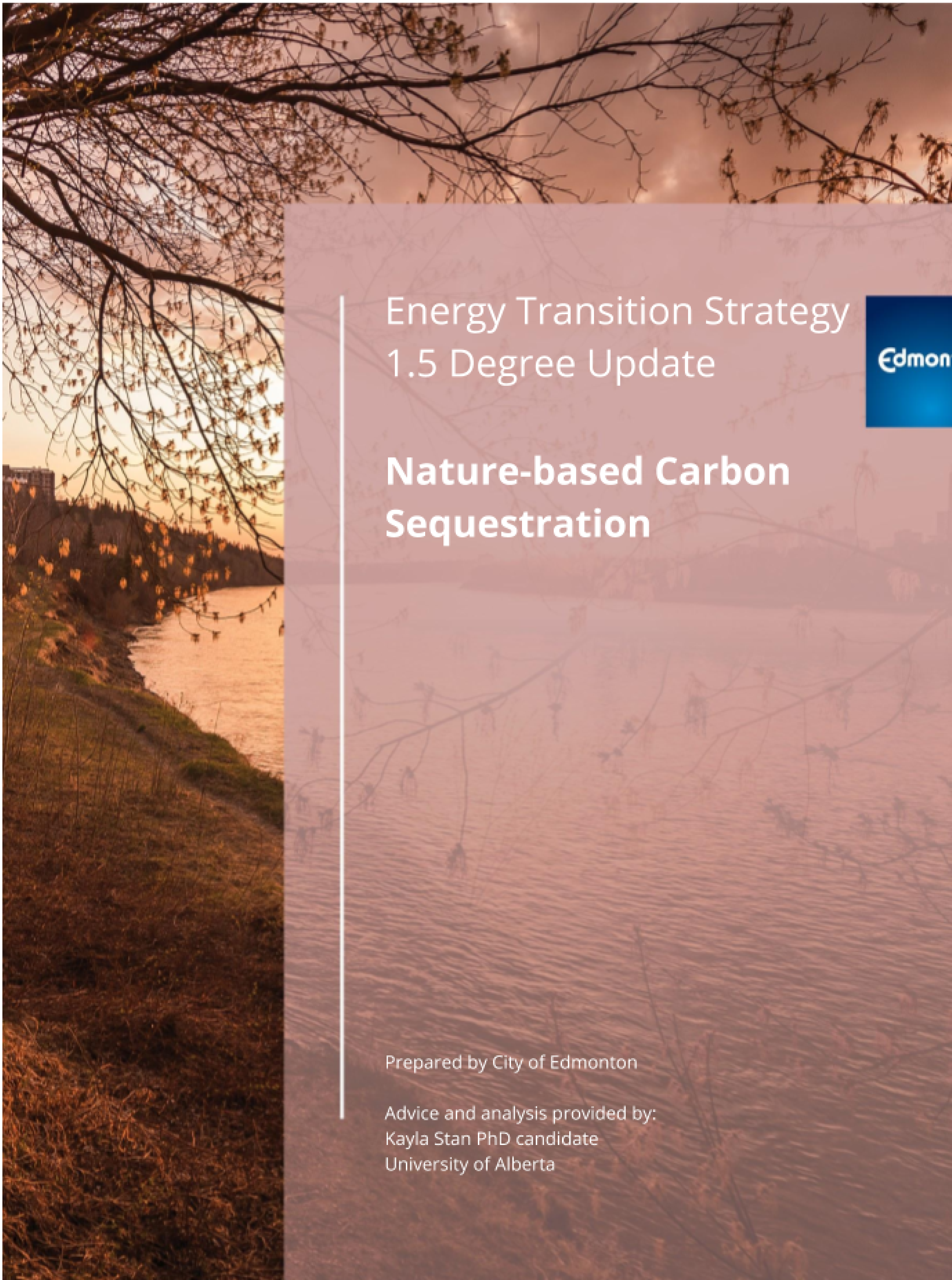

Energy Transition Strategy
1.5 Degree Update

Nature-based Carbon Sequestration

Prepared by City of Edmonton

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ISSUE IDENTIFICATION

On August 26th, 2019, the City of Edmonton declared a climate emergency and requested that City administration take steps to bring back a revised Community Energy Transition Strategy.

On August 26th, 2019, City of Edmonton (the City) Council declared a climate emergency and requested that City administration take steps to bring back a revised Community Energy Transition Strategy (CETS) by the end of third Quarter 2020 that aligns the current GHG emissions targets and actions with the local carbon budget for City Council's approval. The requested work involved the City modelling a 2050 carbon neutral scenario which showed that even with interventions and aggressive adoption of renewable energy technologies, the City will not be able to reduce enough GHG emissions to stay within its carbon budget developed under a 1.5 ^{o}C scenario. The work concluded that the City will need to utilize GHG mitigation mechanisms like carbon offsets to mitigate the residual GHG emissions to remain within the 155 MT carbon budget.

The objective of this policy brief is to examine key questions and provide recommendations related to the City's land use, natural areas and forestry management and the related carbon sequestration associated with those practices. This will specifically focus on contrasting the expected annual carbon stored in City boulevard trees under a "Business as Usual" and "Preferred" scenario reflective of how the City Plan currently under development might impact the annual amount of carbon stored.

