# ECS Lunch and Learn

*Supporting internal knowledge transfer within TRCA*

February 8, 2023

**Toronto and Region Conservation Authority**

# Valuation of Ecosystem Services in City-owned and Operated Parks, Golf Courses, and Open Green Spaces in Toronto

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Analyst, Ecosystem and Climate Science

February 2023

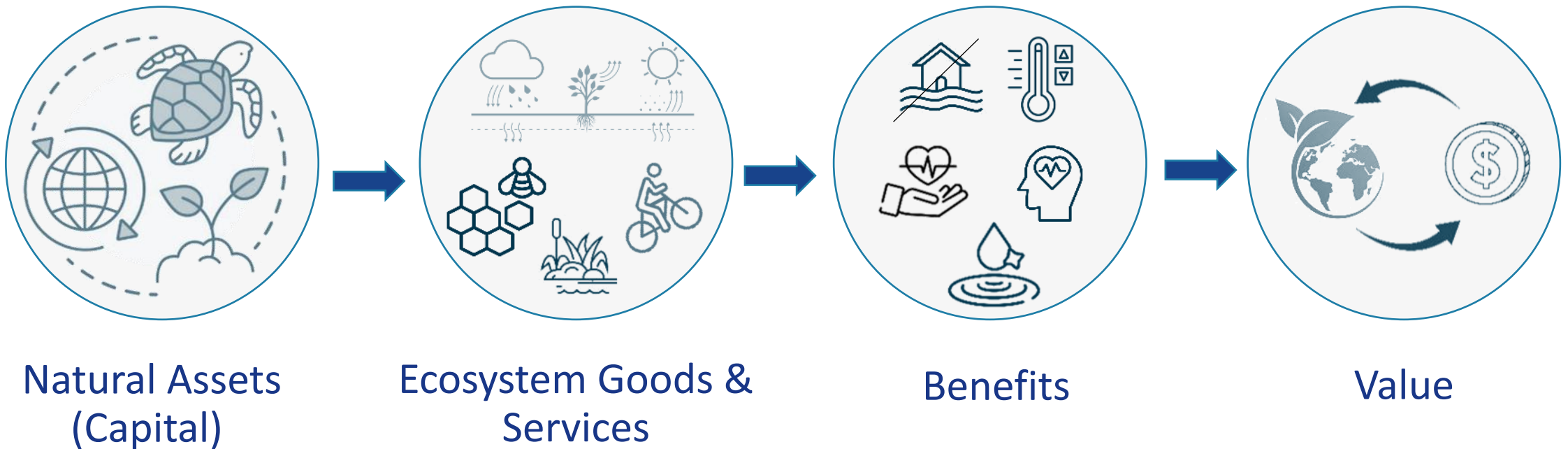Toronto and Region
Conservation
Authority
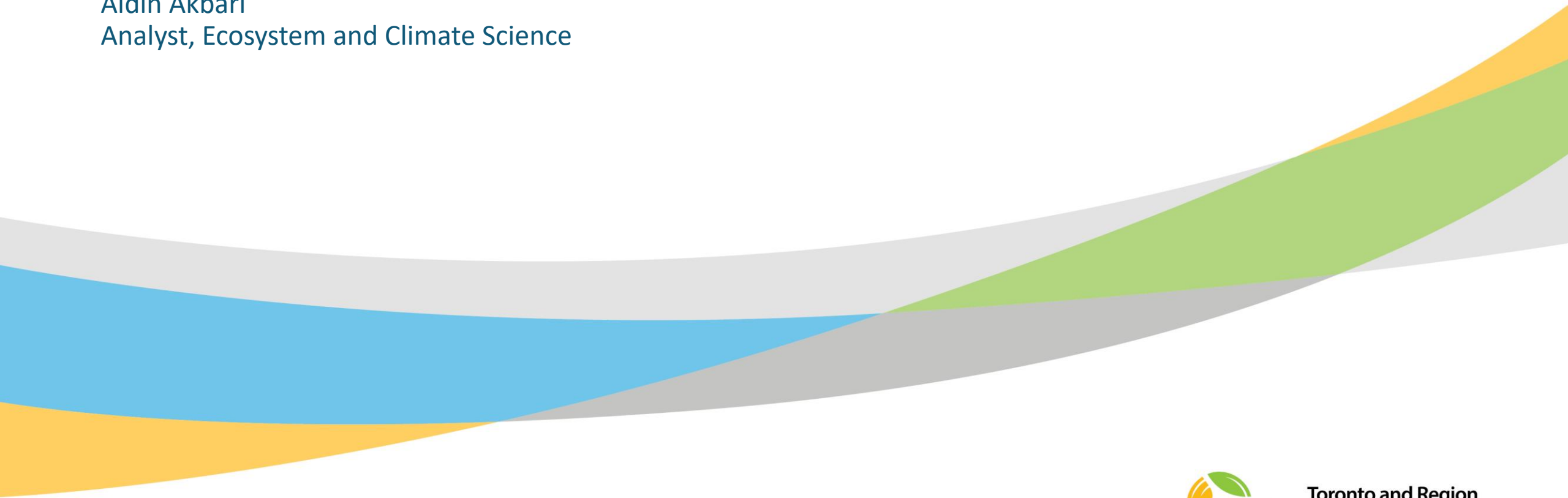
# Outline

- **Section 1: Natural Assets and Ecosystem Goods and Service Valuation**

- **Section 2: Ecosystem Services of Toronto's Parks, Golf Courses, and Open Green Spaces**
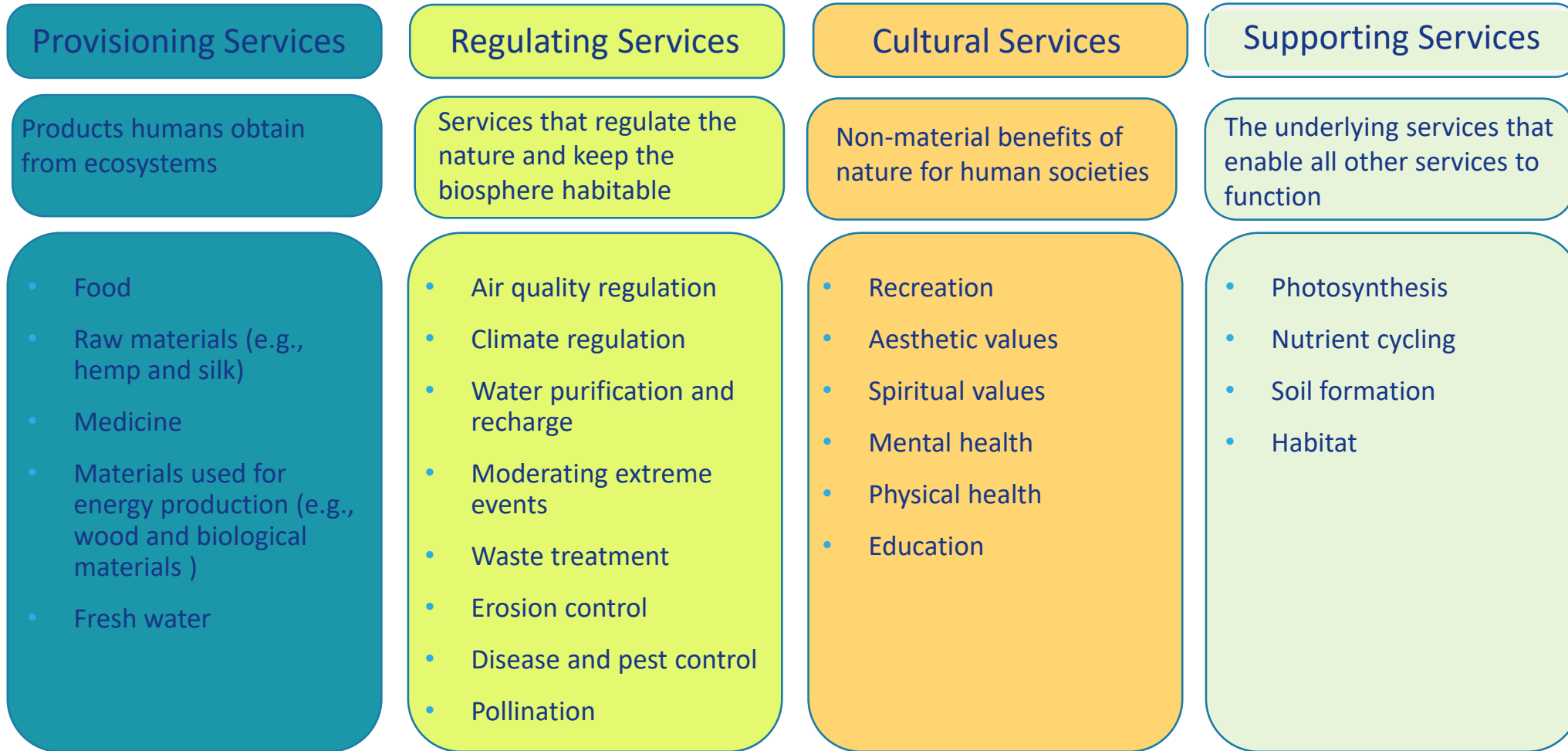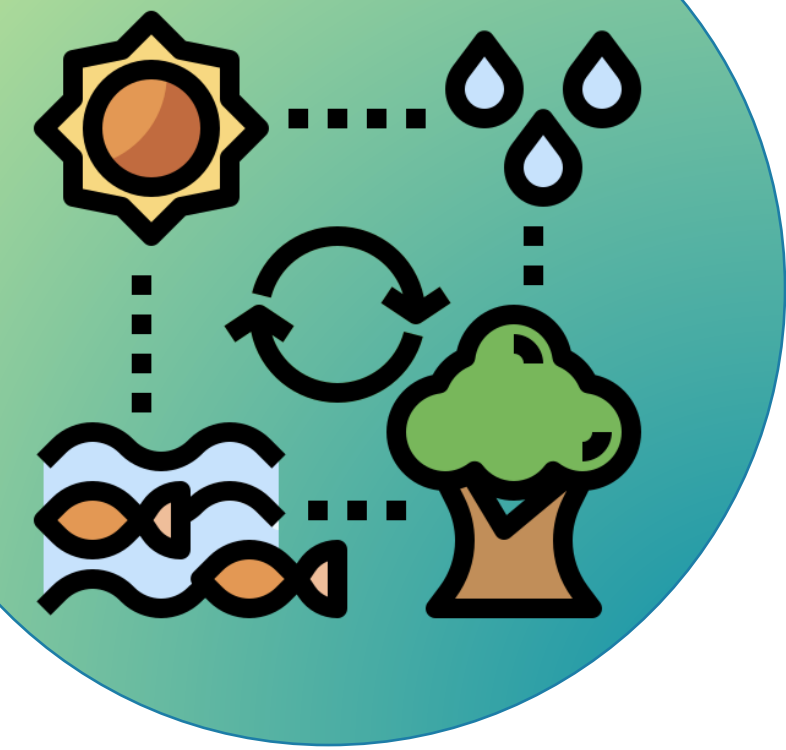
- **Section 3: Aggregate Benefits**

