system
km	Kilometre
km2	Square kilometre
LiDAR	Light Detection and Ranging
m	Metre
MERN	*Ministère de l'Énergie et des Ressources naturelles* [Ministry of Energy and Natural Resources]
MLDP	Metropolitan land use and development plan
MRNF	*Ministère des Ressources naturelles et de la Faune* [Ministry of Natural Resources and Wildlife]
NDVI	Normalized Difference Vegetation index
NIR band	Near-Infrared band
PDF	Portable document format
RED band	Red band
R-G-B	Red-Green-Blue
SQRC	*Système québécois de référence cartographique* [Quebec Topographic System]
UHD	Units of hydrographic division
USEPA	United States Environmental Protection Agency

ABSTRACT

THE *LAWNSHARE* CAMPAIGN

The David Suzuki Foundation and its partners launched the LawnShare campaign in 2024, with the goal of supporting people who want to change how they care for their lawns or wish to share them with nature by creating new habitats. This collaborative and inclusive initiative seeks to build awareness among households, organizations, businesses and municipalities about the environmental issues related to the over-representation of turfgrass lawns in urban landscapes, inviting them to get involved by trying out some lawnsharing actions that return a certain portion of their lawn space to native flora and fauna. Interested individuals will receive simple lawncare tips to reduce their impact on the water, air and soil, as well as a toolkit divided into 10 easy steps for beginners and experts alike, showing them how to transform these conventional spaces and increase biodiversity. Another goal of the campaign is to encourage municipal incentives that foster biodiversity in urban and peri-urban environments.

OUR MANDATE

For the project's educational angle, the David Suzuki Foundation and its partners needed visual aids that highlight the scope of potential change that can be created in public and private lawn spaces. However, the lack of publicly accessible map-based data on lawns in Canada was a significant hurdle to overcome. In the face of this challenge, one of the central objectives of the LawnShare campaign was to develop a simple and easily replicated methodology for identifying where lawns are located within Canadian municipalities.

THE RESEARCH

This report presents the methodological approach that was developed to map lawns within the four first Canadian cities that were targeted by this campaign: Laval, Montréal, Saint-Jérôme and Sherbrooke. These four municipalities in Quebec were selected based on the accessibility of data, the diversity in their sizes and their regional ecology (ecoregion). This methodology, which draws on the use of digital aerial images and LiDAR-derived products, is described in detail so that it may be easily adapted for use in other large Canadian cities.

Despite some methodological limitations, our results confirm that this approach helps palliate the lack of data needed to develop visual aids that highlight the breadth of potential change in public and private lawn space. As a result, the LawnShare campaign can draw on spatial data from this report to support its educational and mobilization efforts. The report highlights the key role played by map-based data on Canadian lawns in facilitating public education and awareness-raising about the importance of urban green spaces, as well as in supporting mobilization campaigns on lawn management and alternatives. The data provide us with valuable insight on opportune locations for complexification, which are crucial in guiding stakeholders in their efforts to transform turfgrass lawns into biodiversity-rich green spaces. The report also highlights other potential applications for these data, including in the fields of sustainable urban planning and academic research.

RECOMMENDATIONS

The following recommendations are intended for the general public, as well as government bodies, and focus on how to encourage keystone habitat creation for local flora and fauna, thereby improving our chances of reaching collective targets. Developing such measures would benefit civil society, not only by preserving biodiversity, but also by encouraging social cohesion, reducing maintenance expenses, and helping to increase municipalities' resilience in the face of climate change.

GENERAL RECOMMENDATIONS FROM THE CAMPAIGN

1. **Rethinking the role of lawns in our green spaces and taking action**

   Households, organizations, businesses and municipalities are invited to question the role of lawns in their communities and to reimagine their gardens, yards and neighbourhoods, taking action to make these spaces more friendly to local biodiversity.

2. **Adopting municipal by-laws that benefit local biodiversity**

   Muncipalities are invited to revisit their by-laws to encourage, or at least not hinder, grassroots initiatives that benefit local biodiversity. Here are a few ideas for actions, accompanied by more concrete examples:

   - ***Loosening guidelines about the height of vegetation.***
     - A guide published by the Union des municipalités du Québec (UMQ) suggests abolishing maximum heights for grass and instead requiring a minimum grass height of 20 cm to control heat during the summer and reduce water use (Laterreur et al., 2022).
     - Sherbrooke's By-law 1300, which defines the general rules to be followed within the city limits, stipulates that a landowner must not allow vegetation to grow excessively tall, without specifying a maximum height, which leaves room for interpretation and allows for a greater diversity of landscaping options (Ville de Sherbrooke, 2024).
     - Laval's City Council amended its Nuisances By-law (L-12084) to void its maximum plant height stipulations (i.e., paragraphs 2.2, 2.3 and 2.4) during the period of May 1 to May 31, inclusively. This change allows Laval residents to participate in No Mow May without risking a by-law violation (Ville de Laval, 2023).
   - ***Regulating lawn space.***
     - The same guide published by the UMQ includes a reflection on forward-thinking by-laws that seek to better regulate the space used for turfgrass lawns, either by setting a maximum area for each lot, or requiring that a variety of grass species and perennials be planted (Laterreur et al., 2022).
   - ***Regulating the sale and use of pesticides.***
     - In addition to the existing, province-wide Pesticides Management Code (Pesticides Management Code - p-9.3 - Pesticides Act, 2023), approximately 160 municipalities in Quebec regulate the use of pesticides within their jurisdictions (MELCCFP, 2023). As of January 1, 2022, the City of Montréal banned the sale and use of products containing any of the 36 active ingredients listed in Schedule 1 of the By-law Concerning Pesticide Sales and Use (21-041) (Ville de Montréal, 2023a).
   - ***Regulating the sale and use of small gas-powered lawn equipment.***
     - As of January 1, 2024, California banned the sale of small gas-powered equipment (including lawnmowers) in order to limit its smog-producing pollutant emissions (2021 Bill Text CA, AB-1346).

3. **Encouraging landscaping companies to take action**

   Landscaping companies are invited to be part of the solution, as they have the power to participate in or lead projects that seek to create or consolidate new habitats that are rich in biodiversity. These companies are often forgotten when developing avenues for environmental solutions, but they have a huge potential for outreach and action, given the large number of workers they employ and the scope of the land area on the properties they maintain.

SPECIFIC RECOMMENDATIONS FROM THE REPORT

4. **The research community is invited to use the data on lawn locations**

   For the purposes of research that seeks to better understand the influence of climatic, geographical, political, social and economic factors on the proportion and spatial distributions of lawns, the research community is invited to use data on their locations.

5. **Municipalities are invited to consult data on lawn locations**

   Municipalities draw on various geographical layers in their decision-making. They are invited to make use of the data on lawn locations to improve their evaluation of the land under their jurisdictions, target areas for priority intervention, implement incentives and track the progress of their initiatives.

6. **Regional bodies are invited to produce their own datasets**

   Given the interest in using the data on lawn locations to support urban planning efforts, it seems sensible that regional bodies should produce their own datasets and regularly update them. It would be easy for the Communauté métropolitaine de Montréal (CMM) to slightly modify the methodology used to calculate and track the evolution of high (exceeding 3 m) and low (under 3 m) vegetation, adding a category to identify low vegetation likely to be lawns (30 cm and under).

7. **Follow up with visual evaluations of the identified spaces in order to determine the accuracy of the results**

   A visual comparison of the lawn surfaces identified using the methodology presented in this report would make it possible to identify the gaps at the local and municipal level in terms of the application of aerial photography and evaluate the accuracy of our results.

INTRODUCTION

Turfgrass lawns are one of the most powerful symbols in our modern urban landscapes. The first lawns date back to the European Middle Ages, in fields used by villagers for communal grazing of their livestock. This constant grazing would have led to a very short meadow with a surface that resembled hair (Hodgson, 2016). As a result, the French word for lawn, "*pelouse*", derives from the Latin "*pilosus*", meaning "hair" (*poil* in french) (CNRTL, 2024). The English word, "lawn" comes from the Old French "*lande*" meaning "clearing, barren land."

The first true lawn did not appear until the late 1600s (between 1662 and 1687) at the Château of Versailles, designed by French landscape architect André Le Nôtre (Baridon, 1992). Lawns then spread throughout Western Europe, as most aristocrats sought to imitate the famous Sun King (Louis XIV) by integrating them into their gardens (Hodgson, 2016). The cool and humid climate in this region supported this innovation, but only the wealthiest could permit themselves such a luxury, as lawns required teams of workers to regularly scythe the grass. While occasionally used for garden parties or luncheons on the grass with hundreds of guests, lawns were essentially a means through which landowners could demonstrate that they had the resources required to devote huge swaths of valuable land to purely aesthetic functions. Starting in 1830, the first lawnmowers emerged, bringing the cost of lawn maintenance to a level that minor nobility and members of the bourgeoisie could afford, allowing them to adopt the trend (Hodgson, 2016). European colonists brought with them the idea that turfgrass lawns conveyed a sense of civilization, progress and success. For this reason, many now consider them to be symbols of colonialism (Doreen, 2023; Ignatieva et al., 2020).

In North America, turfgrass lawns began to surround houses in the countryside starting in the 1870s, giving rise to modern lawn-dominated suburbs. Houses began to be built in the middle of lots as opposed to along the roadway, so they could be bordered by lawns. Between the commercialization of inexpensive lawnmowers, the implementation of the 40-hour work week and the accessibility of automobiles, the middle class was able to leave the city for the suburbs, which has previously been reserved for the wealthy. What had previously been a fashion quickly became the norm; each small house suddenly had to be surrounded by lawns (Hodgson, 2016).

The first North American lawns were made up of a variety of plants that could withstand regular mowing and foot traffic. They included many native grass species, as well as clover, plantain, dandelion and chamomile. Only thorny or stinging plants would have been weeded out by hand. After World War II, herbicides that could kill unwanted plants without affecting grasses saw immediate success among the public, who were now able to have greener and more homogenous lawns, like those on golf courses (Hodgson, 2016). Due to environmental and public health concerns, the government of Quebec implemented significant measures that banned most pesticides used on lawns in 2003 (Pesticide management code - p-9.3 - *Pesticides Act*, 2023; MELCCFP, 2003). Unfortunately, pesticide use for "weed" control continues, to the concern of ecologists and health care professionals (Chouinard, 2023; Rigal, 2019).

The term "lawn" is generally used to describe a grassy surface or green space where plant height is kept relatively short through regular mowing. Turfgrass lawns are created by either laying prepared sod, which comes in rolls or strips of grassy turf, or from seed, by sowing grass seed in the soil. Sod and grass seed mixes usually contain a limited variety of species to ensure that the resulting ground cover has a more homogenous appearance (Martineau et al., 2008).

In Quebec, Kentucky bluegrass (*Poa pratensis*) is by far the most popular species used for lawns. With its resistance to cold climate and rhizomic root structure, this grass cultivar is most commonly used in sod production (Martineau et al., 2008). Sodded lawns are almost entirely composed of different cultivars of the same species, while seeded lawns are usually made up of several different grass species (Martineau et al., 2008). In addition to the popular *P. pratensis*, the most commonly found grasses in Quebec's lawns include red fescue (*Festuca rubra* subsp. *rubra*), tall fescue (*Lolium arundinaceum*), sheep fescue (*Festuca trachyphylla*), Chewing's fescue (*Festuca rubra* subsp. *commutata*) and English ryegrass (*Lolium perenne*) (Martineau et al., 2008). The majority of these species or subspecies were introduced to Canada (Canadensys, 2024f, 2024g, 2024c, 2024b, 2024d, 2024e, 2024a). Established lawns will evolve and their composition may change as new species are introduced, either deliberately or accidentally. Some of these new species are considered "weeds," such as black medick, yarrow, dandelions, crabgrass, ground ivy, quack grass, white clover, wood sorrel, broadleaf plantain, wild strawberries and violets (Herbu, 2024; Iriis phytoprotection, 2024; Vertdure, 2024). Some of these plants are gradually shedding their reputation as "weeds" and are even starting to be included in wildflower or native turf grass mixes (Groupe Richer, 2021; Herbionik, 2024).