CARBON SEQUESTRATION OVERVIEW

Land use and management influence a variety of ecosystem processes that affect greenhouse gas flow, such as photosynthesis, respiration, decomposition, disturbance, and combustion. These processes all involve transformations of carbon that are driven by natural and anthropogenic biological and physical processes (see Figure 1).

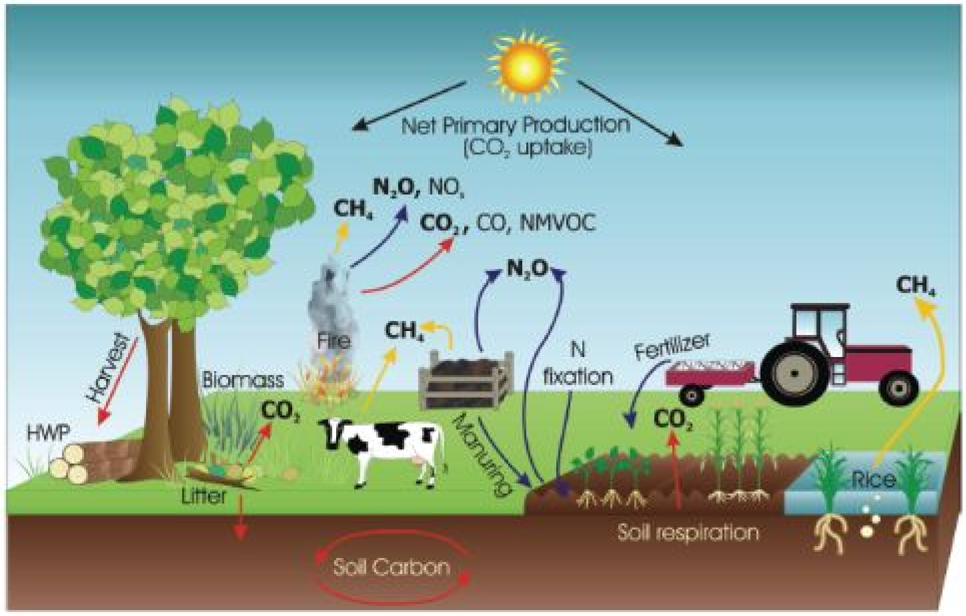

Figure 1: The main greenhouse gas emission sources/removals and processes in managed ecosystems. (Source: 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4: Agriculture, Forestry and Other Land Use).

Carbon dioxide is removed from the atmosphere and stored in plant biomass, including both the above-ground and below-ground biomass

Carbon dioxide is removed from the atmosphere and stored in plant biomass, including both the above-ground and below-ground biomass. Carbon dioxide is also released during normal plant respiration, decomposition or combustion; requiring that both the stored and released carbon dioxide must be considered to determine the net carbon stored through land use.[1] Carbon is also stored directly in soils, binding to certain minerals that are present depending on the soil type.[2]

CARBON STORED IN BOULEVARD TREES

The analysis undertaken to inform this briefing was a preliminary estimate of the carbon stored in Edmonton's boulevard trees under a 'Business as Usual' approach and under the City plan under development (referred to as the 'Preferred Scenario'). The scope of the analysis was limited due to a lack of data required to provide a more accurate estimate of the carbon stored in

[1] Keith Paustian, N.H. Ravindranath, and Andre van Amstel. "2006 IPCC Guidelines for National Greenhouse Gas Inventories; Volume 4: Agriculture, Forestry and Other Land Use". 2006.
[2] Technische Universitaet Muenchen. "Climate change: How does soil store carbon dioxide?." ScienceDaily. www.sciencedaily.com/releases/2014/01/140108102441.htm (accessed December 5, 2019).

__Boulevard Trees__ are all trees growing in City-owned boulevards, medians and park buffer zones. They do not include trees found in natural forest stands and other Natural Areas.

soils, and other land uses. It must be recognized that the analysis undertaken is a subset of the total carbon stored by Edmonton's trees. More detailed monitoring and measurement is required to also accurately infer the status of carbon sequestration from natural tree stands, other natural areas (e.g. wetlands, grasslands, shrublands), and their associated soils. The results of this analysis must be interpreted with a clear understanding of what carbon storage aspects were included and excluded. For example, the trees in natural dry land areas is a large carbon storage pool but was not included in the analysis and therefore it is not possible to infer any trends for this land type from the analysis.

Figure 2 provides an illustration of the limits of the analysis, highlighting that natural dryland areas with dense tree cover (in dark green) were unable to be included in this analysis.