# Section 1

# Natural Assets and Ecosystem Goods and Service Valuation

# Natural Assets and their Ecosystem Goods and Services



Natural Assets (Capital) → Ecosystem Goods & Services → Benefits → Value

# Ecosystem Services

| Provisioning Services | Regulating Services | Cultural Services | Supporting Services |
|---|---|---|---|
| Products humans obtain from ecosystems | Services that regulate the nature and keep the biosphere habitable | Non-material benefits of nature for human societies | The underlying services that enable all other services to function |
| • Food<br>• Raw materials (e.g., hemp and silk)<br>• Medicine<br>• Materials used for energy production (e.g., wood and biological materials )<br>• Fresh water | • Air quality regulation<br>• Climate regulation<br>• Water purification and recharge<br>• Moderating extreme events<br>• Waste treatment<br>• Erosion control<br>• Disease and pest control<br>• Pollination | • Recreation<br>• Aesthetic values<br>• Spiritual values<br>• Mental health<br>• Physical health<br>• Education | • Photosynthesis<br>• Nutrient cycling<br>• Soil formation<br>• Habitat |

# What is the Purpose of Ecosystem Service Valuation?

- Understand the costliness of replacing these services with engineered assets

- Make the exploitation of natural resources a much less attractive strategic choice for private interests

- Protect public interests by developing and implementing land use planning and resource management policies aimed at protecting, enhancing, and restoring natural assets

# Section 2

# Ecosystem Services of Toronto's Parks, Golf Courses, and Open Green Spaces

# Parks, Golf Courses, and Open Green Spaces in Toronto

**Legend**

- City Park
- Golf Course
- Large Park
- Legacy Park
- Medium Park
- Open Green Space
- Parkette
- Small Park

*Lake Ontario*

0  1.5  3  6  9  12  Km

N

Area

- 8084 ha of park space
- 82 ha of open green spaces
- 199 ha of golf courses

Proportion of the total urban land

- 13%

Park classification according to parkland strategy grouping

- Parkette < 0.5 ha
- Small parks 0.5-1.5 ha
- Medium parks 1.5-3 ha
- Large parks 3-5 ha
- City park 5-8 ha
- Legacy park +8 ha

# Natural Assets

**Legend**
- Allotment Garden Site
- Beach/Bluff
- Community Garden
- Mature Forest
- Golf Course
- Meadow
- Open Waterbody
- Recreational/Open Space
- Stormwater Pond
- Successional Forest
- Wetland

*Lake Ontario*

0  1.5  3  6  9  12  Km

N
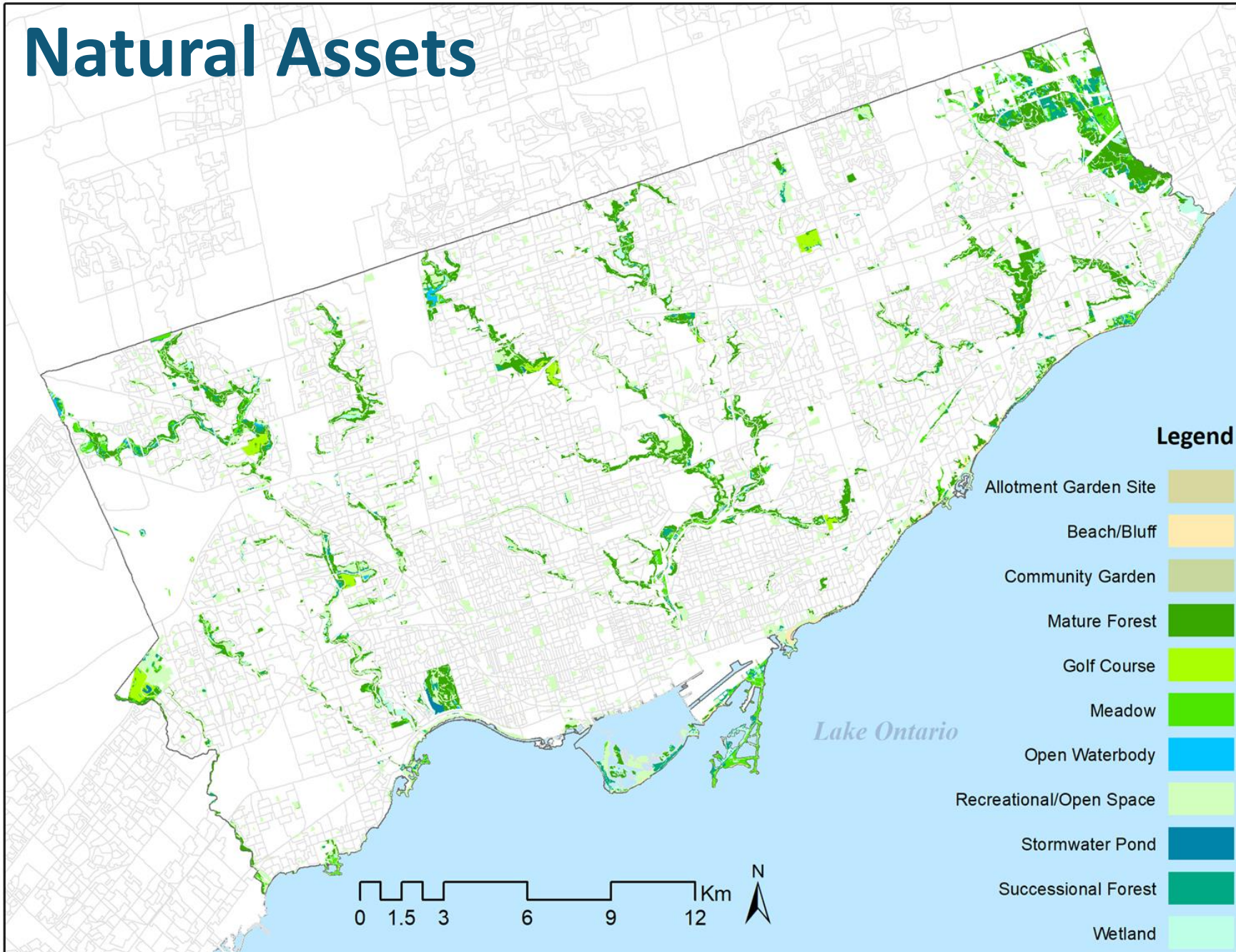
Area (ha)

- Mature Forest: 2820
- Successional Forest: 486
- Wetland: 583
- Allotment Garden Site: 10
- Community Garden: 3
- Open Waterbody: 33
- Stormwater Management Pond: 34
- Meadow: 598
- Beach/Bluff: 107
- Recreational/Open Space: 2544
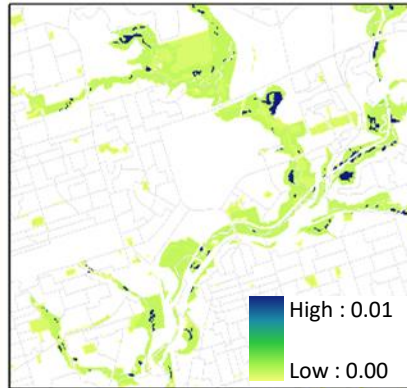- Golf Courses: 207

Total area: 7376 ha

Stormwater Retention & Two Water Quality Indicators

# Stormwater Retention & Two Water Quality Indicators

- Model computes annual stormwater retention and associated water quality benefits

- Water quality indicators are avoided loads of suspended solids and phosphorus

- Estimation of annual hydrologic response is more practical for planning purposes

- Retention = Interception + Infiltration + Evaporation + Transpiration

# Stormwater Retention & Two Water Quality Indicators

LULC

Average Annual precipitation

Runoff Coefficients

Event Mean Concentration of Pollutants

Roads Centerline

Replacement Costs

# Stormwater Retention & Two Water Quality Indicators



LULC map

Legend

- Agricultural
- Aquatic
- Beach/Bluff
- Cemetery
- Commercial
- Forest
- Golf Course
- High Density Residential
- Industrial
- Institutional
- Meadow
- Medium Density Residential
- Railway
- Recreational/Open Space
- Roads
- Rural Residential
- Vacant Land

0 1.5 3 6 9 12 Km

N

Average Annual Precipitation (1981-2010)

Richmond Hill

Toronto Buttonville A

852.9 mm

895.2 mm

785.9 mm

831.1 mm

Pearson International Airport

Toronto

# Stormwater Retention & Two Water Quality Indicators

| Land use/cover | Runoff Coefficient | EMC_P (mg/l) | EMC_TSS (mg/l) |
|---|---|---|---|
| Agricultural | 0.35 | 0.23 | 100 |
| Beach/Bluff | 0.25 | 0.2 | 27 |
| Cemetery | 0.25 | 0.32 | 100 |
| Commercial | 0.9 | 0.23 | 90 |
| Forest | 0.25 | 0.23 | 55 |
| Golf Course | 0.25 | 0.32 | 100 |
| High Density Residential | 0.85 | 0.23 | 90 |
| Industrial | 0.85 | 0.23 | 90 |
| Institutional | 0.75 | 0.23 | 90 |
| Rural Residential | 0.65 | 0.23 | 90 |
| Meadow | 0.28 | 0.23 | 100 |
| Medium Density Residential | 0.75 | 0.23 | 90 |
| Railway | 0.35 | 0.23 | 90 |
| Recreational/Open Space | 0.25 | 0.2 | 27 |
| Roads | 0.9 | 0.23 | 90 |
| Vacant Land | 0.3 | 0.09 | 7 |
| Aquatic | 0.05 | 0.81 | 13 |