Apart from their aesthetic qualities, turfgrass lawns are widely used to cover recreational fields and parks, as they provide a safe, natural, cool and pleasant surface on which to play. Grass playing fields offer excellent grip and shock-absorbing capacity, which helps considerably reduce the risk of injuries among users (Martineau et al., 2008). With their roots acting as anchors, plants help stabilize topsoil on slopes that are at risk of erosion from wind and water (Desjardins, 2019). Several public bodies and organizations have produced best-practices guides that include seeding and sodding as quick and permanent measures to stabilize both steep and shallow slopes (Guay et al., 2012; Ville de Québec, 2005). The turquoise slopes visible following hydroseeding operations are an example of stabilization efforts that are visible to the public eye. Hydroseeding involves sowing seeds that have been encapsulated in a pulp of colored cellulose mixed with water. The pulp helps protect the seeds from drought as well as erosion caused by precipitation, in addition to encouraging germination and root establishment. This technique allows for the quick return of grasses to bare soil to prevent erosion, which is especially important on sloped surfaces.

Carbon sequestration is another ecosystemic benefit of grasses (Gibson & Newman, 2019). However, any positive effects from the organic carbon sequestration taking place in domestic lawn soil are largely reduced by the greenhouse gas (GHG) emissions generated from lawn management operations like mowing and irrigation, as well as fertilizer or pesticide use (Selhorst & Lal, 2013; Zirkle et al., 2011). In addition to GHG, gas-powered small lawncare equipment, such as lawnmowers and leaf blowers, emit as many smog-generating pollutants in one hour of use as a car traveling 482 km (CARB, 2021).sequestration rates varied among sites from 0.9 Mg carbon (C

Beyond considerations related to GHG emissions and other atmospheric pollutants, mowing conventional turfgrass lawns influences other aspects of the ecosystem. While lawns themselves are diversified ecosystems that are home to many living organisms (Martineau et al., 2008), lawn maintenance is often to the detriment of pollinators and other small native creatures. Lawns already contain only limited nectar-bearing plant species, and the few that may be found there are usually cut before they can flower. Mowing is also the direct cause of death for a large number of insects, especially wingless insects or those in vulnerable life stages, as in egg or larval form (Proske et al., 2022; Ville de Montréal, 2022). Francoeur et al., (2021) noted that mowed lawn surfaces contained a significantly lower biomass of arthropods compared to surfaces occupied by other types of field-level vegetation, such as minimally maintained hedges, unmaintained meadows and scrublands.recent studies have demonstrated the potential of greenspaces in cities to promote biodiversity conservation. One of many factors negatively affecting arthro pods in urban areas are unsuitable habitats, as non-woody greenspaces predominantly consist of manicured lawns. Maintenance practices such as high mowing frequencies, can have direct and indirect negative impacts on the local flora and fauna. The present study examines the effects of different mowing regimes on arthropod abundance and diversity by conducting meta-analyses of studies assessing the effect of mowing on arthropod abundance (46 datasets

Lawns' cooling effect has long been recognized and is often used to defend the importance of turfgrass lawns as compared to grey infrastructure (Martineau et al., 2008). However, surfaces occupied by minimally maintained hedges, unmaintained meadows and scrublands would be significantly more effective than lawns in dissipating heat (Francoeur et al., 2021). Shade from trees also has far more significant cooling effects for energy-saving in buildings than those generated by lawn evapotranspiration (Z.-H. Wang et al., 2016).

The process of evapotranspiration is directly related to lawns' cooling capacity and depends largely on water availability (Ignatieva et al., 2020). Grassy surfaces act as natural sponges, absorbing rainwater and reducing runoff. As grass grows longer, its root system becomes more robust, making lawns more drought resistant. Conversely, mowing grass too short reduces its drought resistance. Grass that is too short is also less healthy and less able to tolerate subsequent heavy rain. Surfaces covered in healthy grasses help prevent flooding, soil erosion and water pollution by allowing rainwater to filter through the soil and recharge aquifers. A lawn composed of Kentucky bluegrass can absorb up to 25 mm of water very quickly without causing significant runoff (Martineau et al., 2008). In arid and semi-arid regions, the amount of water needed for lawn maintenance is an issue, as lawns without appropriate irrigation can become dry, brown, dusty and unattractive to look at (Ignatieva et al., 2020). In the United States, gardening and watering lawns makes up about 30% of total annual household water usage, reaching up to 60% in dry climates. On average, an American household uses 50,500 gallons of water each year to water its lawns and gardens (USEPA, 2021). We were unable to find an exact statistical equivalent in Canada, but 43% of Canadian households with yards reported that they water them (Statistics Canada, 2017).

Given the urgent challenges related to climate change and biodiversity loss, many experts recommend increasing forest cover in lawn-dominated urban zones, in addition to replacing some lawns with other landscaping that provides greater ecological benefits and requires maintenance with a lower environmental impact (Lerman & Contosta, 2019). Making lawns more complex is considered to be an accessible and affordable option to increase ecosystemic benefits, especially in areas where preferences, physical constraints or management would make tree-planting impossible (Francoeur et al., 2021).including frequent mowing, which may influence CO2 emissions from both biogenic and anthropogenic sources. We tested whether different lawn mowing frequencies (every one, two or three weeks

With the signature of the Paris Agreement in 2015 and the Kunming-Montréal Agreement in 2022, Canadian government bodies were spurred to propose new policies to reduce Canada's carbon footprint, increase its resilience in the face of climatic events and protect its biodiversity. Under this backdrop, many municipal governments published strategic documents defining their objectives and actions to be implemented to help reach collective targets—several of which specifically focus on grass lawn management or transformation (Rosemont-La Petite-Patrie, 2022; Ville de Montréal, 2022). Adapting management practices for the green spaces in their jurisdictions is a popular goal for municipalities. This includes reducing the frequency of lawn-mowing, encouraging targeted management, minimizing or banning the use of pesticides, revising local by-laws on plant height in front yards and implementing distribution campaigns of nectar-producing and native plants (Ville de Montréal, 2022). A majority of strategic documents call for the mobilization of the entire community, because participation from all stakeholders in society is key to a successful ecological transition (MELCCFP, 2022; Ville de Montréal, 2020).

With the goal of integrating this dynamic between actors with a role to play in transforming grassy areas into spaces that are rich in biodiversity, the David Suzuki Foundation and its partners launched the LawnShare campaign in 2024. This collaborative and inclusive initiative starts with building awareness among cities, private businesses, organizations and the population about the environmental issues related to the over-representation of turfgrass lawns in our environments, and then invites them to get involved by trying out some lawnsharing actions that return a certain portion of this lawn space to native flora and fauna. Interested individuals or institutions will receive simple lawncare tips to reduce their impact on the water, air and soil, as well as a toolkit divided into 10 easy steps for beginners and experts alike, showing them how to transform these conventional spaces and increase biodiversity.

MAPPING CANADIAN LAWNS

As part of the project's educational angle, the David Suzuki Foundation and its partners needed visual aids that highlight the scope of potential change that can be created in private and public lawn spaces. Using maps to categorize urban green spaces, especially lawns, has interested several research teams in recent years. The methodology used often varies from one study to another, with each study's data being ad hoc, in addition to presenting highly variable temporal and spatial resolutions. Map results are often inaccessible, and the few that can be accessed are often difficult to compare due to their heterogeneity. To our knowledge, there are no publicly available data mapping Canadian lawns that can be used to inform the population and decision-makers of the proportion of both public and private land they occupy.

Given this challenge, one of the central objectives of the LawnShare campaign was to develop a simple and easily replicated methodology to identify lawns within Canadian municipalities using digital aerial images. The approach to mapping developed for this campaign can help address the lack of data and facilitate comparisons between different regions. In addition, the data collected can be used as key indices for finding opportune areas for complexification and guiding local conservation and adaptation efforts. The remainder of this report will present the details of our methodology, and the results obtained for the first four cities in Quebec that were targeted by this campaign: Laval, Montréal, Saint-Jérôme and Sherbrooke. These four municipalities in Quebec were selected based on the accessibility of data, the diversity in their sizes and their regional ecology (ecoregion).

Photo : J. Kaur

MATERIALS AND METHODS

GUIDING PRINCIPLE AND DATA USED

The methodology used in this study was inspired by one developed by the CMM to track the evolution of the canopy in the area (CMM, 2017). Spatial data were obtained on the provincial portal "*Données Québec*" as well as the academic platform "Geoindex" (Table 1). All of the data used were transformed, processed, analyzed and projected into the coordinates reference system NAD83 (CSRS) / MTM zone 8 (EPSG:2950), with the help of the following software: R, version 4.3.1 (R Core Development Team, 2023), Quantum GIS, version 3.34.1 (QGIS Development Team, 2023) and ArcGIS Pro, version 2.8 (ESRI Ltd., Redlands, USA). Table 2 presents the *Système québécois de référence cartographique* ([Quebec Topographic System], SQRC) mapsheet numbers used to download the orthophoto mosaics (Décennal-C 2018) and the mosaics of the LiDAR-derived products (i.e., CHM and DTM) for each city we studied.

TABLE 1. Spatial Data Used.

DATA	YEAR	FORMAT	SOURCE
Découpages administratifs 1/20000 - munic_s.shp	2023	SHP	Données Québec - MRNF
Décennal-C 2018 (Mosaics of RGB orthophotos)	2018	JP2	Geoindex - MERN
Décennal-I 2018 (Model/Photo RGBI) + .PAR files	2018	TIF + PAR	Geoindex - MERN
Units of hydrographic division (UHD)	2019	SHP	Données Québec - MRNF
Canopy Height Model (CHM) - Laval	2017	TIF	Données Québec - MRNF
Canopy Height Model (CHM) - Montréal	2015	TIF	Données Québec - MRNF
Canopy Height Model (CHM) - Sherbrooke & Saint-Jérôme	2018	TIF	Données Québec - MRNF
Digital Terrain Model (DTM) - Laval	2017	TIF	Données Québec - MRNF
Digital Terrain Model (DTM) - Montréal	2015	TIF	Données Québec - MRNF
Digital Terrain Model (DTM) - Sherbrooke & Saint-Jérôme	2018	TIF	Données Québec - MRNF
Predominant usages	2022	SHP	Geoindex - MAMH

*See **Table S1** in annex to access links to download the datasets. SHP: Shapefile, TIF: Tagged Image File Format, JP2: JPEG 2000 - Joint Photographic Experts Group 2000 and PAR: Parchive File.*

TABLE 2. SQRC Mapsheet Numbers for Each City.

CITY	SQRC MAPSHEET NUMBERS
Laval	31H12NO, 31H12NE, 31H12SO, 31H12SE
Montréal	31H05NO, 31H05NE, 31H12SO, 31H12SE, 31H12NE, 31H11NO
Saint-Jérôme	31G16SE, 31G09NE, 31H13SO, 31H12NO
Sherbrooke	31H08NE, 31H08SE, 21E05NO, 21E05SO

ORTHOMOSAIC

Quebec's *Ministère de l'Énergie et des Ressources naturelles* ([Ministry of Energy and Natural Resources], MERN), via the Geoindex platform, provides the academic community with 239 colour R-G-B (Red-Green-Blue) digital orthomosaics, divided into mapsheets according to the SQRC (Décennal-C 2018). These mosaics, which cover different administrative regions of the province (i.e., Estrie, Lanaudière, Laurentides, Laval, Montréal and Montérégie), were assembled by MERN using four-band (i.e., R, G, B, and NIR (Near-infrared)) orthorectified aerial photos. Unfortunately, the final product could not be used to calculate the vegetation index using the Normalized Difference Vegetation Index (NDVI), because the NIR band was removed from the dataset (see the NDVI equation).