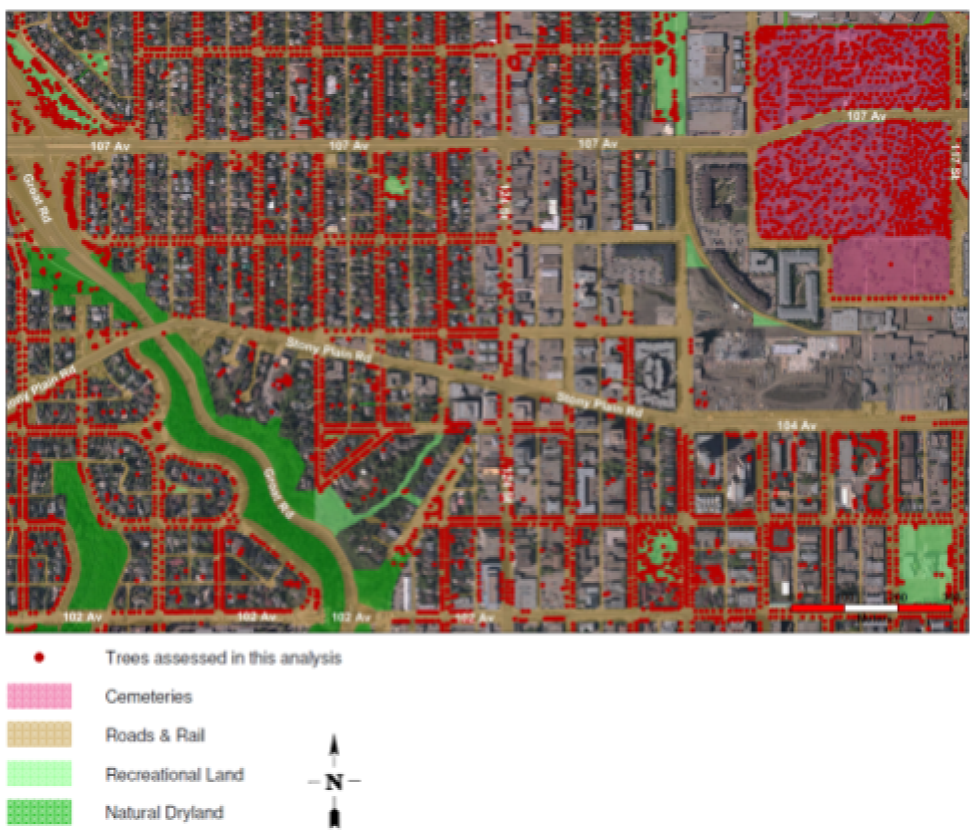

Figure 2: Boulevard trees included in analysis

Methodology and Analysis

To determine the expected annual carbon storage under a "Business as Usual" and "Preferred" scenario (reflecting the updated City Plan), a combination of allometric and modelling techniques were used. The carbon storage pools were divided into the above-ground biomass (carbon stored in tree trunks, branches, stem, foliage), below-ground biomass (carbon stored in roots), the soil carbon, and the dead carbon (fallen leaves and branches).

The dataset of tree locations, diameters, and species was derived from the Open Data Tree catalogue, which includes all boulevard trees that are maintained by the City of Edmonton. It is important to note that this dataset does not include any trees on private property or river valley and tableland natural area forests, and therefore the results underestimate the total carbon stored throughout the City in tree biomass. Assuming similar levels of Natural Area conservation between scenarios, the underestimation is presumed to be consistent between the two development scenarios investigated, allowing for a comparison between the scenarios, however, further investigation would be necessary to confirm this conservation assumption. The absolute storage values of each case, however, does not provide a precise estimate of overall carbon storage in the City of Edmonton and should not be relied on to estimate total carbon storage in the City of Edmonton due to vegetation and soils.

***Natural Areas** are areas of land or water that is dominated by native vegetation in naturally occurring patterns. Such areas could include grasslands, forests, wetlands, peatlands or riparian areas.*

Data used to determine soil carbon was taken from an interpolation of soil organic carbon, depth, and bulk density, using soil cores from the Really Grate Tree Project and regional cores[3] . Soil data is sparse throughout Edmonton, with only downtown and regional locations taken from two separate sources. Due to the limited data, the results of the interpolation was that all of the land cover types had the same soil carbon amount. Soil carbon accounts for a high proportion of the total storage capacity in the City of Edmonton, particularly in undisturbed soils such as those found in natural areas,[4] but the data

[3] Shaw C, Hilger A, Fillatrault M, Kurz W. (2018). A Canadian upland forest soil profile and carbon stocks database. *Ecology.* 99(4). doi: 10.1002/ecy.2159.
[4] Ontl, T.A. & Schulte, L.A. (2012) Soil Carbon Storage. Nature Education Knowledge 3(10):35 https://www.nature.com/scitable/knowledge/library/soil-carbon-storage-84223790/

currently available limits our ability to understand soil carbon content beyond that found in modified soil types within Edmonton's boulevards.

From these data, carbon storage in the above ground, below ground, soil, and deadfall were determined using equations from literature[5] [6]. Each of these factors were calculated for every individual tree included in the dataset. The results were then summed by location for each polygon in the current land use map of the City of Edmonton and divided by the area of the polygon. The soil carbon was calculated by interpolating the soil organic carbon, bulk density, and soil depth from the soil cores, and then calculating the total soil carbon pool for each polygon. All carbon pools for each polygon were then averaged by each land use category to provide an average for each land use type across the City of Edmonton. The wetland land use was an exception as they contain no boulevard trees, but are known to be large repositories for carbon storage. The wetlands carbon storage was averaged from literature[7].

The carbon storage in Edmonton's boulevard trees was found to be highest in cemeteries, road/rail/urban transit systems, and recreational land, highlighting the land use types that contain larger proportions of boulevard trees

These average values were used as input in the InVEST Carbon Storage and Sequestration model. This model takes the average carbon storage values provided and maps them on the current and future land use maps. Based on the current storage and future storage, the difference between these two is considered the carbon sequestration and is found both as a total number and over the spatial area. This model, therefore, provides us with the total net and annual sequestration, but also which areas of the City will gain or lose carbon sequestration.