# Stormwater Retention & Two Water Quality Indicators
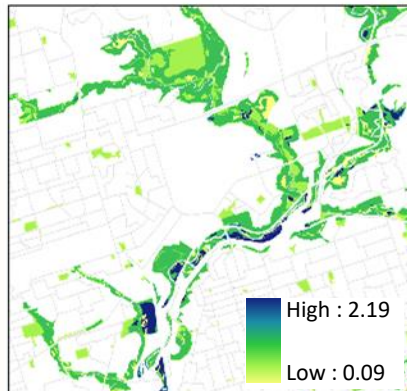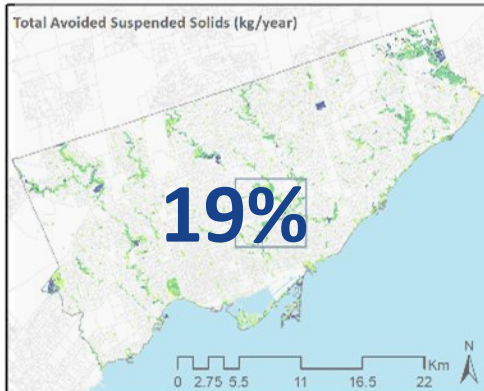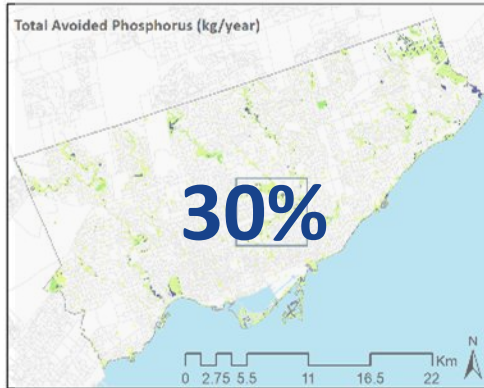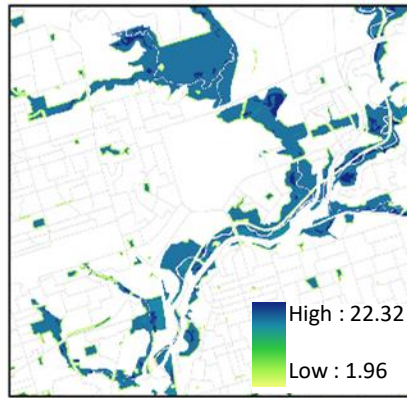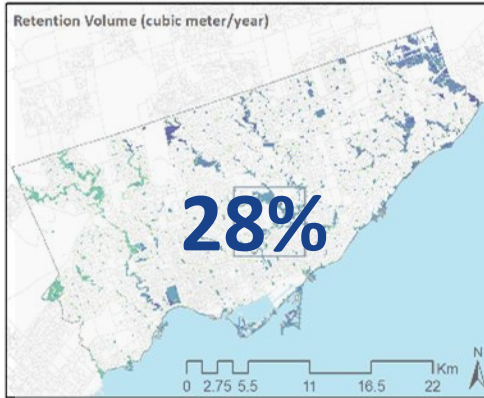


| Service category | Unit | Land use | Value | Percentage of total (%) |
|---|---|---|---|---|
| Stormwater retention | m³/year | Parks | 53,695,841.84 | 96.51 |
| | | Open Green Spaces | 472,184.20 | 0.84 |
| | | Golf Courses | 1,474,175.56 | 2.65 |
| Total | | | 55,642,201.60 | 100.00 |
| Water quality (P) - Prevented load of Phosphorus | Kg/year | Parks | 14,734.58 | 96.01 |
| | | Open Green Spaces | 156.99 | 1.03 |
| | | Golf Courses | 455.23 | 2.96 |
| Total | | | 15,346.80 | 100.00 |
| Water quality (SS) - Prevented load of suspended solids | Kg/year | Parks | 2,424,405.42 | 94.13 |
| | | Open Green Spaces | 22,383.12 | 0.87 |
| | | Golf Courses | 128,884.81 | 5.00 |
| Total | | | 2,575,673.35 | 100.00 |

# Stormwater Retention & Two Water Quality Indicators

$ 39.14/m^3

121.43/m3

$ 203.73/m^3

55 million m³/year

$ 6.7 Billion

Carbon Storage & Sequestration

Carbon Storage & Sequestration

# Carbon Storage & Sequestration



**Above-ground Biomass**

**Dead Organic Matter**

**Soil Organic Carbon**

**Below-ground Biomass**

Natural Asset Carbon Assessment Guide and Toolbox
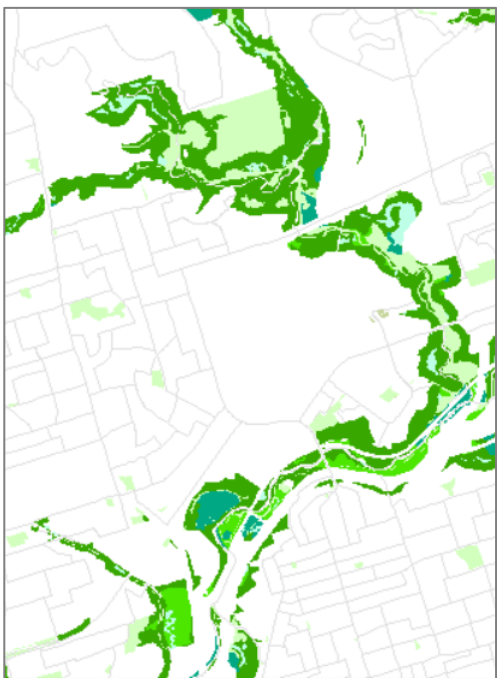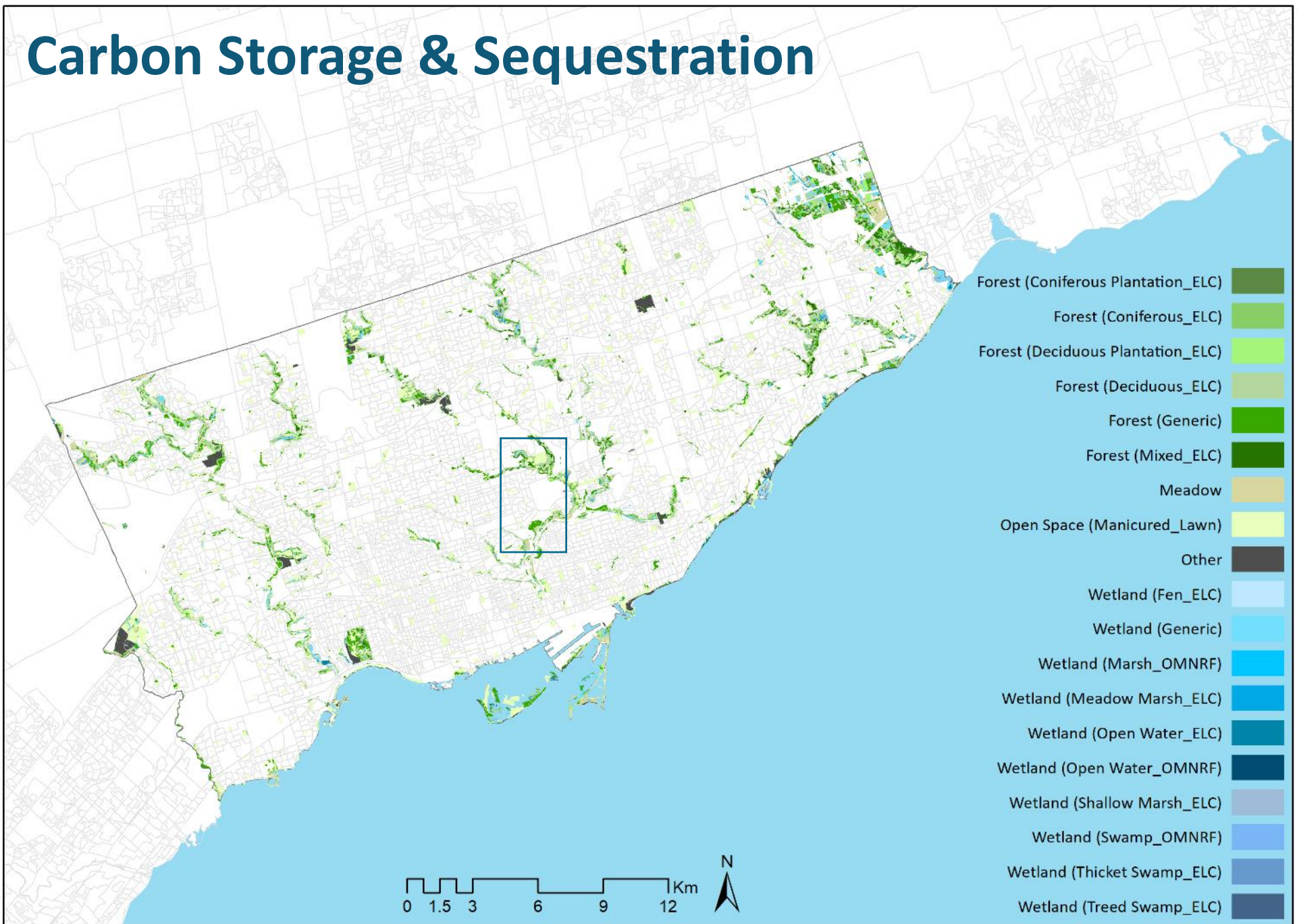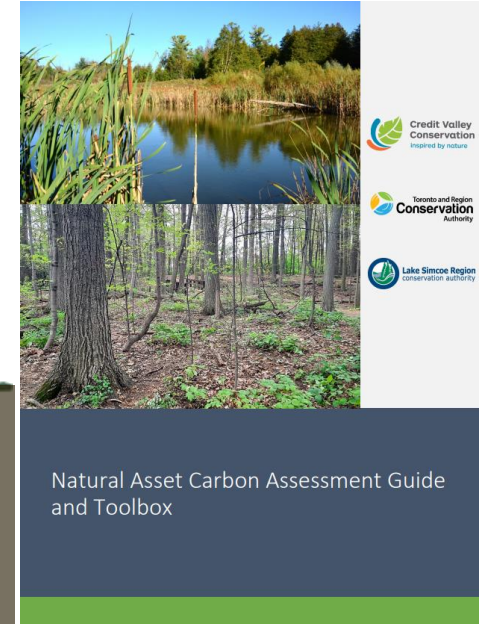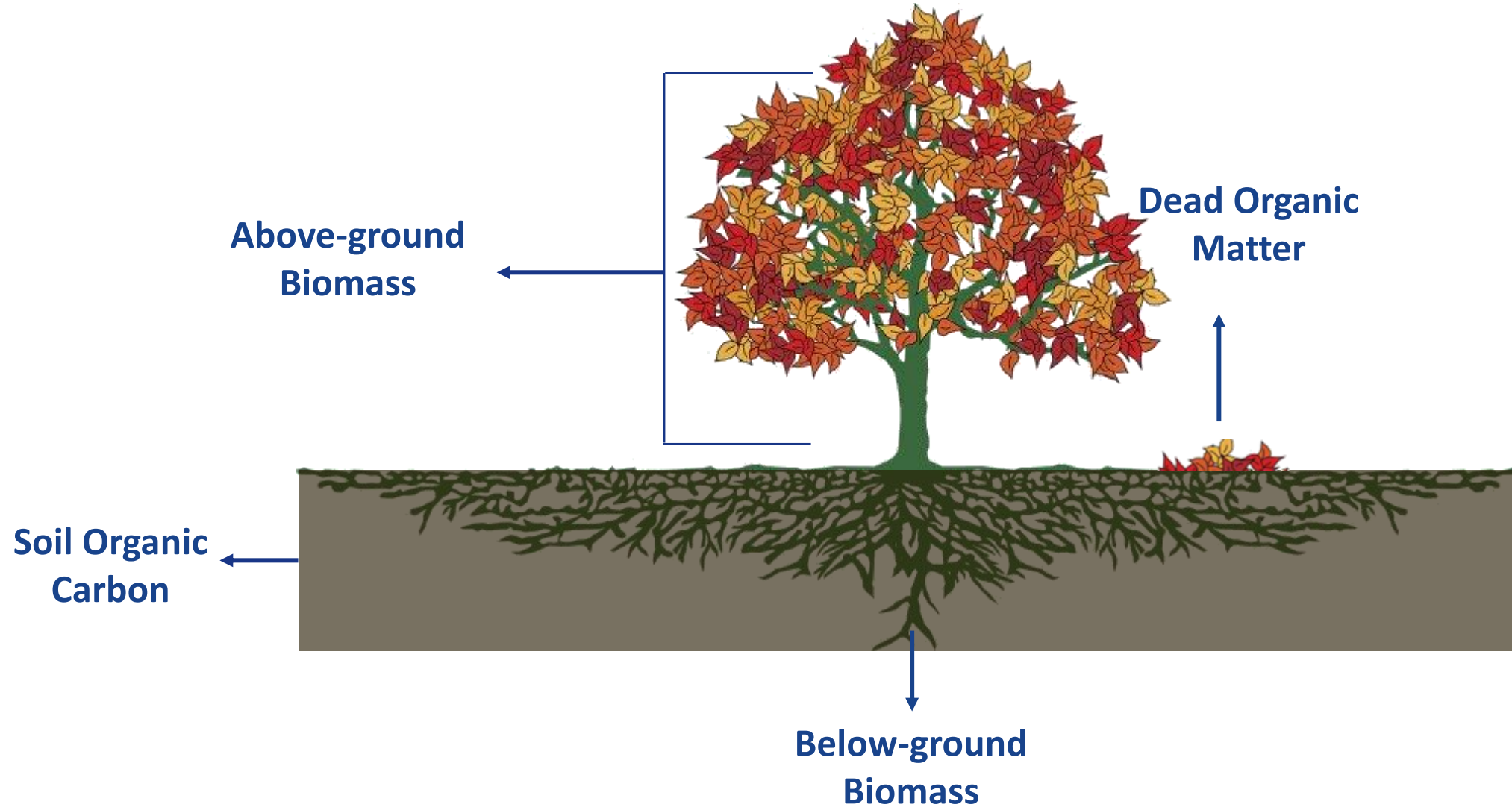
# Carbon Storage & Sequestration