As a result, we needed to use the original R-G-B-NIR aerial photos (Décennal-I 2018), as well as their parameter file (.PAR), to produce new orthophoto mosaics that could be used to calculate the NDVI. These images were orthorectified using ArcGIS Pro (ESRI Ltd., Redlands, USA), to be spatially coherent with the R-G-B orthophoto mosaics (Décennal-C 2018) from MERN. The latter were used as reference images to automatically generate ground control points (GCP). The GCPs were filtered using a mask layer to eliminate anomalies, such as points located high up or in aquatic areas. This mask layer was created in vector format (SHP) by combining surface entities with Units of hydrographic division (UHD), using vectorized pixels that correspond with elevation zones > 0.3 m of the MRNF canopy height model (CHM). The R-G-B-NIR orthophoto mosaics were generated with a 20 cm resolution using the MRNF digital terrain model (DTM) as an altitude source.

STUDY AREA

The official administrative limits of the cities of Laval, Saint-Jérôme and Sherbrooke were extracted in vector format (SHP) by filtering their names under the "MUS_NM_MUN" attribute in the "Découpages administratifs 1/20000 - munic_s.shp" layer. For Montréal, the "MUS_NM_MRC" attribute was used in the same layer, filtered by its name to demarcate the official limits of the RCM/agglomeration/island of Montréal. The boundaries of each territory were used as a basis to create elementary tiles of one square kilometre (1 km^2) to divide the orthophoto mosaics and facilitate their processing.

NDVI

High-resolution multispectral imaging brings together a collection of data that can be used to create imaging derivatives with which it is possible to predict the type of ground cover. In this study, vegetation was determined using NDVI, which is a green vegetation indicator calculated using near-infrared (NIR) band and red band (RED), through the following equation:

NDVI values are ranged from -1 to 1. Negative values generally represent clouds, water and snow, while values near zero generally represent sterile surfaces such as rocks, concrete or sand, and positive values represent vegetation. Moderate values (from ≈ 0.2 to ≈ 0.3) represent shrubs and meadows, whereas higher values designate sparse vegetation (from ≈ 0.3 to ≈ 0.4) and dense vegetation (≈ 0.4 and more) (Akbar et al., 2019; Codemo et al., 2022).

$$NDVI = \frac{\text{Near infrared band (NIR)-Red band (RED)}}{\text{Near infrared band (NIR)+Red band (RED)}}$$

NDVI threshold values depend on multiple factors such as the season, the time of day and the study zone (Pei et al., 2019). Values may need to be corrected and adapted, depending on the area under study. The NDVI calculation was applied to the R-G-B-NIR orthophoto mosaics, which had previously been divided into elementary tiles of one square kilometre (1 km^2). After several trials and visual validations, the threshold of 0.2 was established for identifying presumptive vegetation-covered areas, therefore producing a new layer of canopy cover for each of the four cities studied. The pixels of presumptive vegetation starting from values below 55 (Laval and Montréal), and below 85 (Sherbrooke and Saint-Jérôme) at the near infrared-band level (NIR) were removed in order to minimize false identification of plant surfaces in shaded areas.

LOW VEGETATION AND LAND-USE CLASSIFICATION

The new layers of canopy cover, still divided into 1 km^2 elementary tiles, were overlayed with CHM. Only pixels with a height under 30 cm were conserved, to identify low vegetation surfaces.

The database of the Quebec *Ministère des Affaires municipales et de l'Habitation* ([Ministry of Municipal Affairs and Housing] MAMH) showing predominant usages (2022) as listed in the municipal property assessments was used to classify the low vegetation pixels by territorial occupation. The initial layer included surface data in vector format (SHP) and represents the territory according to the 16 major land-use classifications (**Table S2**). In this initial layer, multiple land-use classes have been attributed to same polygon, for the most part due to the superposition of distinct properties within the same lot or part of a lot.

To simplify the classification of low vegetation pixels, the multiple attributes for one polygon were catenated into one chain of characters, separated by a slash (/) so that each polygon in the derived layer had only one attribute to describe its land-use (**Table S2**). To reduce the number of different attributes in each city, the attributes made up of initial land-use classes were grouped into 6 new land-use classes (i.e., Agricultural / Forestry, Commercial / Industrial, Transportation infrastructure, Institutional / Parks and recreation, Residential and Vacant lot). A visual validation was conducted to determine the most significant land-use of some multiple attributes that presented with low frequency.

Photo : Nouveaux Voisins

FIGURE 1. Map of low vegetation surfaces in the City of Laval, with two zoomed-in samples.

Sources: Administrative divisions, MRNF; Orthophotos, MERN; GrayLight, EsriCanada.

FIGURE 2. Map of low vegetation surfaces in the City of Montréal, with two zoomed-in samples.

Sources: Administrative divisions, MRNF; Orthophotos, MERN; GrayLight, EsriCanada.

FIGURE 3. Map of low vegetation surfaces in the City of Saint-Jérôme, with two zoomed-in samples.
Sources: Administrative divisions, MRNF; Orthophotos, MERN; GrayLight, EsriCanada.

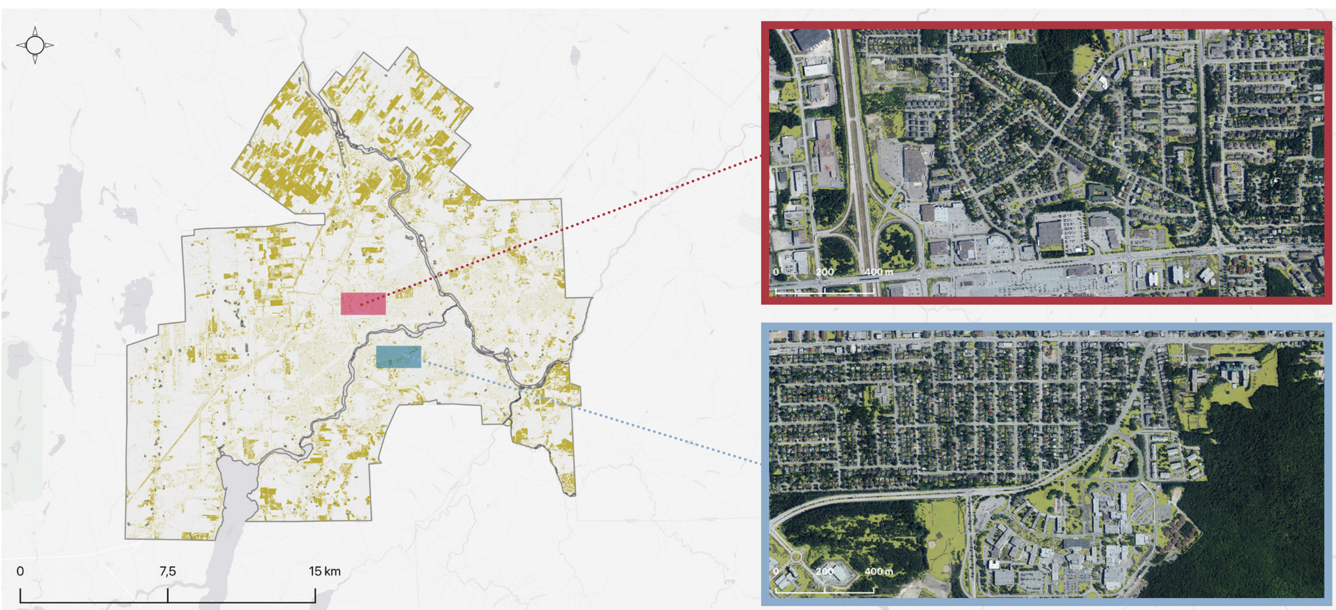


FIGURE 4. Map of low vegetation surfaces in the City of Sherbrooke, with two zoomed-in samples.
Sources: Administrative divisions, MRNF; Orthophotos, MERN; GrayLight, EsriCanada.

RESULTS AND DISCUSSION

PROPORTION OF LOW VEGETATION SURFACES IN EACH CITY

The maps obtained for the cities of Laval, Montréal, Saint-Jérôme and Sherbrooke are presented in **Figures 1** to **4**. The presumed identification of canopy cover using high-resolution multi-spectral imaging suggested that low vegetation surfaces (0-30 cm) take up relatively similar proportions (16.43-20.42%) between the four cities studied (**Figure S1**). In most land-use classes, low vegetation surfaces could be lawns, mosses, herbs, flowering plants, gardens and all other plant ground cover. In agricultural and forestry environments, seedlings and natural ground cover are necessarily identified as low vegetation surfaces, which could lead to an over-estimation of the proportion of lawns.

Upon excluding the data from the “Agricultural / Forestry” group (Figure 5), the results suggest that lawns occupy different proportions (8.18% - 19.45%) between the four cities studied. This could be due to several factors, but the degree of urbanization is certainly not an element to be neglected, as lawns are a powerful symbol of the modern urban landscape (Ignatieva et al., 2015). The four cities studied are in the top 15 most populated municipalities in Quebec. Montréal is in 1st position, with 1,791,508 inhabitants, Laval is in 3rd position with 446,476 inhabitants, Sherbrooke is in 6th position with 175,684 inhabitants and Saint-Jérôme is in 14th position with 82,144 inhabitants (Institut de la statistique du Québec, 2022). In terms of land area, Montréal is the most densely populated of the four, with approximately 3,611 inhab./km^2. It also has the largest proportion of lawns (19.45%). Conversely, Sherbrooke is the least densely populated city, with approximately 498 inhab./km^2, and the lowest proportion of lawns (8.18%). Laval and Saint-Jérôme are situated between the two, with 1,853 and 909 inhab./km^2 and lawn proportions of 14.72% and 13.04%, respectively. It would be interesting to further examine the statistical relationships between the degree of urbanization and proportion of low vegetation surfaces in Canadian cities.

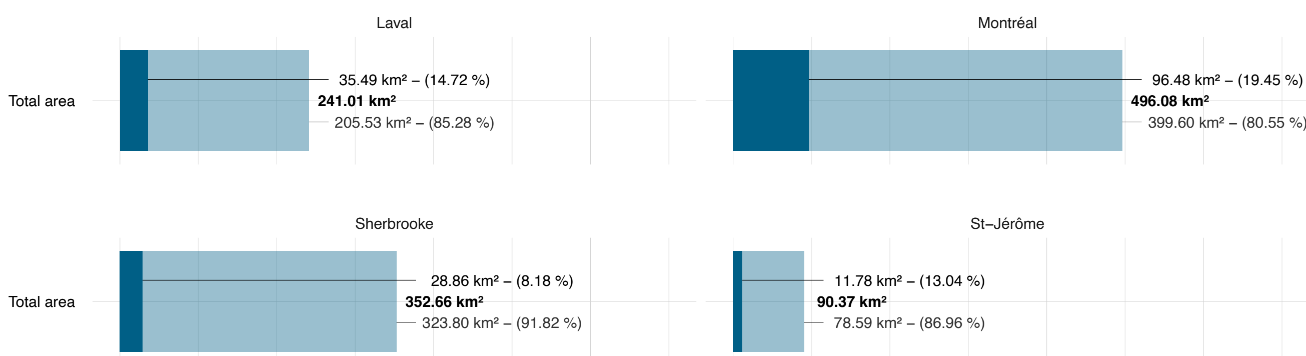


FIGURE 5. Proportion of land identified as lawns in each city.