There are two limits to this modelling approach. The first is that the model assumes a linear carbon sequestration pathway. This assumption does not hold when afforestation (i.e. tree planting) or climatic changes occur; however, in the case of an urban forest where there is a mix of old and young trees, this limitation should have a limited impact over the period considered in this project. The second limit is that this approach assumes that the City of Edmonton's tree planting regime will remain consistent compared to its

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[5] Case BS, Hall RJ. (2008). Assessing prediction errors of generalized tree biomass and volume equations for the boreal forest region of west-central Canada. Canadian Journal of Forest Research. 38: 878-889.
[6] Evans AM, Ducey MJ. (2010). Carbon accounting and management of living deadwood. Forest Guild. Santa Fe, NM. p.1-77.
[7] Moore TR, Bubier JL, Frolking SE, Lafleur PM, Roulet NT. (2002). Plant biomass and production and CO2 exchange in an ombrotrophic bog. Journal of Ecology. 90: 25-36.

historical rate, species composition, and density. If tree planting practices are changed to adapt to new climate conditions or enhance carbon storage, the estimates calculated will be affected.

Results

Figure 3 shows the results of the assessment of carbon storage in boulevard trees by different land types. These results highlight those land types that have a greater proportion of boulevard trees (with the exception of wetlands, which used alternative methods to quantify carbon stored). It is important to note that the results are presented in terms of the weight of carbon, and not carbon dioxide which is the common unit that is used in climate change analysis. The equivalent weight of carbon dioxide sequestered is 3.66 times the weight of carbon reported in these results.

The 'Business as Usual' scenario increases total carbon stored by 2.7% whereas the 'Preferred' scenario increases carbon stored by 14.2%.

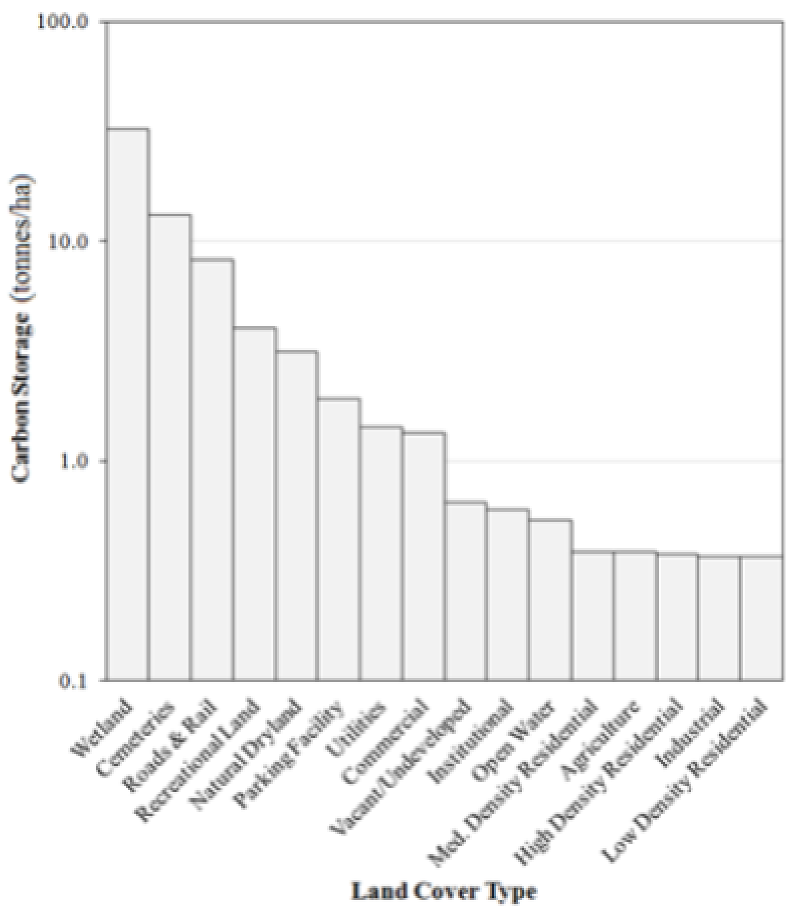

Figure 3: Average carbon storage in wetlands and boulevard trees by land use type in the City of Edmonton. Note: natural forest stands are not included in analysis.

The carbon storage in Edmonton's boulevard trees was found to be highest in cemeteries, road/rail/urban transit systems (i.e. boulevards and central medians), and recreational land. Low-density residential and industrial areas were found to store the least. These results highlight what land use types contain a larger proportion of Edmonton's boulevard trees, but do not reveal the total carbon storage potential in those land types. The carbon storage of Edmonton's boulevard trees ranges between 15.37 tonnes per hectare to 47.34 tonnes per hectare as shown on Figure 3.

The land cover types in Figure 2 were used to model the current carbon stored, and the additional carbon stored under the 'Business as Usual' and 'Preferred' scenarios. The 'Preferred' scenario reflects the expectations under the draft City Plan under development by the City of Edmonton. Figure 4 shows the results of this modelling both with and without the inclusion of soil carbon (as explained in the previous section, the carbon stored in soil is equivalent in both the 'Business as Usual' and 'Preferred' case and therefore does not affect the difference between the two scenarios).