| LULC | Carbon sequestration (tonne/ha/year) | Soil carbon (tonne/ha) [depth of measurement] | Aboveground biomass (tonne/ha) | Belowground biomass (tonne/ha) | Dead organic matter (wood) (tonne/ha) |
|---|---|---|---|---|---|
| Forest (Generic) | 2.19 | 97.2 [70] | 50.62 | 14.88 | 7.42 |
| Forest (Coniferous Plantation_ELC) | 3.96 | 64.6 [100] | 87.75 | 14.36 | 5.70 |
| Forest (Coniferous_ELC) | 3.96 | 64.6 [100] | 87.75 | 14.36 | 5.70 |
| Forest (Deciduous_ELC) | 1.99 | 97.2 [70] | 56.95 | 14.2 | 6.39 |
| Forest (Deciduous Plantation_ELC) | 1.99 | 70.2 [100] | 33.2 | 14.2 | 6.39 |
| Forest (Mixed_ELC) | 2.63 | 52.5 [60] | 18.85 | 18.95 | 13.95 |
| Wetland (Generic) | 5.08 | 125.11 [NA] | 10.62 | 17.01 | 0 |
| Wetland (Marsh_OMNRF) | 6.21 | 116.21 [NA] | 13.25 | 21.37 | 0 |
| Wetland (Meadow Marsh_ELC) | 4.17 | 130 [average of 20 and 16] | 10.3 | 12.8 | 0 |
| Wetland (Open Water_ELC) | 2.38 | 95 [22] | 5.9 | 6.7 | 0 |
| Wetland (Open Water_OMNRF) | 2.38 | 95 [22] | 5.9 | 6.7 | 0 |
| Wetland (Shallow Marsh_ELC) | 8.55 | 110 [average of 15 and 21] | 17 | 30.9 | 0 |
| Wetland (Treed Swamp_ELC) | 2.94 | 87 [average of 14 and 18] | 7.2 | 4.1 | 0 |
| Wetland (Thicket Swamp_ELC) | 1.99 | 170 [average of 21 and 24] | 2.8 | 6 | 0 |
| Wetland (Fen_ELC) | 2.77 | 71 [17] | 11.7 | 2.7 | 0 |
| Wetland (Swamp_OMNRF) | 2.15 | 155.97 | 3.54 | 5.67 | 0 |
| Meadow | 0.5 | 105 [100] | 0 | 0 | 0 |
| Open Space (Manicured Lawn) | 0.34 | 49.76 [15] | 0 | 0 | 0 |
| Other | 0 | 0 | 0 | 0 | 0 |

# Carbon Storage & Sequestration
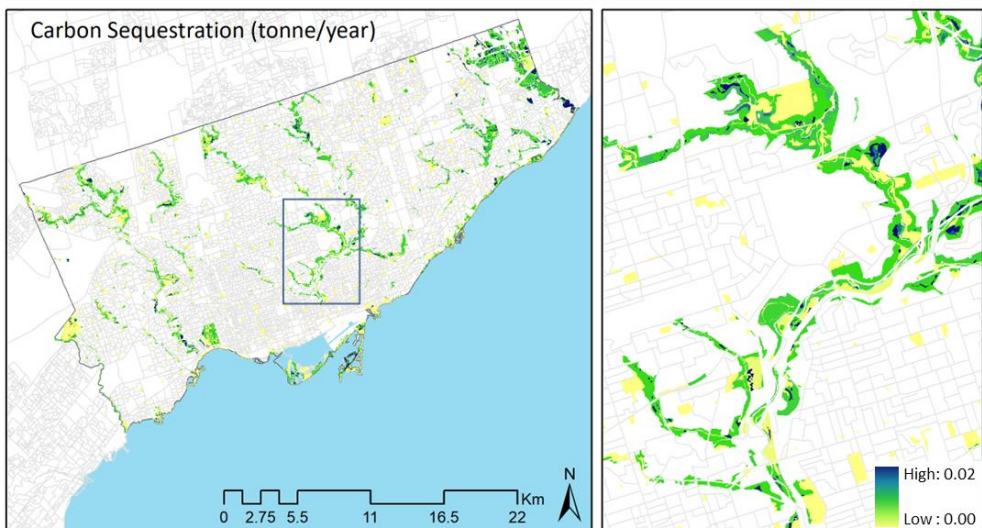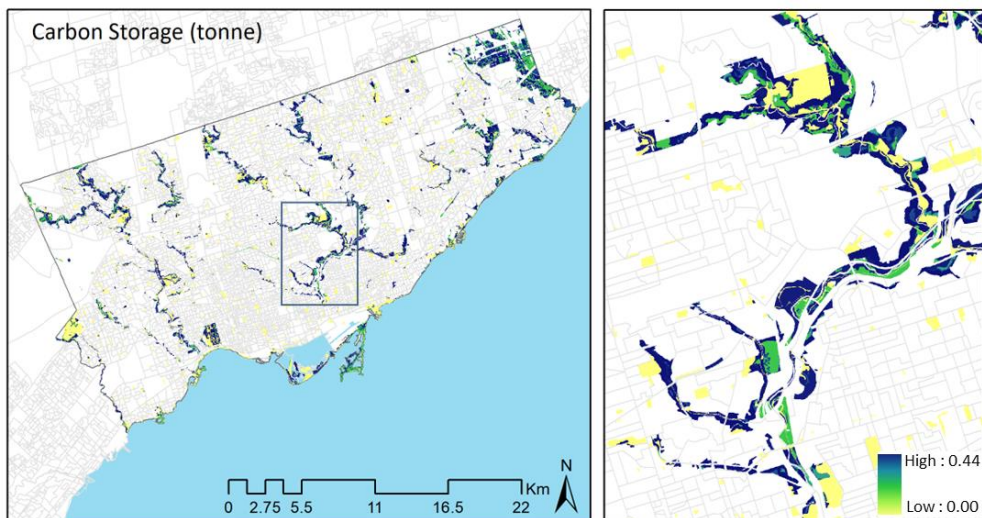


| Land use | Total sequestration (tonne /year) | Total storage (tonne) | Sequestration (%) | Storage (%) |
|---|---|---|---|---|
| Parks | 11,015.21 | 794,923.44 | 98.00 | 98.12 |
| Open Green Spaces | 118.97 | 7,633.37 | 1.05 | 0.94 |
| Golf Courses | 101.83 | 7,672.33 | 0.95 | 0.94 |
| Total | 11,236.01 | 810,229.14 | 100 | 100 |