Darker shades represent low vegetation surfaces, while lighter shades represent other types of surfaces. Values along the lines indicate the area (km2) of each type of surface (i.e., low vegetation and others) and the values in parenthesis present the land proportion (%) occupied by this type of surface. The values in bold present the total land area of each city (km2). The histograms exclude the data from the group “Agricultural / Forestry.”

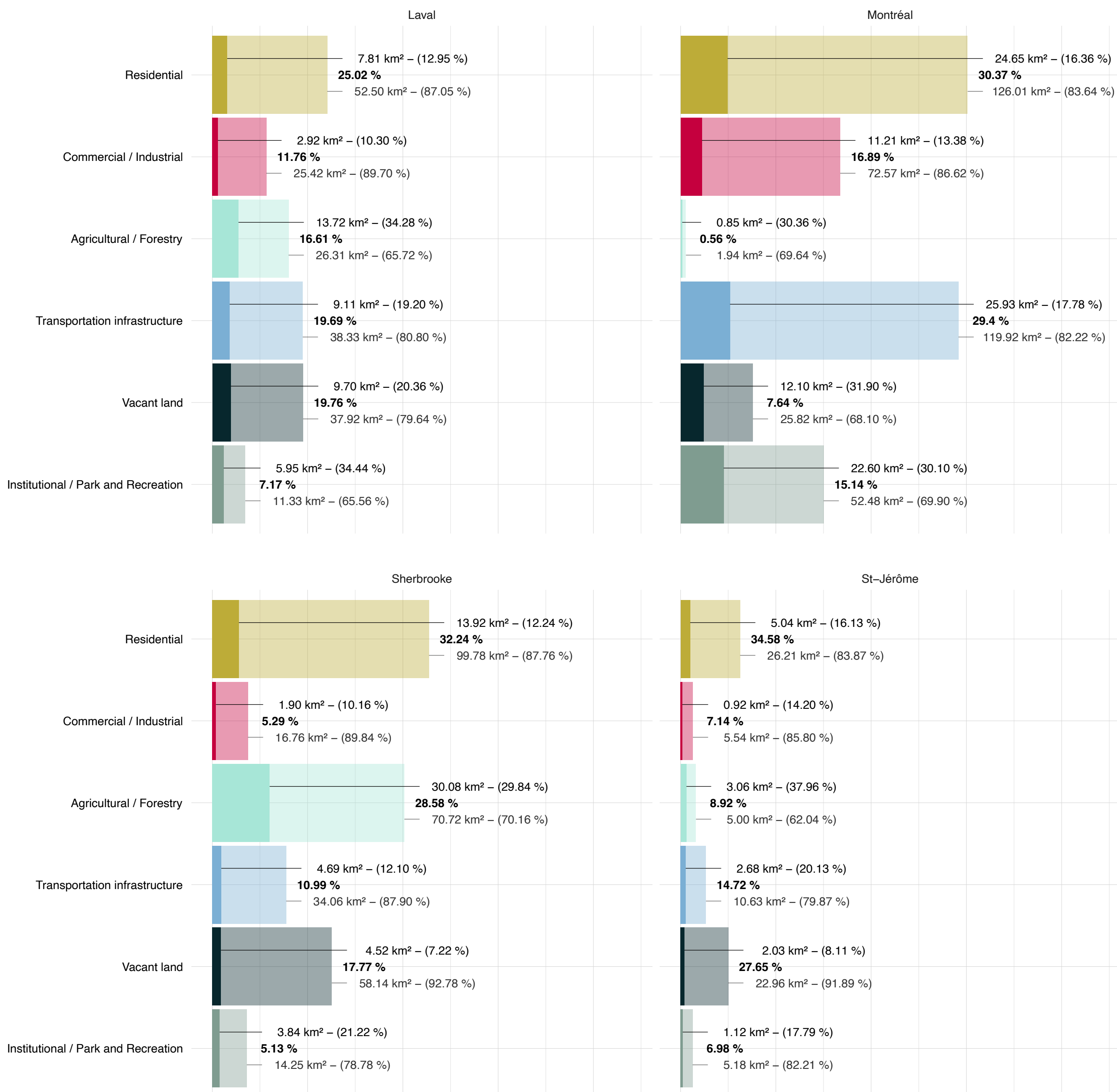


FIGURE 6. Proportion of land identified as lawns in each city according to land-use classes.

Darker shades represent low vegetation surfaces (lawns), while lighter shades represent other types of surfaces. Values along the lines indicate the area (km2) of each type of surface (i.e., lawns and others) and the values in parenthesis present the land proportion (%) respective to this usage class. The values in bold present the proportion of the area (%) occupied by each usage class.

PROPORTION OF LOW VEGETATION SURFACES ACCORDING TO LAND-USE CLASSES.

The classification of low vegetation pixels based on land-use class highlights the relatively similar repartitions between the different cities (**Figure 6**). The largest differences seem to concern "vacant lots" with lawn proportions varying between 7.22% and 31.90%. Lawns identified in "Residential" and "Commercial/Industrial" environments appear to occupy relatively similar proportions across the four cities (between 12.24% and 16.36%, and between 10.16% and 14.20%, respectively), in relationship to their usage class. However, usage classes do not occupy the same proportions from one city to the next. A study of three large Swedish cities estimated that lawns took up between 17.7% and 47.7% of the area in residential neighbourhoods (Ignatieva et al., 2017), which is well above our observations for Laval, Montréal, Saint-Jérôme and Sherbrooke.

Certain climatic, geographical, political, social and economic factors have a well known influence on the proportion and distribution of total vegetation infrastructure (Apparicio et al., 2016; Kiani et al., 2023; Landry et al., 2022). For example, differences in municipal by-laws could potentially explain some of the variations observed in vacant lots. Lawn seeding is often seen as a simple and affordable solution for cover after demolishing a building or to beautify abandoned spaces (Ignatieva et al., 2020). Article 115 of the zoning by-laws of the borough of Verdun in Montréal (1700) stipulates that any lot left vacant following the demolition of a building must be landscaped according to various requirements, including covering with sod (Arrondissement de Verdun, 2024). It would be interesting to conduct further analyses on the lawn dataset to try to explain the differences observed between usage classes.visible minorities, individuals 0e14 years old and persons 65 years old and over.

METHODOLOGICAL LIMITATIONS

The mapping technique presented in this report was applied to the municipal level to identify and measure lawn surfaces. While the results appear very satisfying at this level, the data must be interpreted with prudence, as the accuracy of this technique is known to diminish as the land area under analysis shrinks (CMM, 2017). A visual comparison of the lawn surfaces alongside the aerial photographs would allow us to identify the gaps at the local level and measure their scope at the municipal level. A very similar methodology to ours was tested in the municipality of Trento, Italy, to identify three levels of vegetation (i.e., 0-0.4 m; 0.4-2 m; and over 2 m) and a validation by aleatoric sampling revealed an accuracy level of over 80% (Codemo et al., 2022).

Some vegetation cover identification errors persist, despite several trials and visual validations to find the optimal NDVI threshold and remove some values in the near infrared-band range. Mineral surfaces in shaded areas may have been identified as vegetation, while some areas with sparse vegetation may not have been identified as such.

As this methodology is based on the use of aerial photographs, the perspective effect could make it so that some lawns alongside tall buildings and other tall infrastructure are not visible. Overhanging trees can also limit the visibility of low vegetation or lawns in an area, which may appear swallowed up by the canopy. This lack of accuracy can certainly introduce a bias that would underestimate the total land area of lawns, but this is less important given that the benefits of the canopy on the biodiversity far outweigh those brought by conventional lawns. It is important to note that the method used allowed us to create a good inventory of low vegetation spaces that could benefit from complexification in terms of landscaping. In this light, the transformation of spaces under the canopy can be considered lower priority.

Both the orthophotos and the CHM present their own planimetric inaccuracies. A gap in positioning between these two layers could create conditions such that the outline of the canopy overhanging some low mineral surfaces could have been identified as low vegetation surfaces. Roadway shapes could have been used to filter some of these anomalies, as the City of Montréal did when producing the *Surfaces minérales and végétales* [Mineral and Vegetation Surfaces] layer (Géomatique Montréal, 2022). Unfortunately, this step could not be integrated into our approach, as very few Canadian cities share roadway data that is so detailed. To identify presumptive low vegetation surfaces, only CHM pixels under 30 cm in height were conserved. However, the altimetric inaccuracies in this layer may have led to identification of vegetation that slightly exceeds the 30 cm threshold (MRNF, 2024).

METHODOLOGICAL COMPARISON: 1 M VS 0.2 M RESOLUTION

The use of CHM with a spatial resolution of 1 m could also have limited the identification of low vegetation surfaces located near tall elements (for example, buildings, infrastructure, trees, etc.) or small structures over 30 cm in height (for example, electrical wires, fencing, poles, etc.) as the height of these elements increases the corresponding average CHM pixel value.

A CHM with a better spatial resolution would undoubtably limit the occurrence of these errors at the local scale, but only very few municipalities publish such precise data. The City of Montréal is one of the rare municipalities that share LiDAR data in a cloud-point format, making it possible to create a more precise CHM. To test the impact of CHM resolution at the municipal scale, this methodological approach was repeated in Montréal, including a new CHM with a spatial resolution of 20 cm.

At the local scale (**Figure 7**), the new map with a 20 cm resolution appears more accurate than the original map (1 m resolution). At the municipal scale (**Figure 8** and **Figure 9**), the new data suggest that the total lawn area occupies a slightly larger proportion (23.13%) of the area than what had previously been estimated (19.45%). Increasing the spatial resolution often leads to additional costs in terms of data processing and storage, which could be a limiting factor in many projects, especially large-scale or limited-budget ones. As a 3.68% difference is not huge, it does not seem crucial to use a 20 cm resolution when a 1 m resolution can provide results that more than satisfy the objectives of this campaign. A visual comparison of the lawn surfaces with the aerial photographs would allow us to identify the gaps at the local level to measure the accuracy at the municipal level and determine the optimal resolution to respond to objectives.

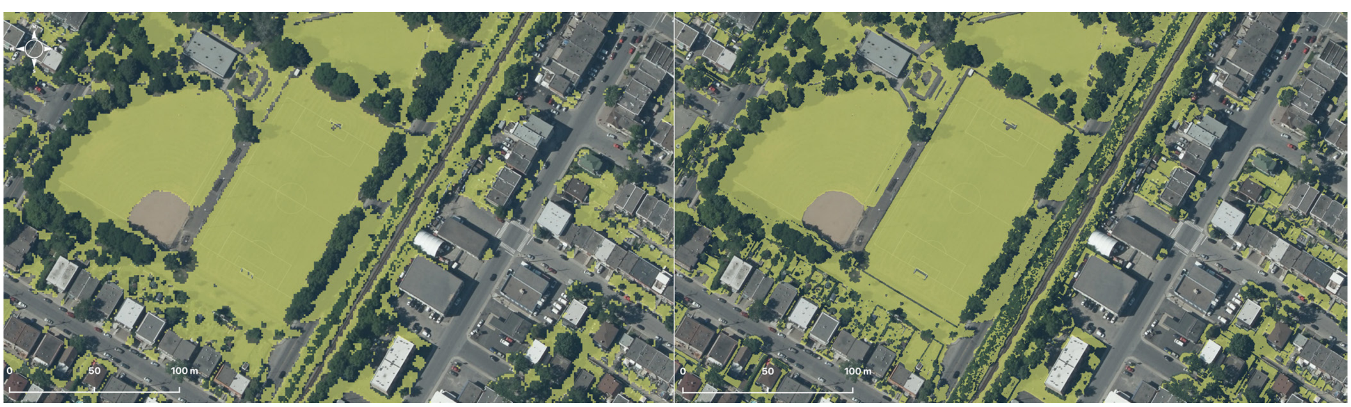


FIGURE 7. Low vegetation surfaces identified with a resolution of 1 m (left) and 20 cm (right).