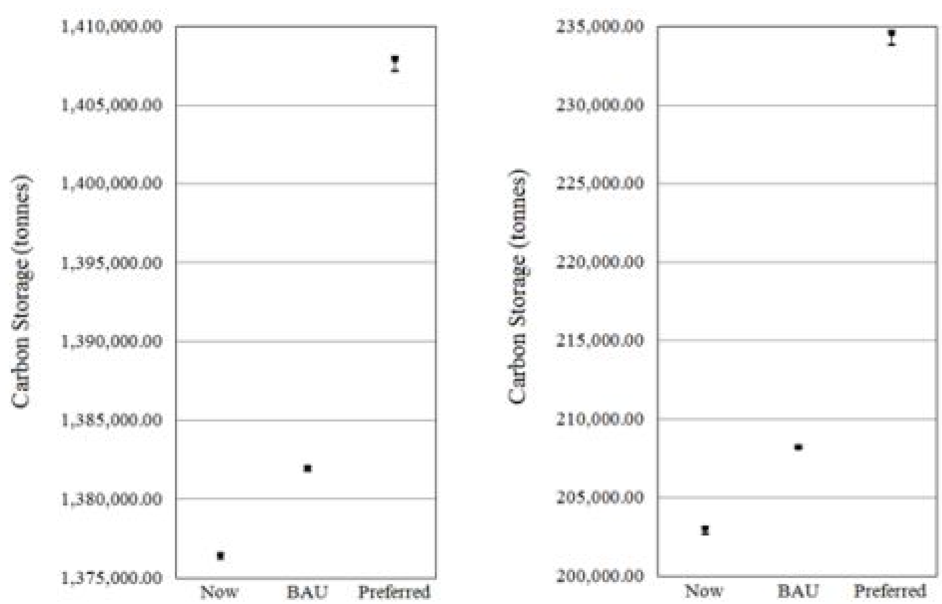

Figure 4: The total carbon stored in 2019 compared with the total carbon stored by 2065 under the 'Business as Usual' and 'Preferred' scenario. The left chart includes carbon stored in soils and the right chart excludes this soil carbon.

Figure 4 shows that there are currently approximately 203,000 tonnes of carbon stored in City boulevard trees (not considering soil carbon). This was determined to increase by 2065 under both the 'Business as Usual' and 'Preferred' scenarios. However, the 'Business as Usual' scenario increases total carbon stored by 2.7% whereas the 'Preferred' scenario increases carbon stored by 14.2%. This is also reflected in the annual carbon storage potential of the 'Business as Usual' and 'Preferred' scenarios, with the 'Preferred' scenario having over 5 times the annual sequestration rate compared with the 'Business as Usual' case by 2065 (see Table 1). Figure 5 provides the distribution of where boulevard tree carbon sinks are lost and gained throughout Edmonton under each scenario.

Table 1: Annual boulevard tree carbon and carbon dioxide sequestration potential by 2065 under the 'Business as Usual' and 'Preferred' land use scenarios.

Scenario	Annual Sequestration (tonnes C/year)	Annual Sequestration (tonnes CO_2/year)
Business as Usual	**120**	**440**
Preferred	**687**	**2,517**

Overall this analysis indicates that the City Plan, as currently envisioned through land use mapping, will be successful at increasing the total amount of carbon stored and the storage potential of City boulevard trees. However, this analysis does not reveal the potential carbon storage potential of natural areas within the City of Edmonton, and assumes that natural areas (both wetland and dryland) currently on the land base are conserved into the future.

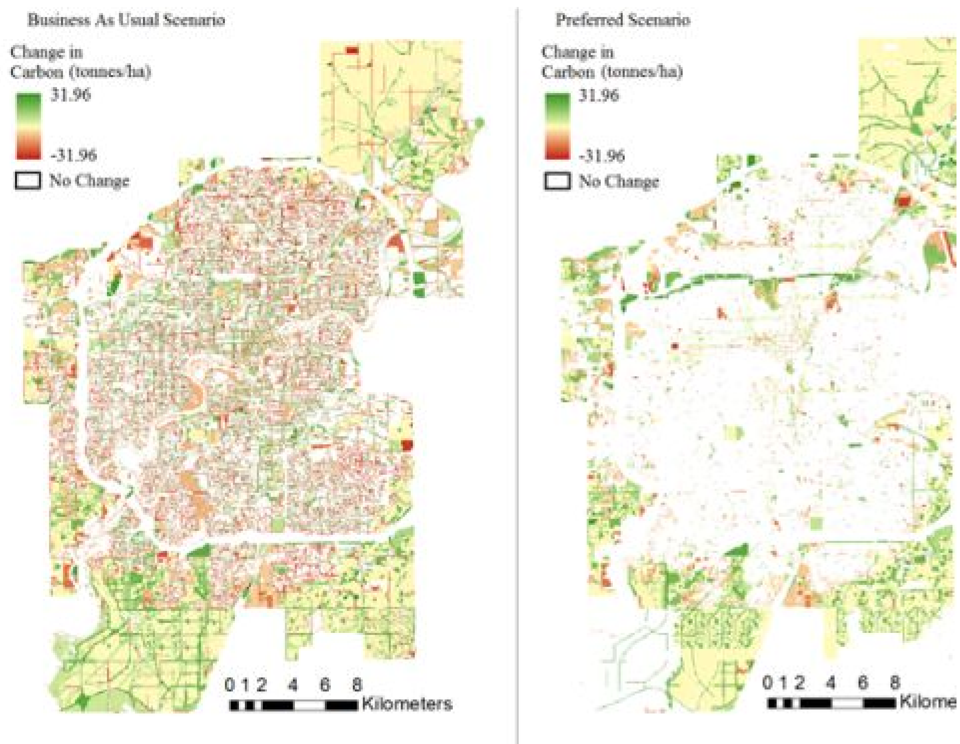

Figure 5: Changes in boulevard tree carbon sequestration potential by 2065 under the 'Business as Usual' (left) and 'Preferred' (right) scenarios.