# Social Cost of Carbon

The economic damage caused by emitting and additional tonne of carbon dioxide into the atmosphere

| Land use | $CO_2$e of total Sequestration (t) | $CO_2$e of total storage (t) | Social cost of carbon (CAD/t $CO_2$e) | Estimated value of sequestration (CAD) | Estimated value of storage (CAD) |
|---|---|---|---|---|---|
| Park | 40,425.82 | 2,917,369.02 | | 2,387,953 | 172,328,988 |
| Open Green Space | 436.62 | 28,014.46 | 59.07 | 25,791 | 1,654,814 |
| Golf Courses | 373.71 | 28,157.45 | | 22,075 | 1,663,260 |
| Total | 41,236.15 | 2,973,540.93 | | 2,435,819 | 175,647,062 |

Air Quality Regulation
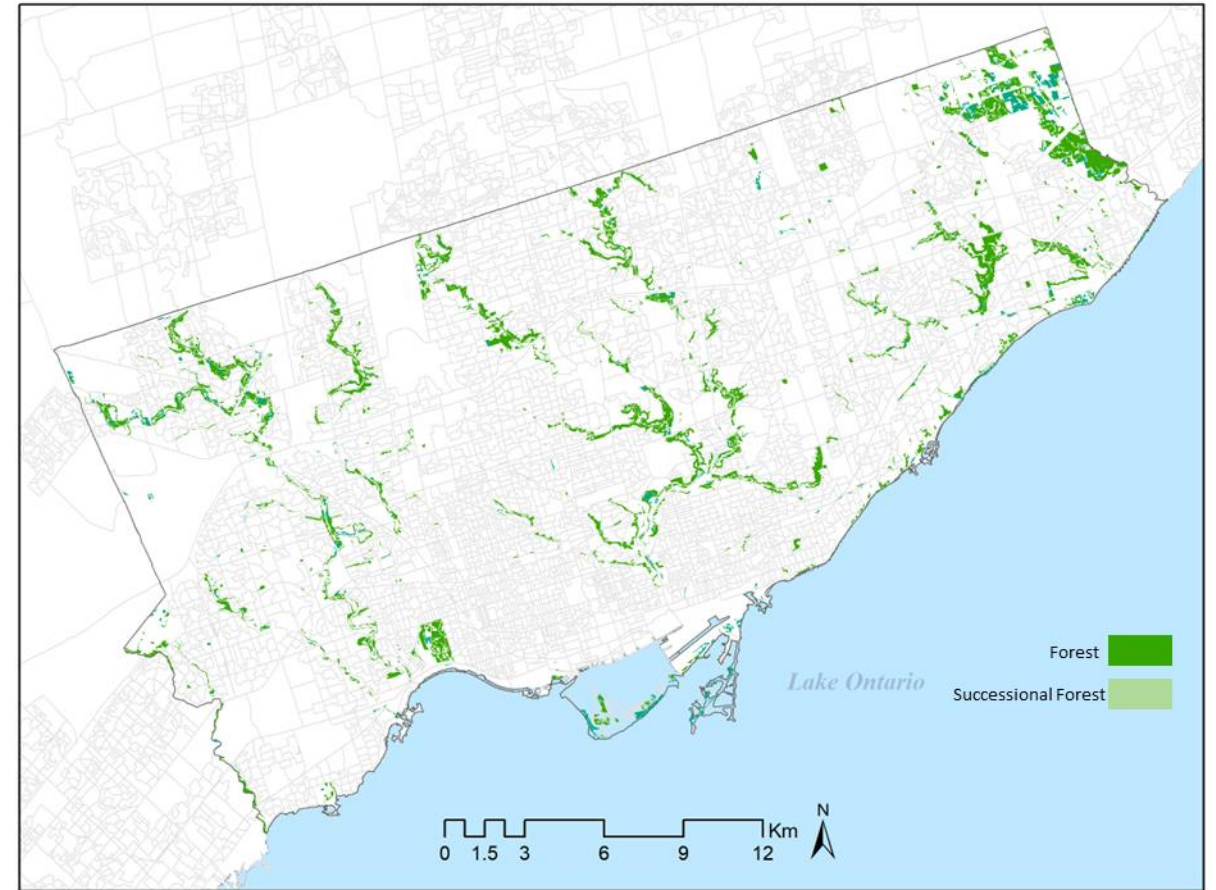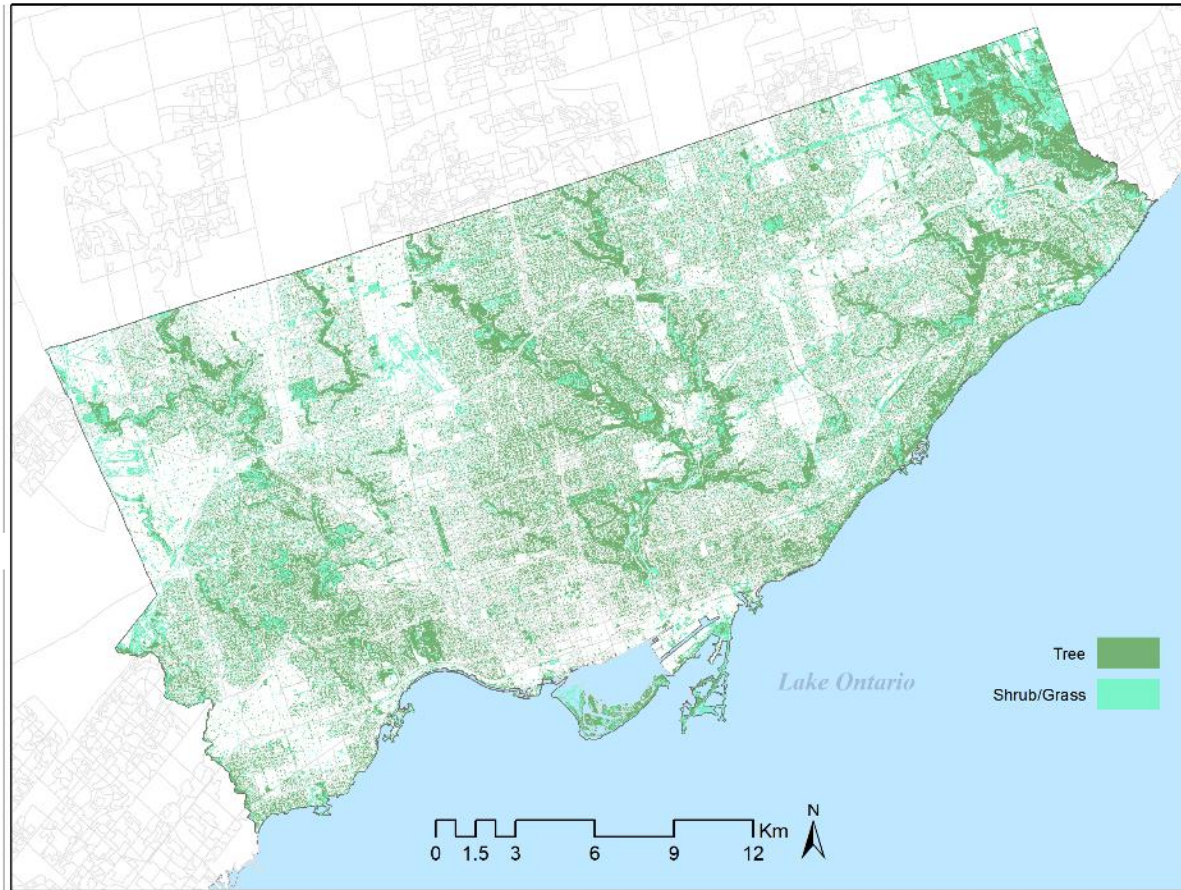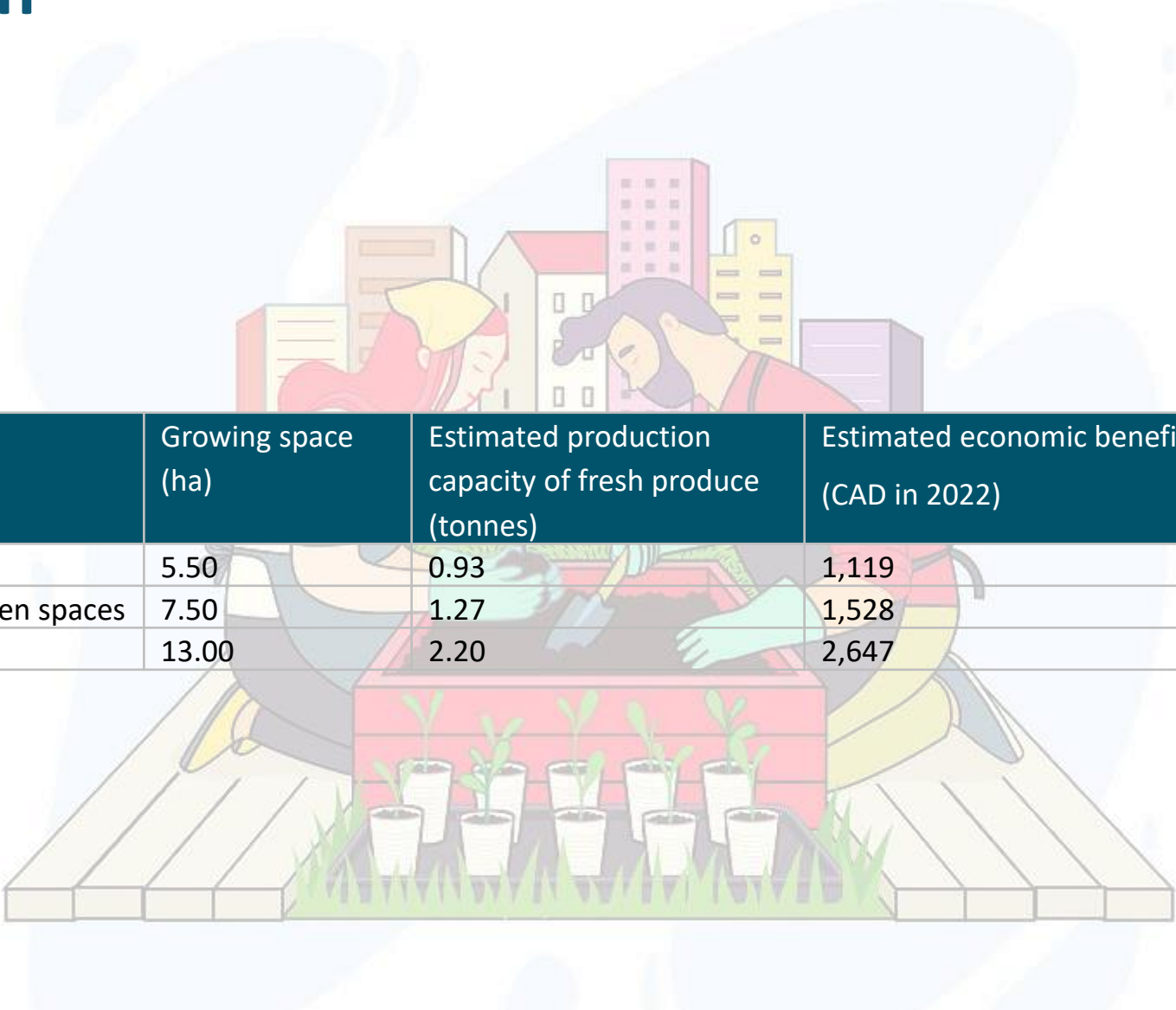
# Air Quality Regulation