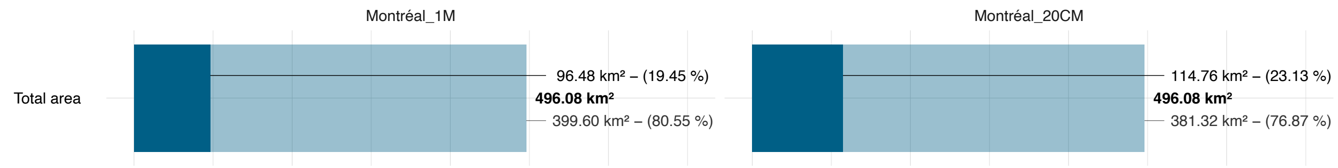


FIGURE 8. Proportion of land identified as lawns with a resolution of 1 m and 20 cm.

Darker shades represent low vegetation surfaces (lawns), while lighter shades represent other types of surfaces. Values along the lines indicate the area (km2) of each type of surface (i.e., lawns and others) and the values in parenthesis present the land proportion (%) respective to this land area. The values in bold present the total land area. The histograms exclude the data from the group "Agricultural / Forestry."

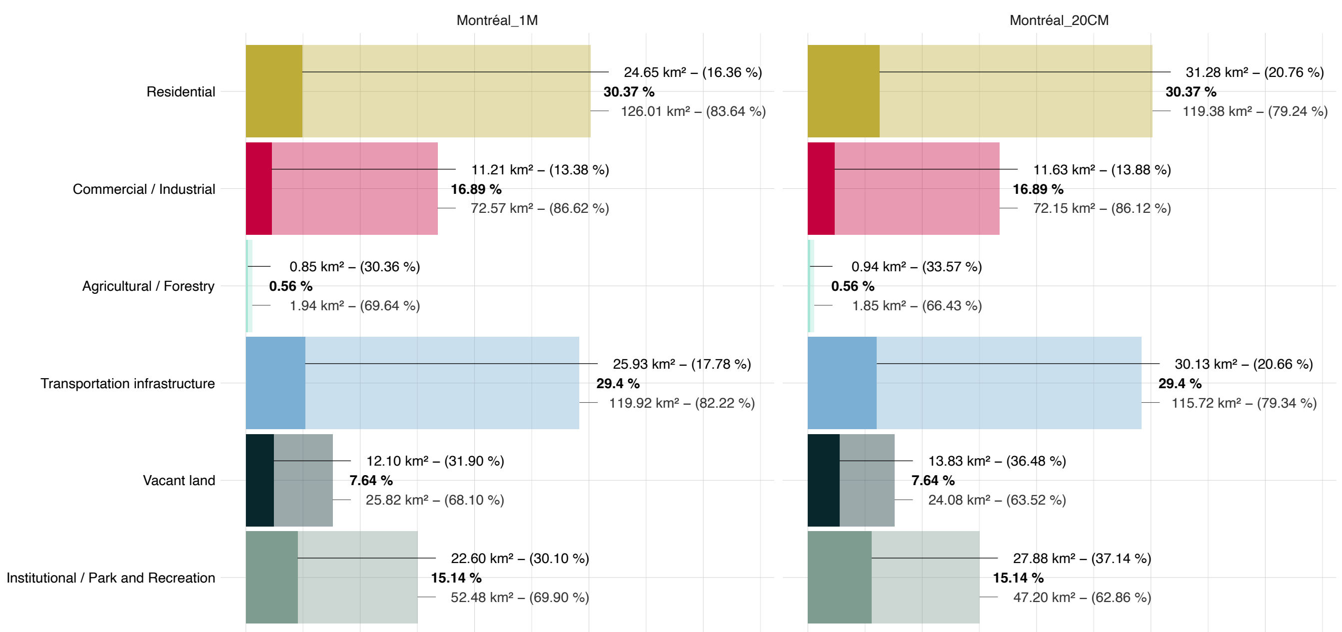
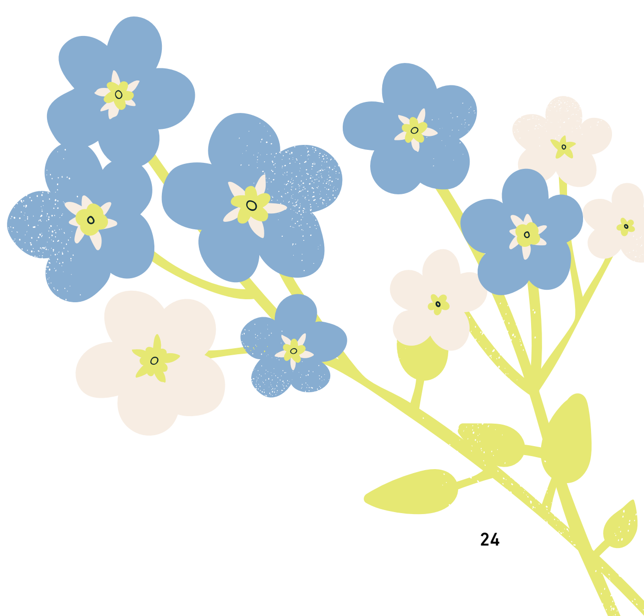


FIGURE 9. Proportion of land identified as lawns in each resolution according to land-use classes.

Darker shades represent low vegetation surfaces (lawns), while lighter shades represent other types of surfaces. Values along the lines indicate the area (km2) of each type of surface (i.e., lawns and others) and the values in parenthesis present the land proportion (%) respective to this usage class. The values in bold present the proportion of the area (%) occupied by each usage class.



VALIDITY OF THE RESULTS

Classifying low vegetation pixels by land-use classes (**Figure 6**) is a fairly innovative aspect of this study, as we are not aware of any previous work that explores this question. In classifying the land area, it became necessary to simplify the multiple combinations of land-use into 6 primary classes. This step certainly represents a source for potential errors, but the scope of these errors is difficult to estimate. Despite these factors, the proportions occupied by each land-use class for Montréal and Laval are relatively similar to the data presented by the CMM in their respective territory profiles (CMM, 2021a, 2021b) (**Figure 10**), which suggests that the results obtained following the simplification of land-use classes (**Table S2**) are sufficiently reliable.

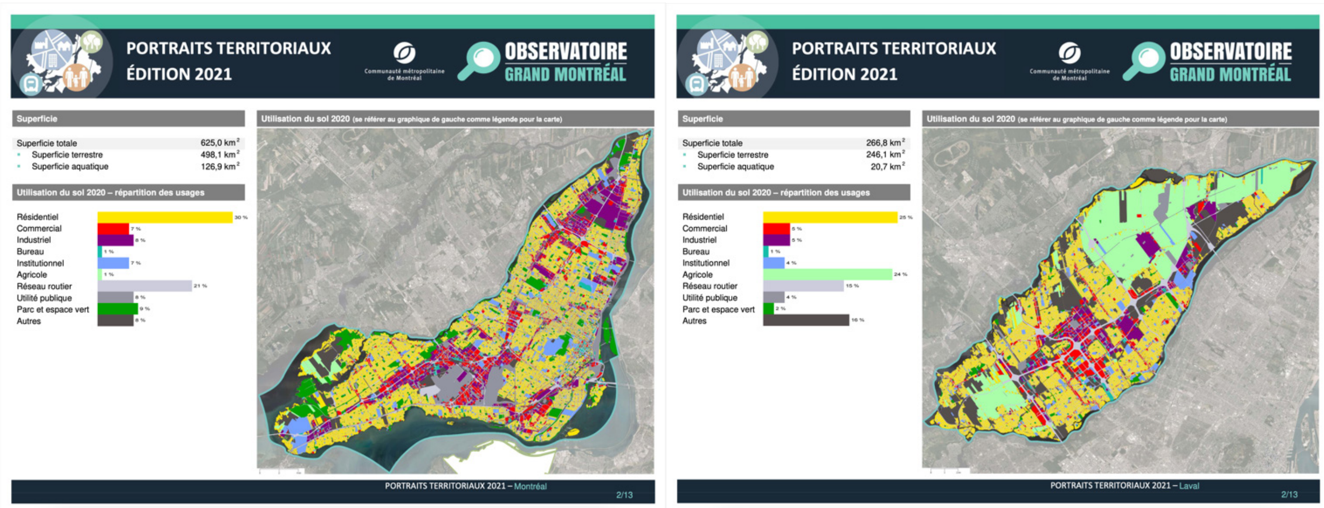


FIGURE 10. Samples from territory profiles.

The figure to the left presents the Agglomeration of Montréal's profile and the figure to the right presents the City of Laval's profile. Source: (CMM, 2021a, 2021b).

As of June 2023, on its open data portal, the City of Montréal published a matrix representation of surface materials in each borough and city in the agglomeration of Montréal for the purposes of land management and planning (Ville de Montréal, 2023b). The product has a spatial resolution of 20 cm and categorizes the pixels into 16 different categories. Despite its spatial precision, it is impossible to use this dataset to estimate lawn surfaces and compare our results, because it does not distinguish between high and low vegetation.

The CMM developed a methodology through which it can track the evolution in the canopy of the 82 municipalities on its territory using aerial photographs taken during the summer. The methodology used by the CMM is very similar to the one used in this study, because the calculations were also made using NDVI and CHM to depict canopy cover in four categories (i.e., low mineral, high mineral, low vegetation and high vegetation) with a 1-metre resolution. Their approach distinguishes low vegetation from high vegetation using a 3-metre height threshold. Low vegetation surfaces within the metropolitan canopy index includes grass, tall plants, crops, as well as small trees and shrubs under 3 metres (CMM, 2017). Initially developed to support the CMM's planning tools, such as the Metropolitan Land Use and Development Plan (MLDP) (CMM, 2019), this geographic layer would later prove useful for research projects evaluating the proportion of low vegetation to be complexified using better-performing natural infrastructure (Francoeur et al., 2018). Unfortunately, given the differences in methodology, our results cannot be compared with the metropolitan canopy index.

METHODOLOGICAL ADVANTAGES AND ALTERNATIVE APPROACHES

The mapping technique was developed to be automatic and easily replicated in other contexts or with updated data. It is relatively simple, requiring only a CHM and orthophoto mosaics that include red-band and near infrared-band. The automatization of this approach is a considerable advantage compared to manual cartography, which can be executed using simple aerial photos, but is very time-consuming (Ignatieva et al., 2017). Other promising alternatives, such as using a deep-learning model to identify lawns using simple satellite images (e.g., Google Maps), is the subject of growing interest (Northrup et al., 2020) as part of a broader trend of the use of artificial intelligence for land and resource management (Drogkoula et al., 2023; J. Wang et al., 2022). Despite some methodological limitations in identifying lawn surfaces, the results allow us to better understand the spatial distribution of different vegetation infrastructures, which constitutes a priceless opportunity to improve land management and planning practices.