Financial Value of Stored Carbon in Boulevard Trees

The financial value of the carbon sequestration was calculated by the InVEST Carbon Storage and Sequestration model. The value attached to carbon sequestration is composed of three parts, the price per metric ton of carbon dioxide, the market discount of the price of carbon dioxide, and the annual rate of change in the price of carbon dioxide. For this project, the market discount in the price of carbon dioxide is 7%, which is the U.S. government recommended discount rate for environmental projects (those projects with an environmental objective, such as reducing GHGs or conserving natural lands), and the annual rate of change of the price of carbon dioxide is 0% implying static prices over time. The value of the carbon dioxide stored was then calculated at two different market prices, $30 and $50 per tonne, representing the current range of carbon dioxide pricing being considered in Canada.

Table 2 presents the results of the financial valuation of sequestration in boulevard trees. The 'Business as Usual' scenario was found to sequester carbon dioxide worth at least $190,000 at $30 per tonne and more than

$321,000 at $50 per tonne. By contrast, the preferred scenario will be worth 6 times that value at $1.1 million and just over $1.8 million at $30 and $50 per tonne respectively.

Table 2: The monetary value of carbon stored in boulevard trees under the Business as Usual and Preferred development scenarios at different carbon price levels.

Scenario	Value of Carbon Dioxide Stored in boulevard trees ($CAD)	
	$30/tonne	$50/tonne
Business as Usual	192,895	321,495
Preferred	1,104,915	1,814,771

The City of Edmonton is committed to preserving Edmonton's urban forest for future generations and to ensure Edmonton remains an attractive, liveable city.

ADDITIONAL CARBON STORAGE OPPORTUNITIES

Edmonton's Urban Forest

The urban forest (consisting of both boulevard trees and natural forest stands) provide Edmonton and surrounding communities a wide range of important environmental, economic, social and health benefits. The City of Edmonton's Urban Forest Management Plan explores these benefits and quantifies the environmental and ecological benefits provided by Edmonton's urban forest in 2009. The scope of Edmonton's Urban Forest Management Plan includes the City's boulevard trees as well as natural forest stands and therefore the co-benefits shown here include a larger scope than the previous analysis, which only included City boulevard trees.

The urban forest improves air quality by filtering dust and absorbing ozone, carbon monoxide, sulphur dioxide, nitrogen oxides, airborne ammonia and heavy metals (see Table 3). They also help reduce the impacts of climate change by moderating the urban heat island effect, reducing temperatures and the energy needed for cooling as well as offering shade to reduce exposure to ultraviolet light.

Table 3: Amount and value of air pollution removed by Edmonton boulevard trees in 2009.[8]

Pollutants removed by Edmonton street trees	Metric Tonnes removed/year	Value in Canadian dollars/year
Carbon monoxide (CO)	6.07	$5,824
Nitrogen dioxide (NO2	75.93	$512,709
Ozone (O3)	254.25	$1,712,673
Particulate matter (PM10)	181.84	$819,744
Sulfur dioxide (SO2)	13.22	$21,850
Total	531.31	$3,076,800

The urban forest also can help filter water pollution and slow flows of water runoff, reducing damage to the stormwater systems and reducing the need to upgrade the capacity of stormwater systems in response to higher flows due to climate change. The urban forest also provides important habitats and corridors for wildlife movement, while also providing opportunity for residents to connect with our natural environment.

An assessment was completed to determine the financial benefits and costs of City boulevard trees. This included financial quantification of the benefits to air quality, stormwater, greenhouse gas emissions, energy use, and aesthetics. The analysis found that the average benefit per boulevard tree in Edmonton's urban forest amounts to $88.22 a year. Contrasting this with a cost of $23.78 per tree to maintain these trees reveals annual benefits of $64.44 per tree from the City's urban forest management[9].

An analysis of the City's urban tree canopy (i.e. the layer of tree leaves, branches, and stems that provide tree coverage of the ground when viewed from above) in 2012 assessed its coverage at 13.8% of the City. Of this, natural forest stands make up 5.44% (Table 4) with the remainder (8.36%) being all other planted trees - whether City or privately owned. Removing the urban tree canopy that covers privately owned lands from the 8.36% canopy, it is estimated that the remaining City owned trees make up 2.77% of all the

[8] City of Edmonton, Urban Forest Management Plan, May 2012. https://www.edmonton.ca/residential_neighbourhoods/PDF/Urban_Forest_Management_Plan.pdf
[9] City of Edmonton, Urban Forest Management Plan, May 2012. Pg. 16.

canopy cover in Edmonton. In general, this can be attributed to the canopy cover related to trees assessed in this analysis.