# Air Quality Regulation

# Food Provision

# Food Provision

| Land use | Growing space (ha) | Estimated production capacity of fresh produce (tonnes) | Estimated economic benefits (CAD in 2022) |
|---|---|---|---|
| Park | 5.50 | 0.93 | 1,119 |
| Open Green spaces | 7.50 | 1.27 | 1,528 |
| Total | 13.00 | 2.20 | 2,647 |

# Civic Contribution

# Civic Contribution

| Park Program | Volunteer hours | Estimated civic contribution (CAD in 2022) |
|---|---|---|
| Planting Events | 6,485 | 97,275 |
| Stewardship Events | 664 | 9,960 |
| Community Stewardship Program | 3,829 | 57,435 |
| Tree Planting Captain Program | 76.5 | 1,148 |
| Don Valley Brickworks Ambassador Program | 91 | 1,365 |
| Total | 11,145.5 | 167,183 |

| Civic contribution category | Estimated Civic Contribution (CAD in 2022) |
|---|---|
| Volunteer hours | 167,183 |
| Average adjusted donation (CAD) based on 2017 and 2018 donation data | 112,069 |
| Total | 279,252 |

# Habitat Suitability

# Habitat Suitability
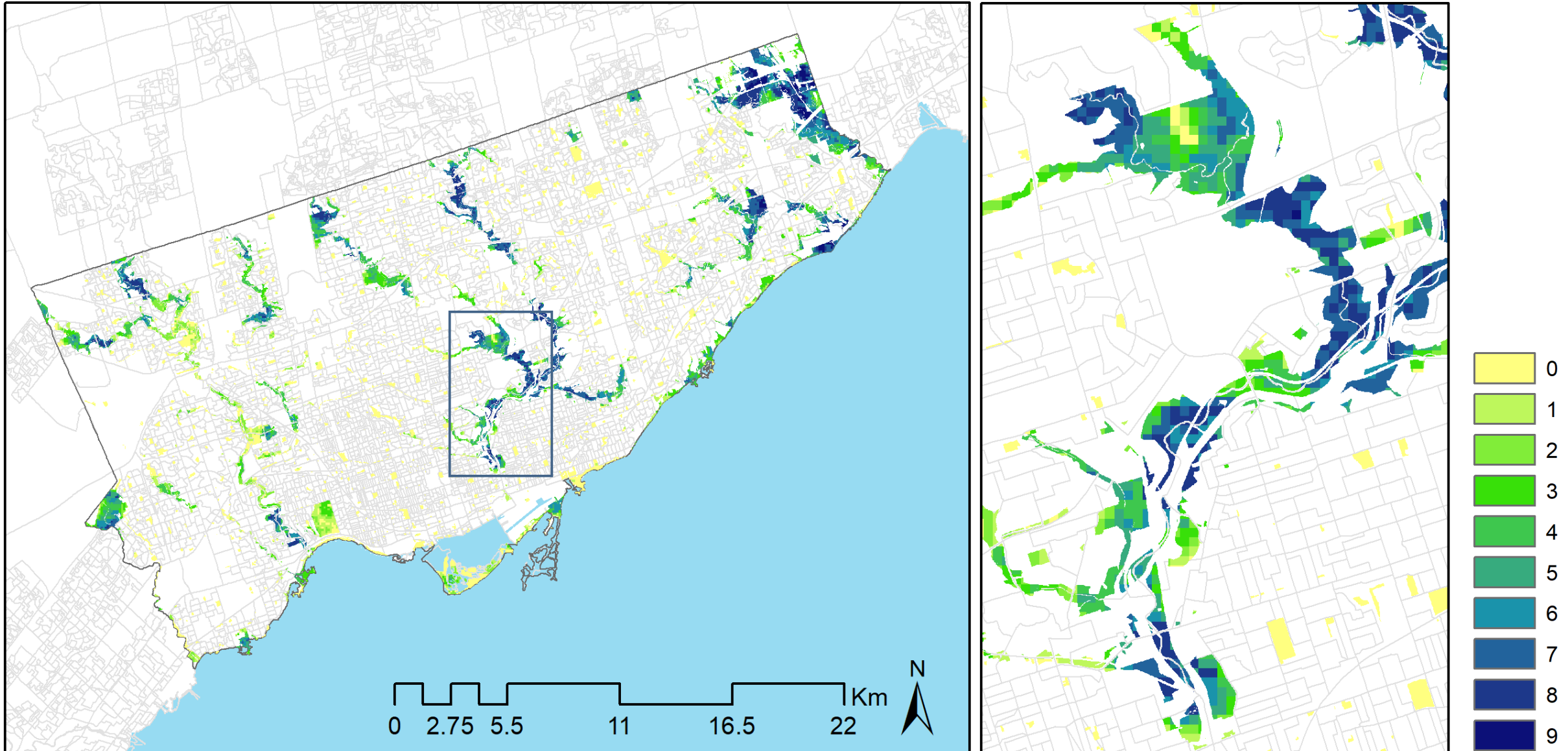
Heat Mitigation

# Heat Mitigation
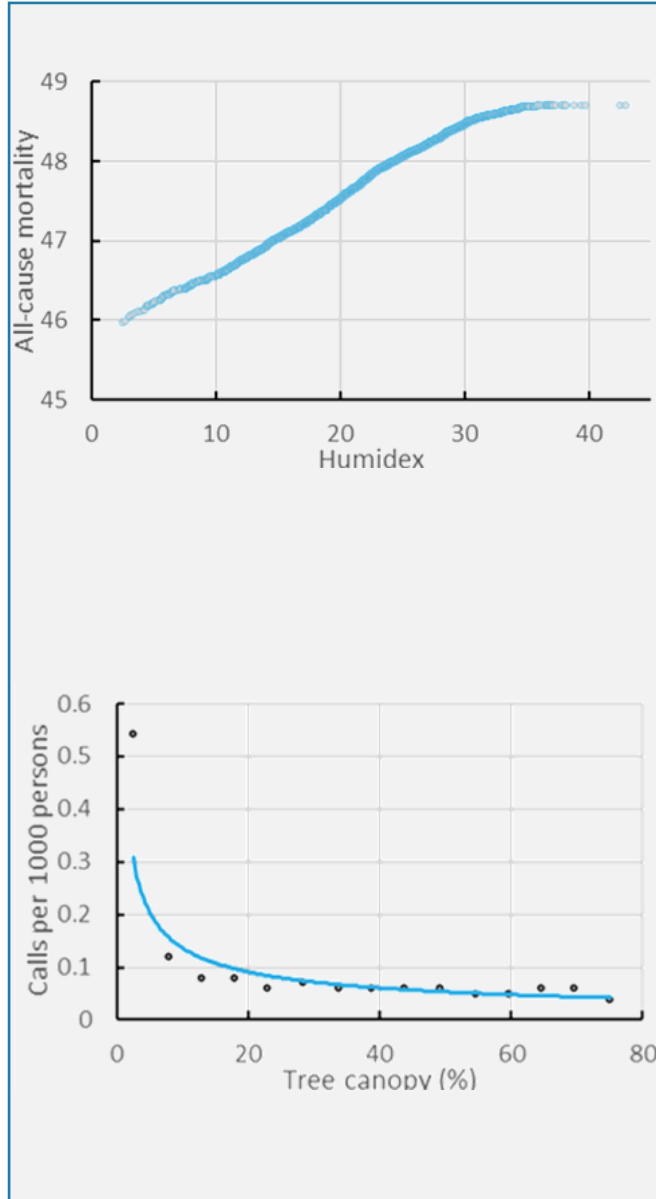


| | Current Condition | | | No-Park Scenario | | |
|---|---|---|---|---|---|---|
| | Vegetative cover | Tree canopy | Water | Vegetative cover | Tree canopy | Water |
| Urban (built area) | 23.5% | 25.9% | 1.3% | 17.1% | 14.2% | 0.7% |
| Parks | 80% | 80% | 5% | 50% | 0% | 0% |

