Clean Air Calculator

Methodology, Data Sources and Metrics Summary

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Contents

1. Acronyms

AFC: Annual Fuel Consumption

C: Carbon

CO_2: Carbon Dioxide

CO_2e: Carbon Dioxide equivalent

GHG: greenhouse gas

GIS: Geographic Information Systems

Ha: Hectare

Kg: Kilogram

Km: Kilometer

Mg: Megagram

NPP: Net Primary Productivity

O_2: Oxygen

m^2: Square meters

m^3: Cubic meters

t CO_2e: Tonnes of carbon dioxide equivalent

y: Year

2. Introduction

There are an approximate 82% of Canadians living in large municipalities and cities in Canada that are experiencing very real, negative health effects from our changing urban climate.

We know that plants act as a carbon sink, and they play an important role in sustaining life on earth, adjusting carbon balance and alleviating the rise of atmospheric carbon dioxide concentration.

Greenery, ranging from trees, turfgrass to shrubs and perennials in urban areas, all have an important role in the carbon balance in our world.

However, the value of greenery not always easily communicated in an engaging way to the public, the Clean Air calculator's goal is to change that and make the interface enjoyable, accessible, and easy to use.

Our Clean Air Calculator combines GIS based interactive maps with a scientific data model to identify the value of actual greenspace in cities, communities, neighbourhoods, and individual properties.

The calculator is based on ArcGIS Online, Esri's web-based software with Geographic Information Systems (GIS) technology.

GIS is a computerized framework for the gathering, managing, and analyzing of data. Built upon the science of geography, it combines robust mapping and visualization with a strong data integration, analysis, and modelling framework.

3. Goals

Our primary goal is to inform, engage and inspire people to connect with their plants and use the Calculator to understand how their trees, gardens and lawn all work together to produce clean air and sequester carbon dioxide.

At the same time, our goal is to create awareness about climate change and the value of climate nature-based solutions in communities across Canada.

4. How does the tool works?

The tool is intended to guide individuals through a series of steps, from locating the urban vegetation on a map, drawing one or many free-form polygons and determining the selection's impact.

The clean air calculator uses data from a key published studies and sources, including the government of Canada, Gina Zirkle, 2010 - Assessment of Carbon Sequestration in the US Residential Landscape, the University of Guelph paper "Development and interpretation of results from an urban landscape calculator," and the U.S Forest Service Department.

Utilizing the information found in the scientific literature, our model was design with average rates to determine the plant's ability sequester carbon and produce oxygen.

First, the carbon dioxide was determine based on the sequestration rates of trees, shrubs, and lawns. Based on the results, the oxygen production was estimated.

The people impacted by the greenery was determined based on the value of the oxygen, and finally the carbon dioxide sequestered was extrapolated to the average Canadian vehicle, which burns 2000 L of gasoline every year.

3.1 Carbon Dioxide Sequestration

To determine the Carbon Dioxide CO_2, first we need to determine the weight of carbon. For the purpose of this methodology, we will use the Net Primary Productivity rates to determine the weight of carbon.

Step 1: Weight of carbon

Assumptions:

1. Net Primary Productivity rates to determine the weight of carbon. Net Primary Productivity: which is how much carbon dioxide vegetation takes in during photosynthesis minus how much carbon dioxide the plants release during respiration (metabolizing sugars and starches for energy).

2. Average NPP rates found in literature.

	NPP rates (Mg C ha^{-1} y^{-1})*	Reference
Trees	4.8	[1] [2]
Turf	7.7	[3]
Shrubs	5.0	[4] [5] [6] [7] [8]

*(Average values)

Formula:

Weight of carbon= (NPP rate) (Area)

Step 2: Weight of carbon dioxide (Converting C into CO_2)

Assumptions:

1. The weight of Carbon Dioxide is estimated on a ratio of the molecular weight of Carbon Dioxide $C0_2$ to that of Carbon.

- Carbon Dioxide CO_2 (44)
- Carbon C (12)
- $C0_2$ (44)/C (12) = 3.7

Formula:

Weight of carbon dioxide= (Weight of Carbon) (molecular weight ratio $C0_2$ to that of Carbon)

3.2 Oxygen production/ Volume of clean air

a. Oxygen production

Assumptions:

- The oxygen production is estimated on a ratio based of O_2 and CO_2 atomic weights.
    - Oxygen (16x2=32)
    - Carbon Dioxide (44)
    - O_2 (32)/CO_2 (44) = 0.72

Formula:

Oxygen= (Weight of Carbon Dioxide) (Molecular Weight ratio 0_2 /$C0_2$)

b. Volume of Clean Air

Assumptions:

- Volume of clean air: The air in Earth's atmosphere is made up of approximately 78 % nitrogen and 21 % oxygen.

Formula

Volume of clean air= (Oxygen m^3) (0.21 %)

3.3 Number of people benefited (Human Oxygen Consumption)

Assumptions

- An average human oxygen consumption rate[1] of 215 m^3 /year was used to estimate how much human oxygen consumption would be offset by the urban vegetation production annually.
- To estimate how much human oxygen consumption would be offset, oxygen production was divided by average annual oxygen consumption per person.

Human Oxygen Consumption

HOC	kg	m^3
Day	0.84	0.6
Year	307	215

Nowak and Crane, 2002

Formula

Human Oxygen Consumption= O_2 / Average annual oxygen consumption per person.

[1] Source: Nowak and Crane, 2002.