Given the above analysis, it is important to note that 11.03% of the tree canopy within the City of Edmonton (5.44% natural forest plus 5.59% privately owned trees) costs very little for the City to maintain. Indeed, comparing the costs to maintain the City's boulevard trees versus maintaining the natural forested lands highlights that it is cost effective to conserve, restore and maintain natural forested lands. In addition, it is important to recognize the important role that the public and private industry has in maintaining a significant portion of the City's urban tree canopy.

Future analysis should be completed to ensure that the carbon sequestration potential of natural areas and privately managed trees be incorporated into City wide carbon sequestration analyses. Also, with this analysis there is now the understanding that with greater public involvement and the development of public partnerships for enhancing the urban tree canopy, everyone has the potential to support and participate in an important mitigation action for the City of Edmonton.

Table 4: Key Statistics related to Edmonton's forested natural areas (data from the 2015 City of Edmonton urban Primary Land and Vegetation Inventory).

Forest stand type	% of City	Area (ha) of 2015 City Boundary
Balsam poplar	2.01%	1,410
Black spruce	0.06%	40
Coniferous leading mixedwood	0.23%	158
Deciduous leading mixedwood	0.14%	101
Mixed deciduous	0.11%	78
Trembling aspen	2.20%	1,539
White spruce	0.69%	485
Total natural forest	***5.44%***	***3,811***

Edmonton's Wetlands

Wetlands form an important component of Edmonton's landscape, providing essential ecosystem services like water purification, erosion control and flood management, while supporting a large range of biodiversity. Preserving these areas in the urban landscape can also reduce the need to invest in more expensive built infrastructure. For example, wetlands intercept rainfall and filter pollutants out of water, making Edmonton less dependent on stormwater and water treatment infrastructure.[10]

Wetland vegetation and other plants remove carbon dioxide from the air, reducing the harmful impacts of emissions on climate change. The assessment on Edmonton's boulevard trees found that carbon storage was comparatively higher in wetlands above all other land use types based on the carbon storage found within the boulevard trees and associated modified soils. Wetlands were estimated to sequester 47.34 tonnes per hectare of carbon based on reported estimates, with the next closest treed land use type (i.e. cemeteries) estimated to sequester 14 tonnes per hectare of carbon. While the boulevard tree analysis was unable to estimate the carbon stored in soils, this reveals the higher ability of wetlands to store carbon over other land types.

Edmonton's grass, shrub and agricultural lands.

While wetlands and forests are some of Edmonton's most productive carbon sequesters, the value of Edmonton's other natural areas such as shrublands and grasslands, as well as agricultural lands are also areas important to explore and assess for carbon sequestration potential.

As of 2015, 18.5% of Edmonton's land use was dedicated to agriculture in the form of cropland or pastureland. The City Plan's commitment to protecting agricultural lands presents an opportunity for greater carbon sequestration potential. Current research shows that soil carbon sequestration in agricultural croplands can be improved by selecting and promoting sustainable agricultural management practices - thereby creating a new carbon sink opportunity.[11]

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[10] City of Edmonton. 2012. City of Edmonton Wetland Strategy.

[11] Smukler, S. 2019. Managing Canadian Croplands to Maximize Carbon Sequestration and minimize Other Ecosystem Service Trade-Offs. April 2019. https://capi-icpa.ca/wp-content/uploads/2019/04/2019-02-21-CAPI-land-use-dialogue_Smukler-Paper-WEB-4.pdf

Despite the opportunities for protection of agricultural lands within the City's limits, the importance of conserving Edmonton's few remaining grasslands and shrublands can not be understated. While covering only 1,200 ha of Edmonton in 2015, such areas have been shown to store large carbon pools within their associated soils. Unlike trees and forests, who store a significant amount of their carbon above ground, grasses that dominate grasslands are characterized by extensive fibrous root systems that make up to 80% of the biomass carbon stored in these natural areas. Because of this, natural grassland restoration has become a major focus of carbon sequestration researchers.

The value of restoring native grassland, and the deep roots of its grasses, has been recognized as effective at not only sequestering carbon, but also absorbing far more water when installed around stormwater management facilities than current naturalization practices, thereby reducing pressure on grey infrastructure that are more costly to maintain. In addition, the incorporation of native grasslands also reduces maintenance costs, mainly by reducing mowing, thereby also reducing carbon emissions through reduced fuel use.

MUNICIPAL CONTROLS AND LEVERS

Edmonton's 11,000 hectare Green Network forms a valuable part of the City's landscape and is arguably Edmonton's most valuable community asset. It is made up of multiple natural assets (e.g. wetlands, forests, rivers, soil) that provide important municipal services and contain some of the most resilient and biologically diverse green infrastructure found within our municipal boundaries.

The City of Edmonton is committed to preserving Edmonton's boulevard trees, wetlands and natural forest areas for future generations and to ensure Edmonton remains an attractive, liveable city. The City of Edmonton Corporate Tree Management Policy (C456B) states that the City has a responsibility to protect and preserve all trees on City land from destruction, loss or damage. The purpose of the Corporate Tree Management Policy is to ensure the continued growth, sustainability, acquisition, tree maintenance, protection and preservation of the urban forest in the City of Edmonton. Further, the City's Natural Area Systems Policy (C531) states that "*Edmonton is committed to conserving, protecting, and restoring our natural uplands, wetlands, water bodies, and riparian areas, as an integrated and connected system of natural areas throughout the city*" to sustain the quality of life for Edmontonians by safeguarding our natural capital and the their associated ecosystem services.