SUPPORT FOR URBAN PLANNING

Natural infrastructure provides a multitude of ecological services, which are particularly important in the context of sustainable development, habitat restoration and cities' resilience to climate change (Frédette, 2023). The integration of green infrastructure in urban and land planning is now recognized as a strategic approach that facilitates the fulfillment of several social, economic and cultural objectives related to adapting to climate change and protecting biodiversity (Fortin Faubert et al., 2023). Municipalities rely on various geospatial data to support their vision for planning. For example, spatial information on tree and canopy cover, the transportation network and land-use help the CMM evaluate its territory and determine priority interventions to fulfill its objectives (CMM, 2019). Several boroughs and municipalities have published strategic documents that define objectives, priorities or actions regarding the management or transformation of turfgrass lawns within their territory (Rosemont-La Petite-Patrie, 2022; Ville de Montréal, 2022; Ville de Saint-Jérôme, 2023), but few have access to the statistical or cartographic information they need to make informed decisions and track the progress of their initiatives. Given the interest in using the data on lawn locations to support urban planning efforts, it seems sensible that regional bodies should produce their own datasets and regularly update them. It would be easy for the CMM to slightly modify the methodology used to calculate and track the evolution of high (exceeding 3 m) and low (under 3 m) vegetation, adding a category to identify short vegetation likely to be lawns (30 cm and under).

CALL FOR MOBILIZATION AND ENGAGEMENT

Given the urgent challenges related to climate change and biodiversity loss, governments are increasingly relying on mobilization strategies that call for all societal stakeholders to help reach collective targets (MELCCFP, 2022). Integrating this dynamic between cities, businesses, organizations and individuals requires implementing collaborative and inclusive initiatives that mobilize all the stakeholders.

The mapping technique presented in this report makes it possible to identify lawns within different Canadian municipalities and provides key indices to target opportunities for complexification. Lawns are easier to improve than mineralized surfaces, which are not good sites for tree-planting or planters. Identifying them can help improve some decision-making tools developed by non-profits to help municipalities to better prioritize their greening interventions (Fortin Faubert et al., 2022; Tanguy et al., 2022).

The data from the present study represent key support for the LawnShare campaign to facilitate public education and awareness-raising about the importance of urban green spaces and can be an interesting addition for any number of other mobilization campaigns with a focus on lawns. Alongside municipal administrators, many individuals, civic groups, businesses, schools and organizations can consult these maps to optimize their interventions.

More and more municipalities are taking part in collective movements such as "No Mow May" that seek to promote more sustainable and ecological practices for lawn management, through educational programs about mowing practices and through pesticide- and fertilizer-reducing programs (Ville de Boucherville, 2023; Ville de Magog, 2023; Ville de Québec, 2022). Local governments can play a key role by providing a legal and financial framework that supports the implementation of such initiatives, all while encouraging grassroots participation and collaborating with civil society organizations. Some municipal councils have amended their nuisance by-laws to encourage individuals not to mow their lawns during the month of May without risk of violating by-laws that regulate grass height (Ville de Laval, 2023).

Some municipalities encourage the population to replace their traditional turfgrass lawns, or part of them, with more natural and diversified alternatives, such as flowering meadows, vegetable gardens or natural ground cover, by distributing free seeds to residents. The David Suzuki Foundation's Butterflyway project is a good example of municipal and grassroots engagement for modifying public and private land to invite nature back into our spaces (Fondation David Suzuki, 2024). This movement brings together over 1,700 volunteers from sea to sea across the country, working to create new habitats in their gardens, communities and neighbourhoods to encourage pollinators, more specifically, the corridor along which monarch butterflies migrate to Mexico. Since the program's inception in 2017, over 100,000 native plants and shrubs have been planted across Canada. The cities of Laval, Montréal, Saint-Jérôme and Sherbrooke joined the 450 municipalities in North America that have taken part in the initiative by signing the Mayors' Monarch Pledge.

OTHER INTERESTING APPLICATIONS

In addition to their potential use in the fields of urban planning and grassroots mobilization, map data on lawns seem to present a growing source of interest for landscaping businesses looking to simplify their estimate process and improve their customer service (Northrup et al., 2020). These businesses are invited to be part of the solution, as they have the power to participate in or lead projects that seek to create or consolidate new habitats that are rich in biodiversity. Often overlooked when developing avenues for environmental solutions, these companies have a huge potential for outreach and action, given the large number of workers they employ and the scope of the land area on the properties they maintain.

Map data on lawns also present an interesting potential for use in the academic community for research on spatial relationships between certain types of plant infrastructure and different environmental, urban, political, social and economic factors (Pham et al., 2011). The use of data such as those presented in this study opens the door to new perspectives for interdisciplinary research and research-action projects, which help both to enrich our understanding of urban ecosystems and their role in communities' quality of life, and to lead transformative actions on the ground.

CONCLUSION

The LawnShare campaign, launched by the David Suzuki Foundation and its partners in 2024, seeks to educate key actors on the importance of sharing their green spaces with native fauna and flora. To support this initiative, an automatic and easily replicated mapping technique was developed to identify lawns in Canadian municipalities using digital aerial photographs and LiDAR-derived products. The methodology was described in detail so that it can be adapted and easily applied for use in other large Canadian cities.

The results obtained for the four first cities targeted by the campaign (i.e., Laval, Montréal, Saint-Jérôme and Sherbrooke) confirm that the campaign can draw on spatial data from this report to support its educational and mobilization efforts. Despite some methodological limitations, this approach helps palliate the lack of data needed to develop visual aids that highlight the breadth of potential change in public and private spaces. The data provide priceless indices to identify opportune locations for complexification. They are essential for guiding municipalities, businesses, organizations and individuals in their efforts to transform lawns into spaces that are richer in biodiversity and amplify the initiatives' impacts. All of this work contributes to developing tools to respond to growing challenges related to climate change and the loss of biodiversity.

Photo : Nouveaux Voisins

REFERENCES

Akbar, T. A., Hassan, Q. K., Ishaq, S., Batool, M., Butt, H. J., & Jabbar, H. (2019). Investigative Spatial Distribution and Modelling of Existing and Future Urban Land Changes and Its Impact on Urbanization and Economy. Remote Sensing, 11(2), 105. https://doi.org/10.3390/rs11020105

Apparicio, P., Pham, T.-T.-H., Séguin, A.-M., & Dubé, J. (2016). Spatial distribution of vegetation in and around city blocks on the Island of Montreal: A double environmental inequity? Applied Geography, 76, 128–136. https://doi.org/10.1016/j.apgeog.2016.09.023

Arrondissement de Verdun. (2024). Règlement de zonage (1700) de l'arondissement de Verdun—Ville de Montréal.

Baridon, M. (1992). The Gardens of Versailles. University of Pennsylvania Press. https://archive.org/details/historyofgardens0000bari/page/n3/mode/2up

California Legislative Information. (2021). Bill Text CA, AB-1346, Air pollution: Small off-road engines. https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=202120220AB1346

Canadensys. (2024a). Festuca rubra. In Database of Vascular Plants of Canada (VASCAN). http://data.canadensys.net/vascan/name/Festuca%20rubra?lang=en

Canadensys. (2024b). Festuca trachyphylla (Hackel) Krajina. In Database of Vascular Plants of Canada (VASCAN). http://data.canadensys.net/vascan/taxon/7686

Canadensys. (2024c). Lolium arundinaceum (Schreber) Darbyshire. In Database of Vascular Plants of Canada (VASCAN). http://data.canadensys.net/vascan/taxon/18809

Canadensys. (2024d). Lolium perenne. In Database of Vascular Plants of Canada (VASCAN). http://data.canadensys.net/vascan/taxon/7756

Canadensys. (2024e). Poa nemoralis. In Database of Vascular Plants of Canada (VASCAN). http://data.canadensys.net/vascan/taxon/7886

Canadensys. (2024f). Poa pratensis Linnaeus. In Database of Vascular Plants of Canada (VASCAN). http://data.canadensys.net/vascan/taxon/7893?lang=en

Canadensys. (2024g). Poa trivialis. In Database of Vascular Plants of Canada (VASCAN). http://data.canadensys.net/vascan/taxon/7911?lang=en

CARB (2021). Small off-road engines in California (p. 1). California Air Ressources Board. https://ww2.arb.ca.gov/sites/default/files/2021-10/2021%20SORE%20Fact%20Sheet_0.pdf

Chouinard, É. (2023). Pesticides interdits: Québec « oublie » le glyphosate, selon des militants. Radio-Canada. https://ici.radio-canada.ca/nouvelle/1968315/herbicide-roundup-monsanto-code-liste-quebec

CMM. (2017). Indice canopée métropolitain—Méthodologie (p. 5). Communauté métropolitaine de Montréal. https://observatoire.cmm.qc.ca/documents/geomatique/IndiceCanopee/2015/CMM_indiceCanopee_2015_methodologie.pdf

CMM. (2019). PMAD | Plan d'action 2019-2023. Communauté métropolitaine de Montréal.

CMM. (2021a). Portraits territoriaux: Agglomération de Montréal | Édition 2021. Observatoire Grand Montréal. https://observatoire.cmm.qc.ca/pdf/portraits/Portrait_660.pdf

CMM. (2021b). Portraits territoriaux: Ville de Laval | Édition 2021. Observatoire Grand Montréal. https://observatoire.cmm.qc.ca/pdf/portraits/Portrait_65005.pdf

CNRTL. (2024). Étymologie de PELOUSE. Centre National de Ressources Textuelles et Lexicales. https://www.cnrtl.fr/etymologie/pelouse

Code de gestion des pesticides - p-9.3 - Loi sur les pesticides (2023). https://www.legisquebec.gouv.qc.ca/fr/document/lc/p-9.3

Codemo, A., Pianegonda, A., Ciolli, M., Favargiotti, S., & Albatici, R. (2022). Mapping Pervious Surfaces and Canopy Cover Using High-Resolution Airborne Imagery and Digital Elevation Models to Support Urban Planning. Sustainability, 14(10), 6149. https://doi.org/10.3390/su14106149

Desjardins, D. (2019). FicheTechnique—La Stabilisation des Pentes. Société québécoise de phytotechnologie (SQP).

Doreen, N. (2023). Lawn grass as an expression of colonialism, classism and corporate control. Rabble. https://rabble.ca/environment/lawn-grass-as-an-expression-of-colonialism-classism-and-corporate-control/

Drogkoula, M., Kokkinos, K., & Samaras, N. (2023). A Comprehensive Survey of Machine Learning Methodologies with Emphasis in Water Resources Management. Applied Sciences, 13(22), 12147. https://doi.org/10.3390/app132212147

David Suzuki Foundation (2024). L'effet papillon. https://fr.davidsuzuki.org/passez-a-laction/agissez-localement/effet-papillon/

Fortin Faubert, M., Hénault-Ethier, L., & Duchesne, S. (2023). S'adapter au climat par le verdissement—Guide pour les municipalités. Union des municipalités du Québec (UMQ). https://umq.qc.ca/wp-content/uploads/2023/05/webumqguidereverdissement2023-7.pdf

Fortin Faubert, M., Hénault-Ethier, L., & Hallmich, C. (2022). Adaptation aux changements climatiques et villes durables—Outil d'aide à la décision pour le verdissement de terrains vacants potentiellement contaminés en milieux urbains. David Suzuki Foundation

Francoeur, X. W., Dagenais, D., Paquette, A., Dupras, J., & Messier, C. (2021). Complexifying the urban lawn improves heat mitigation and arthropod biodiversity. Urban Forestry & Urban Greening, 60, 127007. https://doi.org/10.1016/j.ufug.2021.127007

Francoeur, X. W., Dupras, J., Dagenais, D., & Messier, C. (2018, November). La fin du gazon | Comment complexifier les espaces verts du Grand Montréal pour s'adapter aux changements globaux. David Suzuki Foundation. https://fr.davidsuzuki.org/publication-scientifique/la-fin-du-gazon-ou-et-comment-complexifier-les-espaces-verts-du-grand-montreal-pour-sadapter-aux-changements-globaux/

Frédette, C. (2023). Guide d'introduction aux infrastructures végétalisées—Informations générales et bonnes pratiques (Québecvert environnement). Québecvert environnement.