| | | During an extreme heat event | | | | | During a typical summer season | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | $Temp\_avr$ (°C) | $Temp\_max$ (°C) | $E\_use$ (MW) | $Hmdx\_avr$ | $Hmdx\_max$ | $Temp\_avr$ (°C) | $Temp\_max$ (°C) | $E\_use$ (MW) | $Hmdx\_avr$ | $Hmdx\_max$ |
| Urban | Current | 23.3 | 36.3 | 267.5 | 29.7 | 52.3 | 16.5 | 31.9 | 185.7 | 18.8 | 40.6 |
| | No-park scenario | 24.3 | 37.9 | 272.0 | 30.7 | 53.9 | 17.2 | 33.0 | 194.9 | 19.5 | 41.7 |
| | | 4.3% | 4.4% | 1.7% | 3.4% | 3.1% | 4.2% | 3.4% | 5.0% | 3.7% | 2.7% |
| Inside park | Current | 17.8 | 28.6 | 0.15 | 24.4 | 40.8 | 9.9 | 24.9 | 0.16 | 12.3 | 31.4 |
| | No-park scenario | 22.3 | 33.9 | 0.28 | 28.7 | 49.9 | 14.0 | 29.3 | 0.20 | 16.3 | 38.1 |
| | | 25.3% | 18.5% | 86.7% | 17.6% | 22.3% | 41.4% | 17.7% | 25.0% | 32.5% | 21.3% |
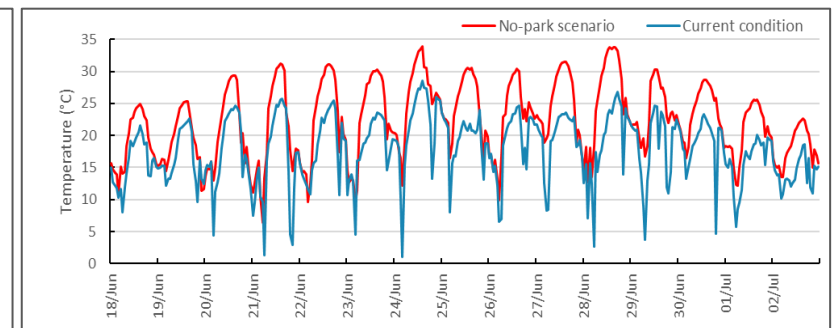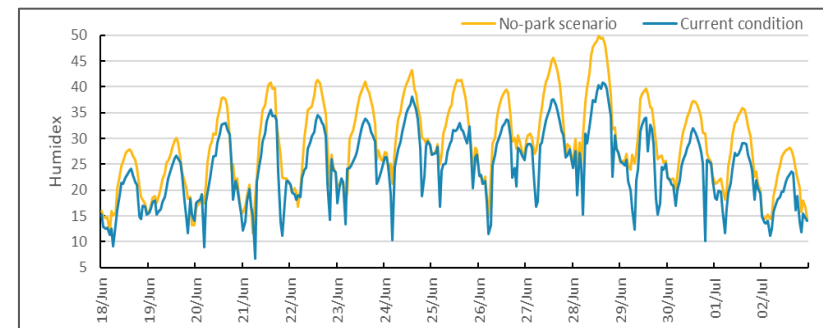
# Heat Mitigation



**Premature Mortality** — ↓ **15**

**Emergency Department Visits** — ↓ **135**

**Ambulance Calls** — ↓ **83**

**Energy Consumption** — ↓ **1.4 million kwh**

**Very hot days** — ↓ **6 days**

# Heat Mitigation

| Economic benefit category | Economic benefits (CAD in 2022) |
|---|---|
| Avoided costs of premature mortality | 133,500,000 |
| Avoided costs of emergency department visits | 46,845 |
| Avoided costs of ambulance service calls | 19,920 |
| Energy savings | 158,200 |
| Increased worker productivity | 32,932,055 |
| Total | 166,657,020 |

# Physical Health

# Physical Health

**1- What is considered a physically active lifestyle?**

According to Canadian Physical Activity Guidelines (CPAG), 150 minutes of moderate to vigorous physical activity per week is considered a physically active lifestyle.

**2- How many people in Toronto use park spaces on a regular basis?**

According to a citywide survey, 56% of people (1,687,701) visit park spaces on a regular basis (at least once a week).

**3- What percentage of these park users engage in physical activities that can lead to an active lifestyle?**

According to Environics MobileScapes dataset, 52.9% of regular park users (887,731), can be considered physically active (i.e., meet the minimum threshold for physical activity).

**4- How many of these active park users engage in physical activity at or above the population wide rate of people who are physically active?**

The population wide rate of people who are physically active is 16.4% (= 276,783 people). The number of park users who are not included in this population wide rate is 610,948.

**5- What is the avoided health care cost associated with physical inactivity per person?**

CAD 323.69 (in 2019)

**Physical Health**

# Economic Value of Physical Activity = CAD 220,598,130 (in 2022)

# Mental Health

Source: Shutterstock

# Mental Health

## 56%
**Frequent Park Users**
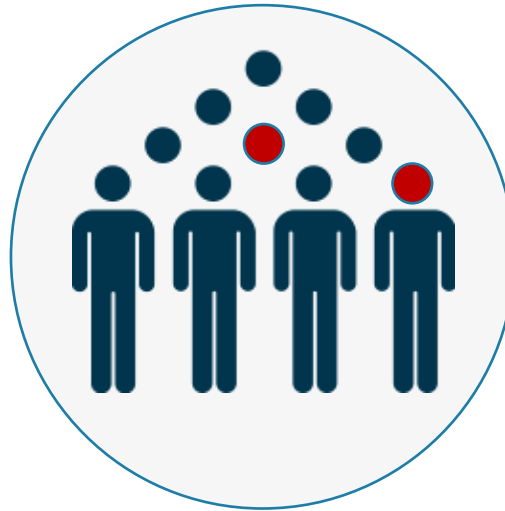
## 8.3%
**Population Prevalence of Mood Disorder Among Park Users**

## 9.6%
**Population Prevalence of Mood Disorder in Toronto**

**Mental Health**

# Mental Health Benefits= 21,940 * CAD 1950 = CAD 42,783,223

# Section 3

# Aggregate Benefits

**Total Economic Benefits:**

CAD 7.37 Billion
in
2022

# Ecosystem Service Provision Index
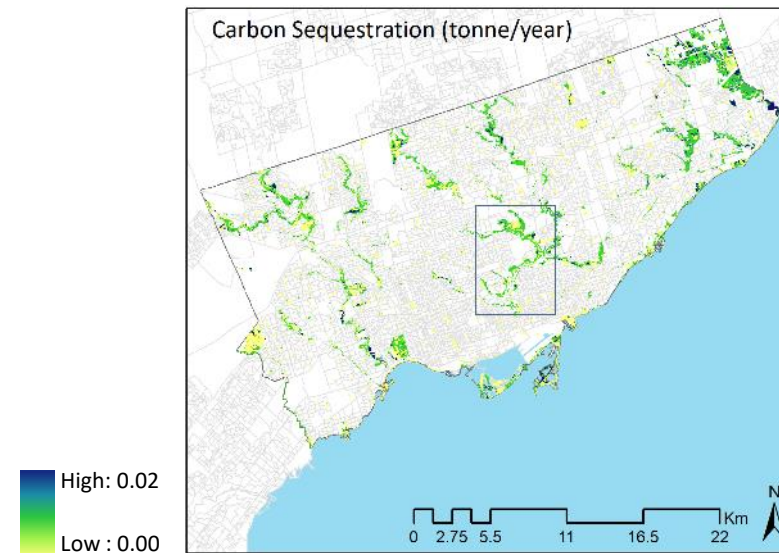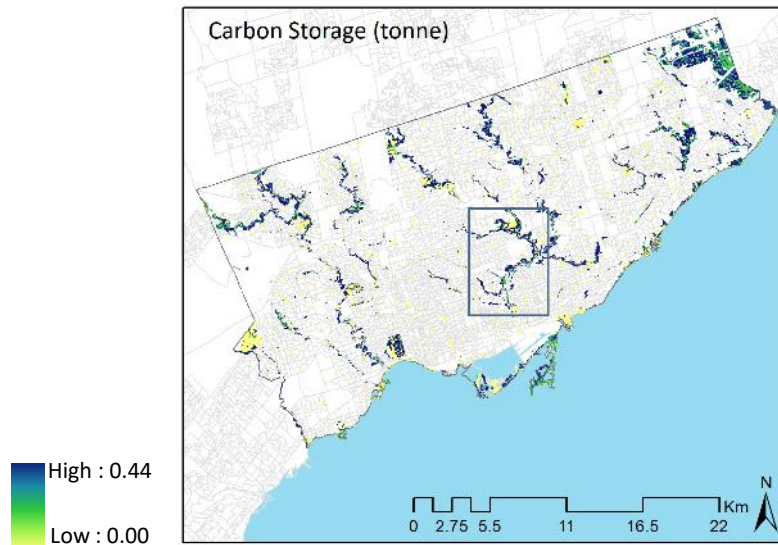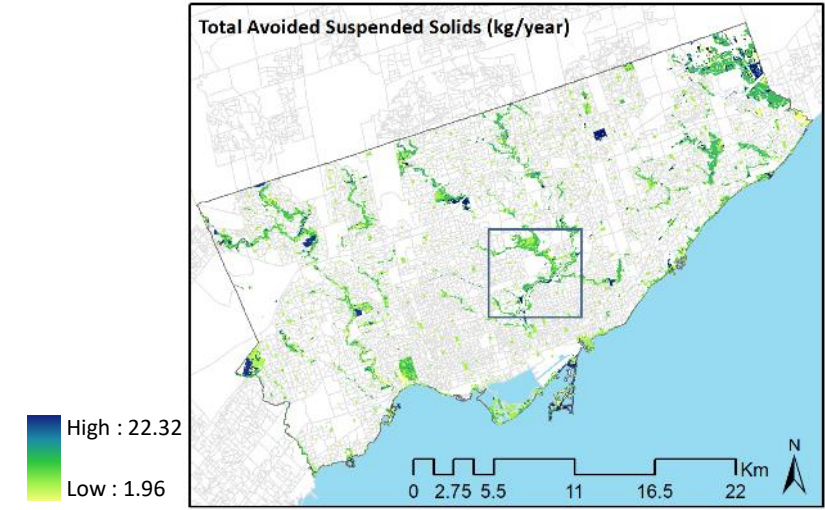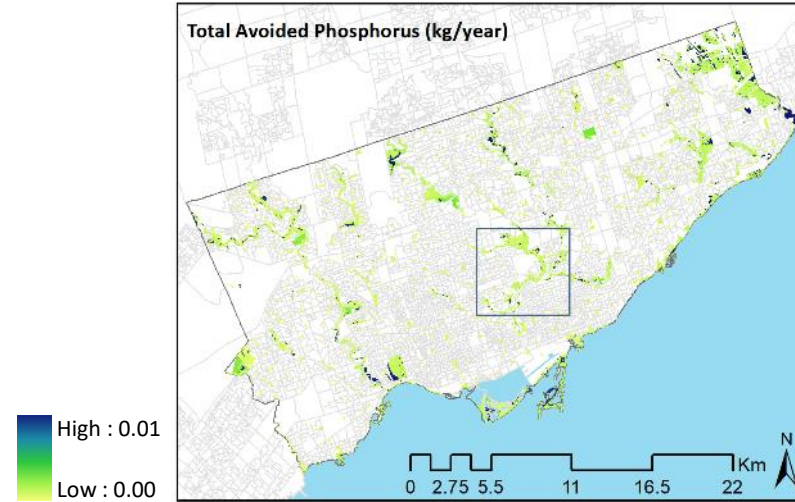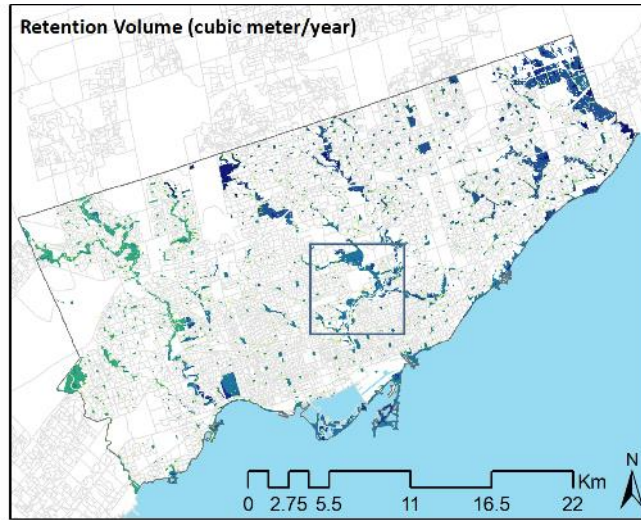
# Ecosystem Service Provision Index