Moving into the future, there is a strong need to identify, monitor and value the environmental, economic and social values that Edmonton's natural assets supply. Using the spatial tools the City has developed to date, and following the City's strong policy framework Edmonton can build a strong environmental and spatial natural asset evidence base that the City can use to enhance residents quality of life by sustaining a healthy environment; demonstrate an equitable balance of ecological, social, and economic considerations in decision making; and make decisions based on the best available research on assessing natural assets.

Related to this work, the draft City Plan acknowledges the importance of the City's natural assets and the accounting of their value within our planning and asset management budgeting frameworks. Such inclusion of natural asset valuation by other Municipalities has shown that appropriate municipal natural asset management can lead to changes in operations and maintenance plans and associated financial planning; development cost and subdivision bylaws, and many other aspects of local government.[12]

FORESEEABLE ISSUES AND MITIGATION STRATEGY

A key issue related to management of all lands for sequestering carbon is related to how we calculate the amount of carbon that is sequestered and how management activities undertaken by the City of Edmonton or others are included or excluded in the methodology.

[12] The Municipal Natural Assets Initiative, *Advancing and Integrating Municipal Natural Asset Management through Asset Management Planning in Ontario,* December 2019. https://mnai.ca/media/2020/01/MNAI_MNAPOntario.pdf

To date, the City of Edmonton has relied upon the methodology described by the 2006 IPCC Guidelines for National Greenhouse Gas Inventories to quantify the carbon sequestration from land use. This methodology employs country- or region-specific data for key land-use categories (defined as a 'Tier 2' estimate). While this methodology provides a reasonable estimate of carbon sequestration, it is possible that local land use management activities and actions are not accounted for within the data employed due to the larger spatial extent of the source data. This might result in the City undertaking land management activities that are beneficial for carbon sequestration but the benefits may not be captured within the GHG inventory.

It is important to note that whichever quantification methodology is employed, it must balance the cost of data collection and analysis with the accuracy and precision needed to account for all key activities occurring on the land. A key requirement for GHG inventory reporting is for consistency in the methodologies employed from year to year, and a change in the methodology employed will not represent an increase or decrease in emissions - simply a better approach to account for all land use activities.

To mitigate this potential issue, a Key Category Analysis should be undertaken as defined by the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. A Key Category Analysis would help the City to identify and achieve the most reliable inventory methodology for quantifying land use carbon sequestration. This analysis is intended to identify which land-uses and management activities are significant for the inventory, and establish the necessary methodological approach to account for those uses and activities.

CONCLUSIONS AND RECOMMENDATIONS

Edmonton's land use, wetlands and urban forest are an important sink of carbon within the City's GHG inventory. The analysis presented within this brief highlights that the draft City Plan as currently envisioned will result in an increase in annual carbon storage from increased boulevard tree coverage - representing a step in the right direction for reducing City emissions.

Although the analysis indicated an increase in annual carbon storage due to the City Plan, it was recognized that the methodology employed for the analysis and currently used within the City of Edmonton GHG inventory may not fully account for local land management activities that the City undertakes that are beneficial for reducing City emissions.

To continue to enhance the carbon storage of the City's land use and urban forest the following actions are recommended:

1. Continue with development of the City Plan, and establish nature-based carbon sequestration requirements within district planning to help ensure the expected increase in annual carbon storage is achieved through City Plan implementation.
2. Establish an integrated ecosystem services team to undertake comprehensive ecological and environmental planning to assist in quantifying and maximizing carbon storage of land use, the urban forest and protection or restoration natural areas (in alignment with Action 17 in Climate Resilient Edmonton: Adaptation Strategy and Action Plan).
3. In alignment with draft City Plan recommendations and Climate Resilient Edmonton, assess, value and incorporate natural infrastructure into asset management planning and decisions, and include full cost accounting for natural assets as part of capital planning and budgeting through the integrated ecosystem services team identified in Recommendation #2.
4. Engage with natural asset experts (e.g. the Municipal Natural Assets Initiative, Innotech Alberta) to develop a municipal asset management framework for the City of Edmonton to adapt existing, and develop new, municipal natural asset management guidance, training material and help-desk functions to be applied in the City of Edmonton.
5. Establish a formal partnership with biodiversity experts (e.g. the Alberta Biodiversity Monitoring Institute, University of Alberta research groups) to provide access and advice to leading environmental monitoring methods and techniques.
6. Undertake a Key Category Analysis (through the ecosystem services team) for the agriculture, wetlands, forestry and all other land use (AFOLU) emission sources and sinks to ensure all major land uses and management actions that contribute to GHG releases/storage are included in the methodology employed in the City's GHG inventory.

7. Based on the results of the Key Category Analysis, implement any changes to the GHG inventory methodology and deploy necessary monitoring to enhance the accuracy and precision of the carbon sequestration estimates from AFOLU.
8. Lead or establish partnerships to establish conservation of key land types that are known to be large carbon sinks resilient to expected climate changes within the City of Edmonton boundary (such as wetlands, natural forests, shrublands or grasslands as appropriate).