Géomatique Montréal. (2022). Informations sur le produit: Surfaces minérales et végétales. Ville de Montréal.

Gibson, D. J., & Newman, J. A. (2019). Grasslands and climate change: An overview. In D. J. Gibson & J. A. Newman (Eds.), Grasslands and Climate Change (1st ed., pp. 3–18). Cambridge University Press. https://doi.org/10.1017/9781108163941.003

Groupe Richer. (2021). Fiche technique—Vert à vie Biodiversité. Groupe Richer. https://groupericher.com/produits/biodiversite

Guay, J., Lajeunesse, S., & Martel, J.-F. (2012). Guide technique—Gestion environnementale des fossés. MRC Brome-Missisquoi. http://www.bv.transports.gouv.qc.ca/mono/1129274.pdf

Herbionik. (2024). Stabilisation indigène d'herbionik. https://www.ecoumene.com/produit/semences/couvre-sol/stabilisation-indigene-dherbionik/

Herbu. (2024). Lupuline. https://www.herbu.com/diagnostic/46-lupuline.html#:~:text=Plante%20annuelle%20qui%20se%20reproduit,tous%20les%20types%20de%20sol.

Hodgson, L. (2016). Histoire de pelouse. leSoleil. https://www.lesoleil.com/2016/07/29/histoire-de-pelouse-09f7bf8349328c5c0a38cff370c55ae4/#:~:text=Les%20citoyens%20du%20village%20avaient,tondue%20rappelait%20celui%20des%20poils.

Ignatieva, M., Ahrné, K., Wissman, J., Eriksson, T., Tidåker, P., Hedblom, M., Kätterer, T., Marstorp, H., Berg, P., Eriksson, T., & Bengtsson, J. (2015). Lawn as a cultural and ecological phenomenon: A conceptual framework for transdisciplinary research. Urban Forestry & Urban Greening, 14(2), 383–387. https://doi.org/10.1016/j.ufug.2015.04.003

Ignatieva, M., Eriksson, F., Eriksson, T., Berg, P., & Hedblom, M. (2017). The lawn as a social and cultural phenomenon in Sweden. Urban Forestry & Urban Greening, 21, 213–223. https://doi.org/10.1016/j.ufug.2016.12.006

Ignatieva, M., Haase, D., Dushkova, D., & Haase, A. (2020). Lawns in Cities: From a Globalised Urban Green Space Phenomenon to Sustainable Nature-Based Solutions. Land, 9(3), 73. https://doi.org/10.3390/land9030073

Institut de la statistique du Québec. (2022). Estimations de la population des municipalités de 25 000 habitants et plus, Québec, 1er juillet 2001 à 2022. https://statistique.quebec.ca/fr/produit/tableau/estimations-de-la-population-des-municipalites-de-25-000-habitants-et-plus

Iriis phytoprotection. (2024). Achillée millefeuille. https://www.iriisphytoprotection.qc.ca/Fiche/MauvaiseHerbe?imageId=5822#:~:text=L%27achillée%20millefeuille%20est%20une%20mauvaise%20herbe%20qui%20infeste%20surtout,%2C7%20à%208%2C0.

Kiani, B., Thierry, B., Fuller, D., Firth, C., Winters, M., & Kestens, Y. (2023). Gentrification, neighborhood socioeconomic factors and urban vegetation inequities: A study of greenspace and tree canopy increases in Montreal, Canada. Landscape and Urban Planning, 240, 104871. https://doi.org/10.1016/j.landurbplan.2023.104871

Landry, F. L., Messier, C., He, J., Smargiassi, A., Kneeshaw, D., Paquette, A., & Dupras, J. (2022). Verdir Montréal pour augmenter la résilience et l'équité: Étude des préférences citoyennes à l'égard de la forêt urbaine. David Suzuki Foundation. https://fr.davidsuzuki.org/wp-content/uploads/sites/3/2021/11/Rapport-Foret-Urbaine-Montreal-jan2022.pdf

Laterreur, I., Royer, R., Ouellette, J., Beaudet, J., & Gosselin, D. (2022). S'adapter au climat par la réglementation—Guide pour les municipalités. Union des municipalités du Québec (UMQ). https://umq.qc.ca/wp-content/uploads/2022/03/guide-climat-reglementation-29mars22.pdf

Lerman, S. B., & Contosta, A. R. (2019). Lawn mowing frequency and its effects on biogenic and anthropogenic carbon dioxide emissions. Landscape and Urban Planning, 182, 114–123. https://doi.org/10.1016/j.landurbplan.2018.10.016

Martineau, C., Mongeau, B., & Rochefort, S. (2008). GUIDE implantation et entretien d'une pelouse durable. Fédération interdisciplinaire de l'horticulture ornementale du Québec (FIHOQ) and Association des producteurs de gazon du Québec (APGQ).

MELCCFP. (2003). Press Release—QUÉBEC ADOPTS THE HIGHEST STANDARDS IN NORTH AMERICA TO DECREASE EXPOSURE TO PESTICIDES. https://www.environnement.gouv.qc.ca/communiques_en/2003/c20030305-pesticides.htm

MELCCFP. (2022). Stratégie de mobilisation pour l'action climatique 2022-2027. Ministère de l'Environnement, de la Lutte contre les changements climatiques, de la Faune et des Parcs.

MELCCFP. (2023). Municipalités du Québec qui réglementent l'usage des pesticides. In Données Québec. https://www.donneesquebec.ca/recherche/dataset/municipalites-pesticides

MRNF (2024). Données lidar. https://mrnf.gouv.qc.ca/repertoire-geographique/lidar/

Northrup, J., Pye, J. B., & Naples, M. (2020). Geospatial Grass Segmentation for Lawn Sizing | Final Report. GitHub. https://github.com/matthewnaples/Lawn_maskRCNN

Pei, Z., Fang, S., Yang, W., Wang, L., Wu, M., Zhang, Q., Han, W., & Khoi, D. N. (2019). The Relationship between NDVI and Climate Factors at Different Monthly Time Scales: A Case Study of Grasslands in Inner Mongolia, China (1982–2015). Sustainability, 11(24), 7243. https://doi.org/10.3390/su11247243

Pham, T.-T.-H., Apparicio, P., Séguin, A.-M., & Gagnon, M. (2011). Mapping the Greenscape and Environmental Equity in Montreal: An Application of Remote Sensing and GIS. In S. Caquard, L. Vaughan, & W. Cartwright (Eds.), Mapping Environmental Issues in the City (pp. 30–48). Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-642-22441-6_3

Proske, A., Lokatis, S., & Rolff, J. (2022). Impact of mowing frequency on arthropod abundance and diversity in urban habitats: A meta-analysis. Urban Forestry & Urban Greening, 76, 127714. https://doi.org/10.1016/j.ufug.2022.127714

QGIS Development Team. (2023). Quantum GIS Geographic Information System. https://www.qgis.org

R Core Development Team. (2023). R: A language and environment for statistical computing. R Foundation for Statistical Computing.

Rigal, R. (2019). Pesticides et Parkinson. Une causalité établie—Des mesures pour protéger tous les citoyens. (p. 33). David Suzuki Foundation and Parkinson Québec. https://fr.davidsuzuki.org/wp-content/uploads/sites/3/2019/09/PARKINSON-Report-FRENCH.pdf

Rosemont-La Petite-Patrie. (2022). Plan directeur de biodiversité de Rosemont-La Petite-Patrie. Rosemont-La Petite-Patrie.

Selhorst, A., & Lal, R. (2013). Net Carbon Sequestration Potential and Emissions in Home Lawn Turfgrasses of the United States. Environmental Management, 51(1), 198–208. https://doi.org/10.1007/s00267-012-9967-6

Statistique Canada. (2017). L'utilisation de l'eau à l'extérieur, 2015. Statistics Canada = Statistique Canada. https://www150.statcan.gc.ca/n1/pub/16-508-x/16-508-x2017002-fra.htm

Tanguy, O., Martins, K. T., Maure, F., St-Denis, A., & Halmich, C. (2022). Augmenter l'adaptation équitable aux changements climatiques: Scénarisation de la plantation de 500 000 nouveaux arbres sur le territoire de la Ville de Montréal. David Suzuki Foundation

USEPA. (2021). Water-Smart Landscapes—Start With WaterSense. Environmental Protection Agency (USEPA). https://www.epa.gov/system/files/documents/2021-12/ws-outdoor-water-smart-landscapes.pdf

Vertdure. (2024). Comment reconnaître les mauvaises herbes sur votre pelouse? https://vertdure.com/fr/blogue/article/comment-reconnaitre-les-mauvaises-herbes-sur-votre-pelouse.21?fbclid=IwAR2nKSQrn13RoGkDWEoMY_7szSKIvsAv0_Gq6dHyoTu2TYCFAHlc05Nf7WA

Ville de Boucherville. (2023). Mai sans tondeuse | Boucherville embarque dans le mouvement! https://www.boucherville.ca/nouvelles/mai-sans-tondeuse-boucherville-embarque-dans-le-mouvement/

Ville de Laval. (2023). Règlement numéro 12084 concernant les nuisances et remplaçant le règlement L-11465 et ses amendements. Ville de Laval.

Ville de Magog. (2023). Mouvement Mai sans tonte. https://www.ville.magog.qc.ca/actualite-mai-sans-tonte-2023/

Ville de Montréal. (2020). Plan climat 2020-2030. Ville de Montréal. https://portail-m4s.s3.montreal.ca/pdf/Plan_climat%2020-16-16-VF4_VDM.pdf

Ville de Montréal. (2022). Plan—Montréal: Territoire de biodiversité par la protection des pollinisateurs (2022-2027). Ville de Montréal.

Ville de Montréal. (2023a). Règlement sur la vente et l'utilisation des pesticides (21-041). Ville de Montréal. https://montreal.ca/reglements-municipaux/recherche/61576d182f8ac90011ca58b5

Ville de Montréal. (2023b). Surfaces minérales et végétales. https://donnees.montreal.ca/dataset/surfaces-minerales-vegetales#methodology

Ville de Québec. (2005). Contrôle de l'érosion: Protection et stabilisation des surfaces. https://www.ville.quebec.qc.ca/gens_affaires/implantation-projets-immobiliers/projets-residentiels/docs/fiches_controle_erosion/Protection_et_stabilisation_des_surfaces.pdf

Ville de Québec. (2022). Mai sans tondeuse. https://www.ville.quebec.qc.ca/citoyens/environnement/milieux-naturels/mai-sans-tondeuse.aspx

Ville de Saint-Jérôme. (2023). Plan d'action environnemental de la Ville de Saint-Jérôme 2024-2026. Ville de Saint-Jérôme.

Ville de Sherbrooke. (2024). Règlement numéro 1300—Ville de Sherbrooke.