3.4 Kilometers offset

Assumptions

- Burning 1 L of gasoline produces approximately 2.3 kg of CO_2[2]. (0.0023 t $CO_{2e.}$)
- CO_2 has a Global Warming Potential of 1. The GWP is the ability of a gas to trap heat in the atmosphere.
- The tonne is a metric unit of mass equal to 1,000 kilograms. It is also referred to as a metric ton. The official SI unit is the megagram, a less common way to express the same mass.
- CO_2e (Carbon dioxide equivalent) is a term for describing different greenhouse gases in a common unit. For any quantity and type of greenhouse gas.
- CO_2e signifies the amount of CO_2 which would have the equivalent global warming impact. A quantity of greenhouse gas can be expressed as CO_2e by multiplying the amount of the Greenhouse gas by its Global Warming Potential GWP.
- E.g., if 1kg of methane is emitted, this can be expressed as 25kg of CO_2e (1kg CH4 * 25 = 25kg CO2e).
- CO_2e= The Global Warming Potential of CO_2 is 1.
- $CO_2e=CO_2$ (t or Mg)
- According to Natural Resources Canada, Office of Energy Resources the average mileage per year in Canada is about 15,200 kilometres [9].

Formulas

Km offset = t CO_2e vegetation/ Annual car emissions t CO_2e

1. Annual car emissions=(AFC) (CO_2 gasoline)

1.1 Annual Fuel Consumption

AFC Gasoline= (Annual distance km) (Consumption L/100 km)
= (15200 km) (8 L/100 km)
=1216 L

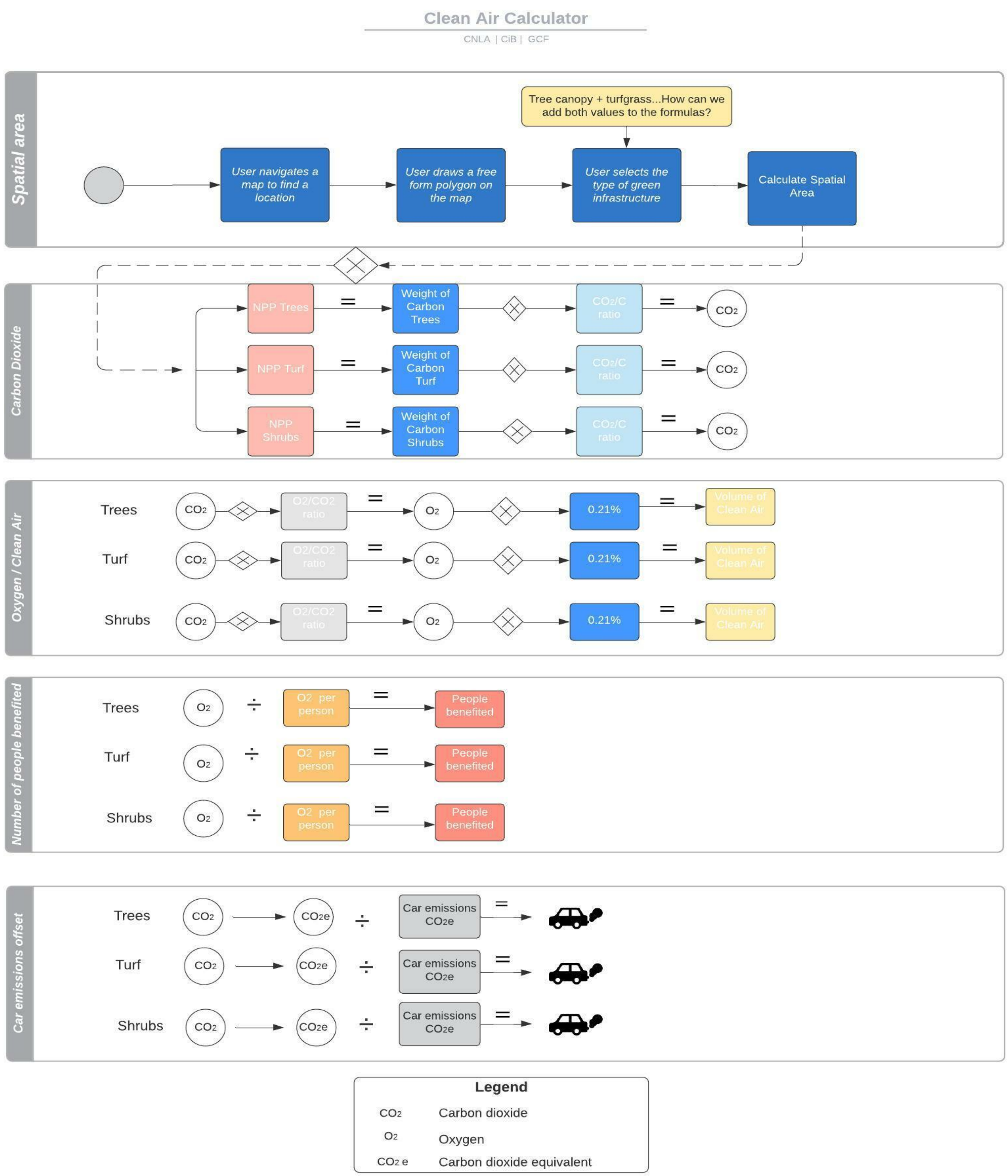
1.2. CO_2 gasoline: 2.3 kg CO_{2e} (0.0023 t $CO_{2e.}$)

3. Annual average car emissions tCO2e

Annual car emissions = (1,216 L) (0.0023 t CO_{2e} /L)
Annual car emissions = 3 t CO_{2e}

[2] [12].

5. Clean Air Calculator Diagram



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