## Fuzzy

### Fuzzy Membership Function

### Fuzzy Overlay Operators

# Fuzzy Membership Function (Linear Increasing)

Applies linear transformation to continuous data

$$\mu(x) = \begin{cases} 0 & x \leq a \\ \dfrac{x-a}{b-a} & a < x < b \\ 1 & x \geq b \end{cases}$$

a and b: user-specified minimum and maximum values determining the acceptable ranges of attribute values in the thematic layers
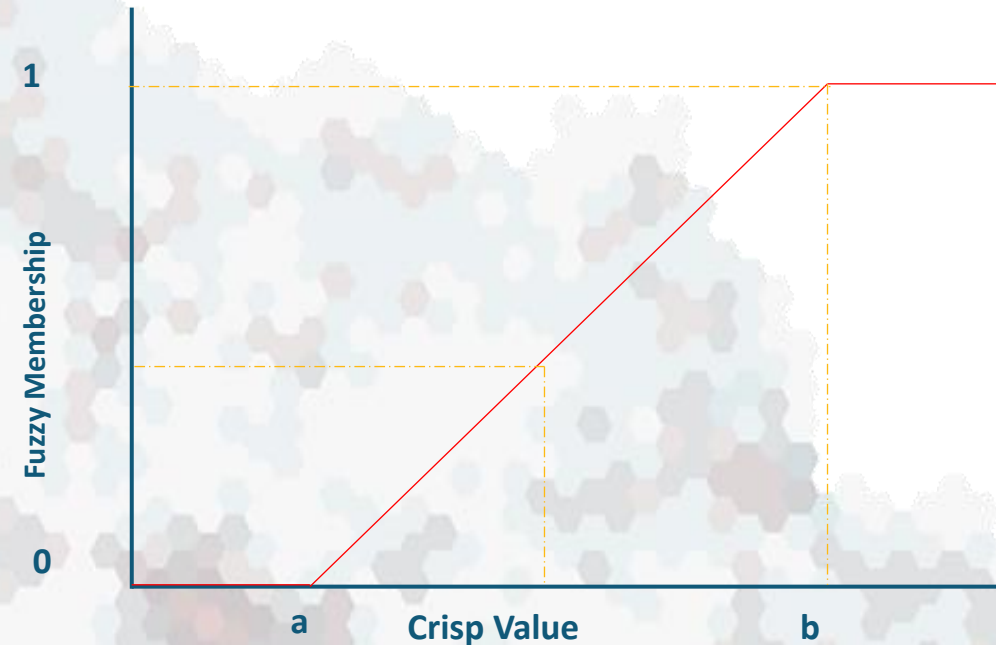
# Fuzzy Overlay Analysis

**Fuzzy "compensatory and" operator**

$$\mu(x) = \left(1 - \prod_{i=1}^{n}(1 - \mu_i(x))\right)^{\gamma} * \left(\prod_{i=1}^{n}\mu_i(x)\right)^{(1-\gamma)} \qquad x \in X \quad 0 \leq \gamma \leq 1$$

Fuzzy Sum     Fuzzy Product

Stormwater Retention

Avoided P

Avoided TSS

Carbon Sequestration

Carbon Storage

High : 1

Low : 0

# Ecosystem Service Provision Index (ESPI)

# Thank You!

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**Toronto and Region Conservation Authority**
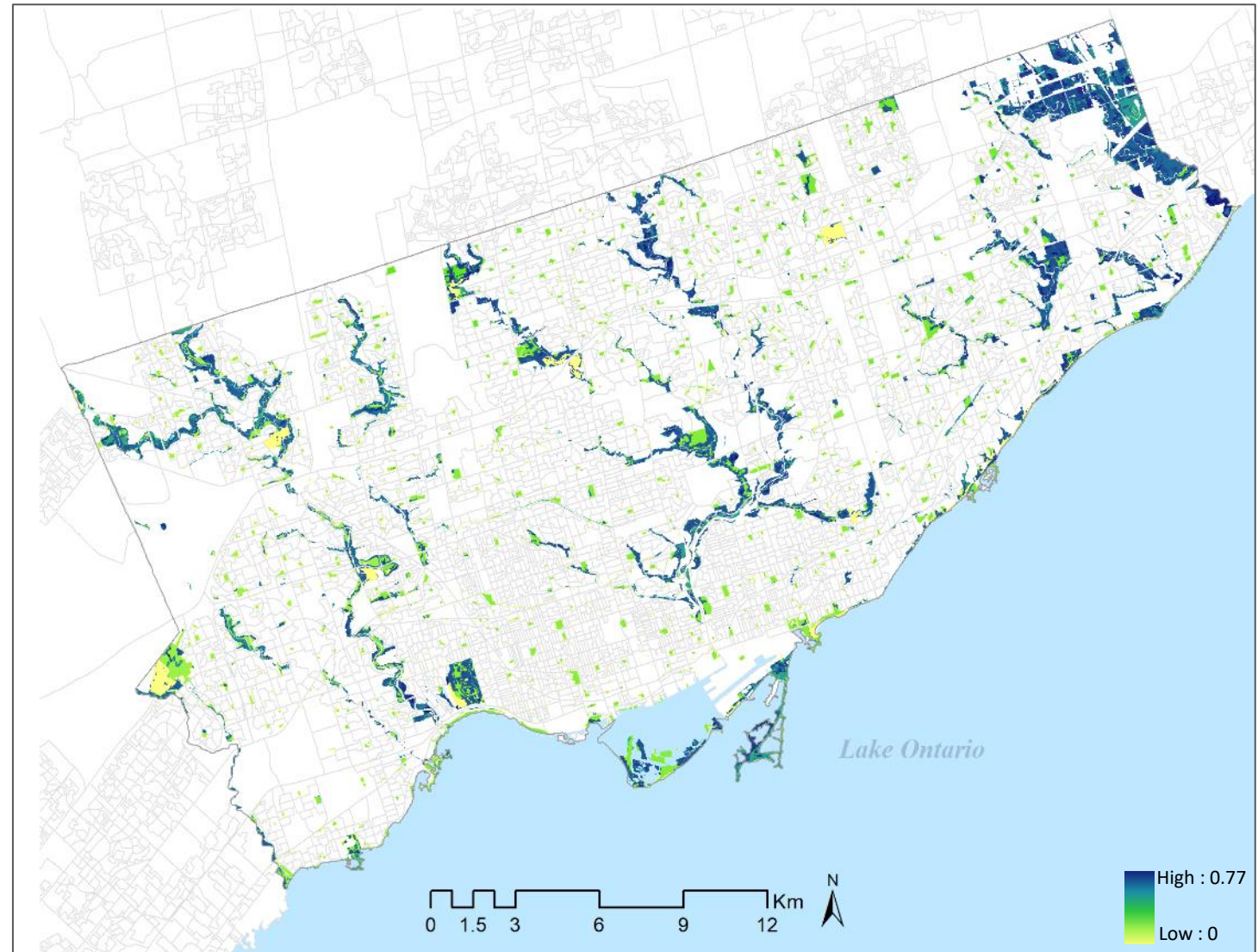
# Upcoming ECS Lunch and Learns!

Tuesday, March 7
11:00am-12:00pm

**Ontario's Excess Soil Regulation**

By Don Ford

Wednesdays/Thursdays
April 19-20 & 26-27
1:00-4:00pm

**Baseline Coastal Habitat Survey for the Canadian Great Lakes**

With ECCC, DFO, MNRF

Tuesday, May 2
11:00am-12:00pm

**Shoreline Hazard Mapping Project**

By Christina Bright

# Learning Management System
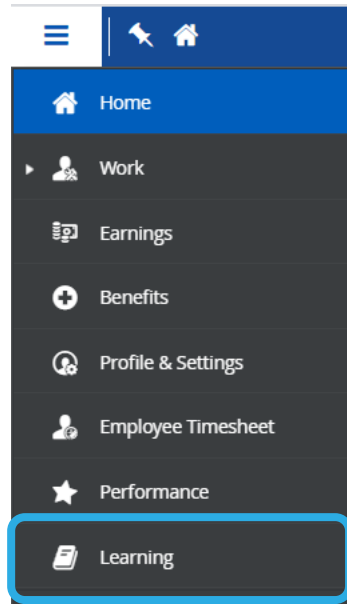
# Scientific Knowledge Sharing Hub

# Past Recordings

# Thank you

For questions about the ECS Lunch and Learn Series, please contact:

Sharon Lam
sharon.lam@trca.ca

**Toronto and Region Conservation Authority**