Wang, J., Bretz, M., Dewan, M. A. A., & Delavar, M. A. (2022). Machine learning in modelling land-use and land cover-change (LULCC): Current status, challenges and prospects. Science of The Total Environment, 822, 153559. https://doi.org/10.1016/j.scitotenv.2022.153559

Wang, Z.-H., Zhao, X., Yang, J., & Song, J. (2016). Cooling and energy saving potentials of shade trees and urban lawns in a desert city. Applied Energy, 161, 437–444. https://doi.org/10.1016/j.apenergy.2015.10.047

Zirkle, G., Lal, R., & Augustin, B. (2011). Modeling Carbon Sequestration in Home Lawns. HortScience, 46(5), 808–814. https://doi.org/10.21273/HORTSCI.46.5.808

ANNEX

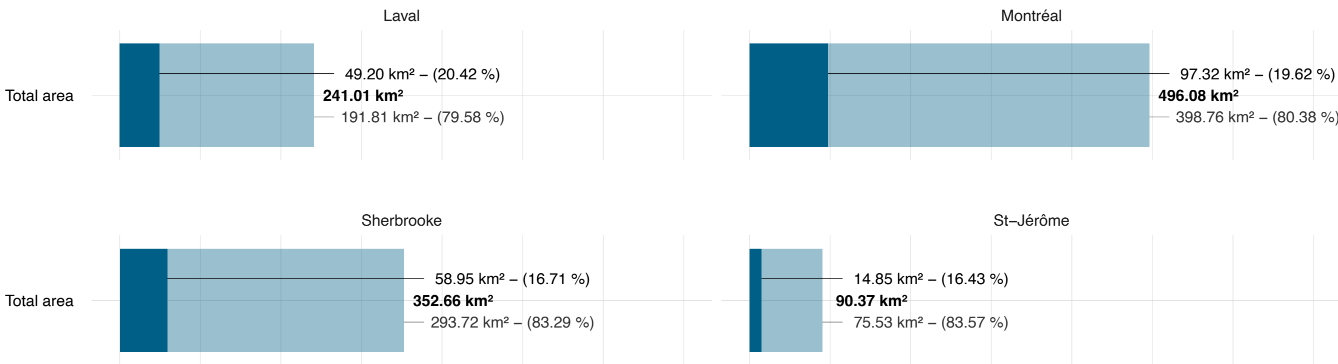


Figure S1. Proportion of land identified as low vegetation in each city.

Darker shades represent low vegetation surfaces, while lighter shades represent other types of surfaces. Values along the lines indicate the area (km^2) of each type of surface (i.e., low vegetation and others) and the values in parenthesis present the land proportion (%) occupied by this type of surface. The values in bold present the total land area of each city (km^2). The histograms include data from all usage classes, including from the group "Agricultural / Forestry."

Table S1. Links to download the datasets

DATA	DOWNLOAD URL
Découpages administratifs 1/20000 - munic_s.shp	https://www.donneesquebec.ca/recherche/dataset/decoupages-administratifs
Décennal-C 2018 (Mosaics of RGB orthophotos)	https://geoapp.bibl.ulaval.ca
Décennal-I 2018 (Model/Photo RGBI) + .PAR files	https://geoapp.bibl.ulaval.ca
Units of hydrographic division (UHD)	https://www.donneesquebec.ca/recherche/dataset/grhq
Canopy Height Model (CHM) - Montréal	https://www.donneesquebec.ca/recherche/dataset/produits-derives-de-base-du-lidar
Canopy Height Model (CHM) - Laval	https://www.donneesquebec.ca/recherche/dataset/produits-derives-de-base-du-lidar
Canopy Height Model (CHM) - Sherbrooke & Saint-Jérôme	https://www.donneesquebec.ca/recherche/dataset/produits-derives-de-base-du-lidar
Digital Terrain Model (DTM) - Montréal	https://www.donneesquebec.ca/recherche/dataset/produits-derives-de-base-du-lidar
Digital Terrain Model (DTM) - Laval	https://www.donneesquebec.ca/recherche/dataset/produits-derives-de-base-du-lidar
Digital Terrain Model (DTM) - Sherbrooke & Saint-Jérôme	https://www.donneesquebec.ca/recherche/dataset/produits-derives-de-base-du-lidar
Usages prédominants 2022	https://geoapp.bibl.ulaval.ca

Table S2. Simplification of predominant usage classes.

ATTRIBUTES COMPOSED OF INITIAL LAND-USE CLASSES	NEW LAND-USE CLASSES
Agricole *	Agricultural / Forestry
Agricole / Résidentiel	Agricultural / Forestry
Agricole / Terrain vague	Agricultural / Forestry
Agricole / Transport et infrastructure	Agricultural / Forestry
Forestier *	Agricultural / Forestry
Forestier / Résidentiel	Agricultural / Forestry
Forestier / Service	Agricultural / Forestry
Commercial *	Commercial / Industrial
Commercial / Industrie lourde / Industrie légère / Service	Commercial / Industrial
Commercial / Industrie lourde / Industrie légère / Service / Terrain vague	Commercial / Industrial
Commercial / Industrie lourde / Service	Commercial / Industrial
Commercial / Industrie légère	Commercial / Industrial
Commercial / Industrie légère / Service	Commercial / Industrial
Commercial / Industrie légère / Terrain vague	Commercial / Industrial
Commercial / Institutionnel	Commercial / Industrial
Commercial / Institutionnel / Restauration et hébergement	Commercial / Industrial
Commercial / Institutionnel / Restauration et hébergement / Transport et infrastructure	Commercial / Industrial
Commercial / Institutionnel / Service	Commercial / Industrial
Commercial / Parc et récréation	Commercial / Industrial
Commercial / Parc et récréation / Restauration et hébergement / Terrain vague	Commercial / Industrial
Commercial / Parc et récréation / Résidentiel	Commercial / Industrial
Commercial / Parc et récréation / Terrain vague	Commercial / Industrial
Commercial / Restauration et hébergement	Commercial / Industrial
Commercial / Restauration et hébergement / Résidentiel / Service	Commercial / Industrial
Commercial / Restauration et hébergement / Service	Commercial / Industrial
Commercial / Restauration et hébergement / Service / Transport et infrastructure	Commercial / Industrial
Commercial / Restauration et hébergement / Transport et infrastructure	Commercial / Industrial
Commercial / Sans correspondance	Commercial / Industrial
Commercial / Sans correspondance / Transport et infrastructure	Commercial / Industrial
Commercial / Service	Commercial / Industrial
Commercial / Service / Terrain vague	Commercial / Industrial
Commercial / Service / Transport et infrastructure	Commercial / Industrial
Commercial / Terrain vague	Commercial / Industrial
Commercial / Terrain vague / Transport et infrastructure	Commercial / Industrial
Commercial / Transport et infrastructure	Commercial / Industrial
Exploitation minière et service connexe *	Commercial / Industrial
Industrie lourde *	Commercial / Industrial
Industrie lourde / Industrie légère	Commercial / Industrial
Industrie lourde / Industrie légère / Service	Commercial / Industrial
Industrie lourde / Industrie légère / Terrain vague	Commercial / Industrial
Industrie lourde / Parc et récréation	Commercial / Industrial

Industrie lourde / Sans correspondance	Commercial / Industrial
Industrie lourde / Service	Commercial / Industrial
Industrie lourde / Terrain vague	Commercial / Industrial
Industrie lourde / Transport et infrastructure	Commercial / Industrial
Industrie légère *	Commercial / Industrial
Industrie légère / Parc et récréation	Commercial / Industrial
Industrie légère / Résidentiel	Commercial / Industrial
Industrie légère / Sans correspondance	Commercial / Industrial
Industrie légère / Service	Commercial / Industrial
Industrie légère / Service / Transport et infrastructure	Commercial / Industrial
Industrie légère / Terrain vague	Commercial / Industrial
Industrie légère / Transport et infrastructure	Commercial / Industrial
Restauration et hébergement *	Commercial / Industrial
Restauration et hébergement / Sans correspondance	Commercial / Industrial
Restauration et hébergement / Service	Commercial / Industrial
Restauration et hébergement / Terrain vague	Commercial / Industrial
Restauration et hébergement / Transport et infrastructure	Commercial / Industrial
Sans correspondance / Service	Commercial / Industrial
Sans correspondance / Service / Terrain vague	Commercial / Industrial
Service *	Commercial / Industriel
Service / Terrain vague	Commercial / Industriel
Service / Terrain vague / Transport et infrastructure	Commercial / Industriel
Service / Transport et infrastructure	Commercial / Industriel
Sans correspondance *	Transportation infrastructure
Sans correspondance / Terrain vague	Transportation infrastructure
Sans correspondance / Terrain vague / Transport et infrastructure	Transportation infrastructure
Sans correspondance / Transport et infrastructure	Transportation infrastructure
Terrain vague / Transport et infrastructure	Transportation infrastructure
Transport et infrastructure *	Transportation infrastructure
Institutionnel *	Institutional / Parks and recreation
Institutionnel / Parc et récréation	Institutional / Parks and recreation
Institutionnel / Parc et récréation / Service	Institutional / Parks and recreation
Institutionnel / Parc et récréation / Terrain vague	Institutional / Parks and recreation
Institutionnel / Restauration et hébergement	Institutional / Parks and recreation
Institutionnel / Restauration et hébergement / Transport et infrastructure	Institutional / Parks and recreation
Institutionnel / Sans correspondance	Institutional / Parks and recreation
Institutionnel / Service	Institutional / Parks and recreation
Institutionnel / Service / Transport et infrastructure	Institutional / Parks and recreation
Institutionnel / Terrain vague	Institutional / Parks and recreation
Institutionnel / Terrain vague / Transport et infrastructure	Institutional / Parks and recreation
Institutionnel / Transport et infrastructure	Institutional / Parks and recreation
Parc et récréation *	Institutional / Parks and recreation
Parc et récréation / Restauration et hébergement	Institutional / Parks and recreation
Parc et récréation / Restauration et hébergement / Service	Institutional / Parks and recreation
Parc et récréation / Sans correspondance	Institutional / Parks and recreation
Parc et récréation / Sans correspondance / Terrain vague	Institutional / Parks and recreation

Parc et récréation / Sans correspondance / Transport et infrastructure	Institutional / Parks and recreation
Parc et récréation / Service	Institutional / Parks and recreation
Parc et récréation / Service / Terrain vague	Institutional / Parks and recreation
Parc et récréation / Service / Transport et infrastructure	Institutional / Parks and recreation
Parc et récréation / Terrain vague	Institutional / Parks and recreation
Parc et récréation / Terrain vague / Transport et infrastructure	Institutional / Parks and recreation
Parc et récréation / Transport et infrastructure	Institutional / Parks and recreation
Commercial / Résidentiel	Residential
Commercial / Résidentiel / Service	Residential
Commercial / Résidentiel / Terrain vague	Residential
Commercial / Résidentiel / Transport et infrastructure	Residential
Institutionnel / Résidentiel	Residential
Institutionnel / Résidentiel / Service	Residential
Institutionnel / Résidentiel institutionnel	Résidentiel
Parc et récréation / Résidentiel	Residential
Parc et récréation / Résidentiel / Service	Residential
Restauration et hébergement / Résidentiel	Residential
Résidentiel *	Residential
Résidentiel / Résidentiel institutionnel	Residential
Résidentiel / Sans correspondance	Residential
Résidentiel / Sans correspondance / Terrain vague	Résidentiel
Résidentiel / Sans correspondance / Terrain vague / Transport et infrastructure	Résidentiel
Résidentiel / Service	Résidentiel
Résidentiel / Service / Terrain vague	Residential
Résidentiel / Service / Transport et infrastructure	Residential
Résidentiel / Terrain vague	Residential
Résidentiel / Terrain vague / Transport et infrastructure	Residential
Résidentiel / Transport et infrastructure	Residential
Résidentiel institutionnel *	Residential
Résidentiel institutionnel / Sans correspondance	Residential
Résidentiel institutionnel / Service	Residential
Résidentiel institutionnel / Terrain vague	Residential
Résidentiel institutionnel / Transport et infrastructure	Residential
Terrain vague *	Vacant lot

15 of the 16 original major usage classifications are identified in bold with an asterisk (*). The classification "Fishing, hunting, trapping and related activities" does not appear because it was not identified within the bounds of the four cities in this study.